Boott Hydropower, LLC
A Subsidiary of Enel Green Power North America, Inc.

100 Brickstone Square, Suite 300 – Andover, MA 01810 – USA
T +1 978 681 1900 – F +1 978 681 7727

Via eFiling

April 30, 2018

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street, N.E.
Washington, D.C. 20426

Re: Lowell Hydroelectric Project (FERC No. 2790);
Notice of Intent and Pre-Application Document.

Dear Secretary Bose:

Boott Hydropower, LLC ("Boott" or "Applicant"), a subsidiary of Enel Green Power North America, Inc., is submitting to the Federal Energy Regulatory Commission ("FERC" or "Commission") the Notice of Intent (NOI) to file an application for a new license and Pre-Application Document (PAD) for the Lowell Hydroelectric Project (FERC No. 2790) ("Project"). The Lowell Hydroelectric Project is located on the Merrimack River in Middlesex County, Massachusetts and in Hillsborough County, New Hampshire. The current FERC license expires on April 30, 2023.

The Applicant is distributing this letter to the parties listed on the distribution list in Appendix B of the PAD. For parties listed in Appendix B who have provided an email address, the Applicant is distributing this letter via email; otherwise, the Applicant is distributing this letter via U.S. mail. All parties interested in the relicensing process, may obtain a copy of the NOI and PAD electronically through FERC's eLibrary system at https://elibrary.ferc.gov/idmws/search/fercgensearch.asp under docket number P-2790. If any party would like to request a CD containing an electronic copy of the NOI and PAD, please contact the undersigned at the information listed below. In addition, the Applicant is providing two courtesy paper copies of the NOI and PAD to Commission Staff in the Office of Energy Projects and Office of General Counsel – Energy Projects, as required by the Commission's filing guidelines. The NOI and PAD are available for inspection at the Applicant's business office during regular business hours located at 100 Brickstone Square, Suite 300, Andover, MA 01810.

Volume II of the PAD includes a single-line diagram of the Project as required by the Commission's PAD content requirements 18 CFR § 5.6(d)(2)(iii)(D). The information contained in this drawing is deemed as Critical Energy Infrastructure Information (CEII) under 18 CFR §388.113 and thus Volume II of the PAD is not being distributed to the public. The Licensee is filing Volume II under the Commission's e-filing guidelines for filing CEII.

In accordance with Section 5.5(e) of the Commission's regulations, 18 CFR §5.5(e), the Licensee requests that the Commission authorize the Licensee to conduct consultation with the Massachusetts Historical Commission and the New Hampshire Division of Historical Resources, pursuant to Section 106 of the National Historic Preservation Act (NHPA), 16 U.S.C. § 470f and the NHPA implementing regulations at 36 CFR Part 800.

In addition, the Licensee requests that FERC designate the Licensee as the nonfederal representative for the Project for the purpose of informational consultation with the U.S. Fish and Wildlife Service and National

Marine Fisheries Service, pursuant to Section 7 of the Endangered Species Act (ESA) and the joint agency ESA implementing regulations at 50 CFR Part 402.

We look forward to working with the Commission's staff, resource agencies, members of the public, and other stakeholders toward developing a license application for this renewable energy facility. If there are any questions regarding this letter or the NOI or PAD, please do not hesitate to contact the Kevin Webb, Hydro Licensing Manager, at (978) 935-6039 or kevin.webb@enel.com.

Sincerely,
Boott Hydropower, LLC

Conrad E. St. Pierre, P.E.
Senior Director of Hydro North America

cc: Attached Distribution List
J. Gibson, HDR
K. Webb, Boott
M. Beauregard, Esq., Boott
M. Donahue, Boott

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Federal and State Agencies

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Boston, MA 02114

Massachusetts Department of Public Utilities
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Massachusetts Division of Fisheries & Wildlife
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Westborough, MA 01581

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Chairman
Massachusetts Division of Fisheries & Wildlife
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Brona Simon
State Historic Preservation Officer
Massachusetts Historical Commission
220 Morissey Boulevard
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Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

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Boston, MA 02125-3314

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Boston, MA 02108-1518

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55 Great Republic Drive
Gloucester, MA 01930

Sue Tuxbury
Fisheries Biologist
National Marine Fisheries Service
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Gloucester, MA 01930

Misty Anne Marold
Senior Review Biologist
Natural Heritage Endangered Species Program
Massachusetts Division of Fisheries & Wildlife
1 Rabbit Hill Road
Westborough, MA 01581

Owen David
Water Quality Certification Program
New Hampshire Department of Environmental Services
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Concord, NH 03302

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Dam Bureau Administrator
New Hampshire Department of Environmental Services
29 Hazen Drive
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Concord, NH 03302

Brad Simpkins
Director
New Hampshire Division of Forests and Lands
172 Pembroke Road
Concord, NH 03301

Elizabeth Muzzey
Director and State Historic Preservation Officer
New Hampshire Division of Historical Resources
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Fisheries Biologist
New Hampshire Fish and Game Department
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Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

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Fish and Wildlife Biologist
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Celeste Bernardo
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Lowell, MA 01852

Kevin Mendik
Hydro Program Manager
US National Park Service
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Indian Tribes

Cedric Cromwell
Chairman
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Ramona Peters
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John Brown
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Narragansett Indian Tribe
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Bonney Hartley
Tribal Historic Preservation Officer
Stockbridge Munsee Community, Wisconsin
65 1st Street
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Cheryl Andrew-Maltais
Chairwoman
Wampanoag Tribe of Gay Head
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Aquinnah, MA 02535

Bettina Washington
Tribal Historic Preservation Officer
Wampanoag Tribe of Gay Head
20 Black Brook Road
Aquinnah, MA 02535

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Municipalities

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Mayor
City of Haverhill, MA
4 Summer Street
Haverhill, MA 01830

Daniel Rivera
Mayor
City of Lawrence, MA
200 Common Street
3rd Floor Room 309
Lawrence, MA 01840

Nicolas Bosonetto
Interim City Engineer
City of Lowell, MA
375 Merrimack Street
3rd Floor, Room 61
Lowell, MA 01852

Edward Kennedy
Mayor
City of Lowell, MA
375 Merrimack Street
2nd Floor, Room 50
Lowell, MA 01852

Christine O'Connor
City Solicitor
City of Lowell, MA
375 Merrimack Street
3rd Floor, Room 64
Lowell, MA 01852

Joyce Craig
Mayor
City of Manchester, NH
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Manchester, NH 03101

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Mayor
City of Methuen, MA
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Methuen, MA 01844

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City of Nashua, NH
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Nashua, NH 03060

Scott Galvin
Mayor
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Woburn, MA 01801

Paul Bergeron
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Goffstown, NH 03045

Toni Pappas
District #1
Hillsborough County, NH
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Suite 120
Goffstown, NH 03045

Robert Rowe
District #3
Hillsborough County, NH
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Goffstown, NH 03045

Steven Ledoux
Town Manager
Town of Acton, MA
472 Main Street
Acton, MA 01720

Andrew Flanagan
Town Manager
Town of Andover, MA
36 Bartlet Street
Andover, MA 01810

Jason Grosky
Chairman
Town of Atkinson, NH
21 Academy Avenue
Atkinson, NH 03811

Robert Pontbriand
Town Administrator
Town of Ayer, MA
1 Main Street
Ayer, MA 01432

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

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Town Manager
Town of Bedford, MA
10 Mudge Way
Bedford, MA 01730

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Town Manager
Town of Billerica, MA
365 Boston Road
Billerica, MA 01821

Alan Benson
Town Administrator
Town of Boxford, MA
7A Spofford Road
Boxford, MA 01921

Amy Warfield
Town Clerk
Town of Burlington, MA
29 Center Street
Burlington, MA 01803

Jon Kurland
Town Moderator
Town of Chelmsford, MA
50 Billerica Road
Chelmsford, MA 01824

Jane Hotchkiss
Chair, Select Board
Town of Concord, MA
P.O. Box 535
Concord, MA 01742

James Morgan
Councilor
Town of Derry, NH
14 Manning Street
Derry, NH 03038

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Town of Dracut, MA
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Town Manager
Town of Groton, MA
173 Main Street
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Timothy Bragan
Town Administrator
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13 Ayer Road
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Town of Hollis, NH
7 Monument Square
Hollis, NH 03049

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Tom Dolan
Chairman
Town of Londonderry, NH
268B Mammoth Road
Londonderry, NH 03053

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

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Town Administrator
Town of Lynnfield, MA
55 Summer Street
Lynnfield, MA 01940

Eileen Cabanel
Town Manager
Town of Merrimack, NH
6 Baboosic Lake Road
Merrimack, NH 03054

Andrew Sheehan
Town Administrator
Town of Middleton, MA
48 South Main Street
Middleton, MA 01949

Andrew Maylor
Town Manager
Town of North Andover, MA
120 Main Street
North Andover, MA 01845

John Murphy
Town Moderator
Town of North Reading, MA
235 North Street
North Reading, MA 01864

Douglas Viger
Chairman
Town of Pelham, NH
6 Village Green
Pelham, NH 03076

Mark Andrews
Town Administrator
Town of Pepperell, MA
One Main Street
Pepperell, MA 01463

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Chair, Board of Selectmen
Town of Reading, MA
16 Lowell Street
Reading, MA 01867

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Town of Salem, NH
33 Geremonty Drive
Salem, NH 03079

Town Administrator
Town of Shirley, MA
7 Keady Way
Shirley, MA 01464

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Town of Stoneham, MA
35 Central Street
2nd Floor
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Town of Tewksbury, MA
1009 Main Street
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Chair, Board of Selectmen
Town of Tyngsborough, MA
25 Bryants Lane
Tyngsborough, MA 01879

Board of Selectmen
Town of Westford, MA
55 Main Street
Westford, MA 01886

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Town of Wilmington, MA
121 Glen Road
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Town of Windham, NH
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Windham, NH 03087

Additional Parties

Robert Nasdor
NE Stewardship Director
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Sudbury, MA 01776

Lowell Hydroelectric Project (FERC No. 2790)
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780 North Commercial Street
Eversource Energy
P.O. Box 330
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President
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77 Tyler Park
Lowell, MA 01851

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Lowell Flood Owner's Group
197 Wellman Avenue
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Lowell Flood Owner's Group
136 Townsend Avenue
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Lynda Ignacio
Lowell Flood Owner's Group
66 Shirley Avenue
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Steve Masse
Lowell Flood Owner's Group
186 Humphrey Street
Lowell, MA 01850

John Nappi
Lowell Flood Owner's Group
279 Pawtucket Boulevard
Tyngsborough, MA 01879

Gene Porter
Lower Merrimack River Local Advisory
77 Concord Street
Nashua, NH 03064

Thomas Golden, Jr.
Massachusetts House of Representatives
24 Beacon Street
Room 473B
Boston, MA 02133

Rady Mom
Massachusetts House of Representatives
24 Beacon Street
Room 43
Boston, MA 02133

David Nangle
Massachusetts House of Representatives
24 Beacon Street
Room 479
Boston, MA 02133

Eileen Donoghue
Massachusetts Senate
24 Beacon Street
Room 405
Boston, MA 02133

Kim Goddu
Merrimack River Watershed Council
60 Island Street
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Lawrence, MA 01840

Rusty Russell
Executive Director
Merrimack River Watershed Council
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Suite 211-E
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Fred Britton
Associate President
Thoreau's Landing Condominium Association
32 Walden Pond Drive
Nashua, NH 03064

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

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President, Nor'East Chapter
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Michele Tremblay
Upper Merrimack River Local Advisory Committee
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Penacook, NH 03303

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US House of Representatives
137 Cannon House Office Building
2nd District
Washington, DC 20515

Seth Moulton
6th District
US House of Representatives
21 Front Street
Salem, MA 01970

Carol Shea-Porter
US House of Representatives
1530 Longworth House Office Building
1st District
Washington, DC 20515

Niki Tsongas
3rd District
US House of Representatives
126 John Street
Suite 12
Lowell, MA 01852

Margaret Hassan
US Senate
330 hart Senate Office Building
Washington, DC 20510

Edward Markey
US Senate
218 Russell Senate Office Building
Washington, DC 20510

Jeanne Shaheen
US Senate
506 Hart Senate Office Building
Washington, DC 20510

Elizabeth Warren
US Senate
317 Hart Senate Office Building
Washington, DC 20510

Dinell Clark
President
Williamsburg Condominium I
197 Wellman Avenue
North Chelmsford, MA 01863

Richard Howe
Register of Deeds - Middlesex County North
360 Gorham Street
Lowell, MA 01852

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Boott Hydropower, LLC Project No. 2790

NOTICE OF INTENT TO FILE APPLICATION FOR NEW LICENSE

Pursuant to 18 CFR § 5.5(b), Boott Hydropower, LLC ("Boott," "Licensee," or "Applicant") notifies the Federal Energy Regulatory Commission ("FERC" or "Commission") of its intention to file an Application for a New License for the Lowell Hydroelectric Project, Project No. 2790. The current project license was issued on April 13, 1983, and expires on April 30, 2023. Accordingly, the Licensee will file an Application for a New License no later than April 30, 2021.

The following information is provided consistent with the requirements of 18 CFR § 5.5(b).

(1) Licensee's Name, Address, and Phone Number:

Boott Hydropower, LLC
100 Brickstone Square, Suite 300
Andover, MA 01810
Telephone: (978) 681-1900

(2) FERC Project Number:

FERC Project No. 2790

(3) License Expiration Date:

April 30, 2023

(4) Statement of Intent to File Application for New License:

Boott hereby unequivocally declares its intent to file an Application for New License for the Lowell Hydroelectric Project on or before April 30, 2021. Boott will utilize FERC's Integrated Licensing Process (ILP) in support of this relicensing.

(5) Principal Works of the Lowell Hydroelectric Project:

The existing Lowell Project consists of: (1) a 1,093-foot-long, 15-foot-high masonry gravity dam (Pawtucket dam) that includes a 980.5-foot-long spillway with a crest elevation of 92.2 feet National Geodetic Vertical Datum 1929 (NGVD 29) and five 5-foot-high pneumatically-operated crest gates; (2) a 720-acre impoundment with a normal maximum water surface elevation of 92.2 feet NGVD 29; (3) a 5.5-mile-long canal system (Northern and Pawtucket Canal System) that includes several small dams and a gatehouse; (4) two intake facilities; (5) a powerhouse (E.L. Field) that uses water from the Northern Canal and contains two turbine-generator units with a total installed capacity of 17.3 megawatts (MW); (6) a 1,000-foot-long tailrace channel; (7) four powerhouses (Assets, Bridge Street, Hamilton, and John Street)

housed in nineteenth century mill buildings along the Northern and Pawtucket Canal System containing nineteen turbine-generator units with a total installed capacity of 7.5 MW; (8) a 4.5-mile long, 13.8-kilovolt transmission line connecting the powerhouses to the regional distribution grid; (9) upstream and downstream fish passage facilities including a fish elevator and downstream fish bypass at the E.L. Field powerhouse, and a vertical-slot fish ladder at the Pawtucket dam; and (10) appurtenant facilities.

(6) Project Location:

The Lowell Project is located on the Merrimack River in the City of Lowell, Middlesex County, Massachusetts, with an impoundment extending into Hillsborough County, New Hampshire. The Project is located within Chelmsford, Lowell, and Tyngsborough, Massachusetts; and Hudson, Litchfield, Merrimack, and Nashua, New Hampshire.

(7) Plant Installed Capacity:

The Project's authorized installed capacity is 24.823 MW.

(8)(i) The names and mailing addresses of every county in which any part of the project is located and in which any federal facility that is used by the project is located are:

Middlesex County
Register of Deeds- Middlesex County North
360 Gorham St.
Lowell, MA 01852

Hillsborough County
Suite 120
329 Mast Road
Goffstown, NH 03045

Portions of the project lie within the boundaries of the National Park Service's Lowell National Historical Park.

8(ii)(A) The names and mailing addresses of every city, town, or similar political subdivision in which any part of the project is or is to be located and any federal facility that is or is to be used by the project is located:

Town of Chelmsford, MA
50 Billerica Road
Chelmsford, MA 01824

Town of Hudson, NH
12 School Street
Hudson, NH 03051

Town of Litchfield, NH
2 Liberty Way
Suite 2
Litchfield, NH 03052

City of Lowell, MA
375 Merrimack Street
Lowell, MA 01852

Town of Merrimack, NH
6 Baboosic Lake Road
Merrimack, NH 03054

City of Nashua, NH
229 Main Street
Nashua, NH 03060

Town of Tyngsborough, MA
25 Bryants Lane
Tyngsborough, MA 01879

There are no federal lands or facilities associated with the Project.

8(ii)(B) The names and mailing addresses of every city, town, or political subdivision that has a population of 5,000 or more people and is located within 15 miles of the Project dam:

Town of Acton, MA
472 Main Street
Acton, MA 01720

Town of Andover, MA
36 Bartlet Street
Andover, MA 01810

Town of Atkinson, NH
21 Academy Avenue
Atkinson, NH 03811

Town of Ayer, MA
1 Main Street
Ayer, MA 01432

Town of Bedford, MA
10 Mudge Way
Bedford, MA 01730

Town of Billerica, MA
365 Boston Road
Billerica, MA 01821

Town of Boxford, MA
7A Spofford Road
Boxford, MA 01921

Town of Burlington, MA
29 Center Street
Burlington, MA 01803

Town of Chelmsford, MA
50 Billerica Road
Chelmsford, MA 01824

Town of Concord, MA
P.O. Box 535
Concord, MA 01742

Town of Derry, NH
14 Manning Street
Derry, NH 03038

Town of Dracut, MA
62 Arlington Street
Dracut, MA 01826

Town of Groton, MA
173 Main Street
Groton, MA 01450

Town of Harvard, MA
13 Ayer Road
Harvard, MA 01451

City of Haverhill, MA
4 Summer Street
Haverhill, MA 01830

Town of Hollis, NH
7 Monument Square
Hollis, NH 03049

Town of Hudson, NH
12 School Street
Hudson, NH 03051

City of Lawrence, MA
200 Common Street
3rd Floor Room 309
Lawrence, MA 01840

Town of Lexington, MA
1625 Massachusetts Avenue
2nd Floor, Town Office Building
Lexington, MA 02420

Town of Lincoln, MA
16 Lincoln Road
Lincoln, MA 01773

Town of Litchfield, NH
2 Liberty Way
Suite 2
Litchfield, NH 03052

Town of Littleton, MA
37 Shattuck Street
3rd Floor, Room 306
Littleton, MA 01460

Town of Londonderry, NH
268B Mammoth Road
Londonderry, NH 03053

City of Lowell, MA
375 Merrimack Street
Lowell, MA 01852

Town of Lynnfield, MA
55 Summer Street
Lynnfield, MA 01940

Town of Merrimack, NH
6 Baboosic Lake Road
Merrimack, NH 03054

City of Methuen, MA
41 Pleasant Street
Methuen, MA 01844

Town of Middleton, MA
48 South Main Street
Middleton, MA 01949

City of Nashua, NH
229 Main Street
Nashua, NH 03060

Town of North Andover, MA
120 Main Street
North Andover, MA 01845

Town of North Reading, MA
235 North Street
North Reading, MA 01864

Town of Pelham, NH
6 Village Green
Pelham, NH 03076

Town of Pepperell, MA
One Main Street
Pepperell, MA 01463

Town of Reading, MA
16 Lowell Street
Reading, MA 01867

Town of Salem, NH
33 Geremonty Drive
Salem, NH 03079

Town of Shirley, MA
7 Keady Way
Shirley, MA 01464

Town of Stoneham, MA
35 Central Street
2nd Floor
Stoneham, MA 02180

Town of Tewksbury, MA
1009 Main Street
2nd Floor
Tewksbury, MA 01876

Town of Tyngsborough, MA
25 Bryants Lane
Tyngsborough, MA 01879

Town of Westford, MA
55 Main Street
Westford, MA 01886

Town of Wilmington, MA
121 Glen Road
Room 11
Wilmington, MA 01887

Town of Windham, NH
3 North Lowell Street
Windham, NH 03087

City of Woburn, MA
10 Common Street
Woburn, MA 01801

8(iii) The names and mailing addresses of every irrigation district, drainage district, or similar special purpose political subdivision (A) in which any part of the project is located, and any Federal facility that is or is proposed to be used by the project is located, or (B) that owns, operates, maintains, or uses any Project facility or any Federal facility that is or is proposed to be used by the Project:

There are no irrigation or drainage districts or similar special purpose political subdivisions associated with or in the general area of the Project.

8(iv) The names and mailing addresses of every other political subdivision in the general area of the project that there is reason to believe would likely be interested in or affected by the notification:

There are no other political districts or subdivisions that are likely to be interested in or affected by the notification.

8(v) The names and mailing addresses of affected Indian tribes:

Mashpee Wampanoag Tribe
483 Great Neck Road South
Mashpee, MA 02649

Wampanoag Tribe of Gay Head (Aquinnah)
20 Black Brook Road
Aquinnah, MA 02535

Penobscot Nation
23 Wabanaki Way
Indian Island, Maine 04468

Narragansett Indian Tribe
PO Box 268
Charlestown, RI 02813

Stockbridge Munsee Tribe of Mohican Indians
N8467 Moh He Con Nuck Road
Bowler, WI 54416

Boott is filing this Notice of Intent (NOI) concurrently with a Pre-Application Document (PAD). In accordance with 18 CFR § 5.5(c), the Licensee is sending notification of these filings to the Distribution list included in Appendix B of the PAD; the list includes applicable resource agencies, local governments, Indian tribes, and non-government organizations.

In accordance with 18 CFR § 5.5(e), Boott is requesting designation as the non-federal representative for Endangered Species Act consultation and for consultation under Section 106 of the National Historic Preservation Act.

CERTIFICATE OF SERVICE

I hereby certify that I caused to be served, by U.S. First Class Mail or by electronic mail, the Notice of Intent to File Application for New License upon all interested parties designated on the attached service list in the Lowell Hydroelectric Project, Project No. 2790, in accordance with Rule 2010 of the Rules of Practice and Procedure, 18 C.F.R. § 385.2010.

April 30, 2018

Kevin M. Webb
Hydro Licensing Manager
Boott Hydropower, LLC

Pre-Application Document

Volume I of II

Lowell Hydroelectric Project (FERC No. 2790)

April 30, 2018

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Acronyms

°C	degree Celsius
°F	degree Fahrenheit
µS/cm	microsiemens per centimeter
CEII	Critical Energy/Electric Infrastructure Information (CEII)
CFPP	Comprehensive Fish Passage Plan
CFR	Code of Federal Regulations
cfs	cubic feet per second
CMR	Code of Massachusetts Regulations
CSO	combined sewer overflows
CSPA	Comprehensive Shoreland Protection Act
CWA	Clean Water Act
DO	dissolved oxygen
EFH	essential fish habitat
EPT	Ephemeroptera, Plecoptera, and Trichoptera
FERC or Commission	Federal Energy Regulatory Commission
FHA	Federal Highway Administration
FPA	Federal Power Act
GIS	geographical information systems
ILP	Integrated Licensing Process
IPaC	USFWS Information for Planning and Consultation
IPANE	Invasive Plant Atlas of New England
kV	kilovolt
kW	kilowatt
LMRLAC	Lower Merrimack River Local Advisory Council
LRWU	Lowell Regional Water Utility
M	magnitude
MADCR	Massachusetts Department of Conservation and Recreation
MADEP	Massachusetts Department of Environmental Protection
MADFW	Massachusetts Division of Fish and Wildlife
MADMF	Massachusetts Division of Marine Fisheries
Massachusetts NHESP	Massachusetts Natural Heritage and Endangered Species Program
MassGIS	Massachusetts geographical information systems
MCH	Massachusetts Historical Commission
MDPW	Massachusetts Department of Public Works
MEOEEA	Massachusetts Executive Office of Energy and Environmental Affairs

MESA	Massachusetts Endangered Species Act
mg/L	milligrams per liter
MRI	Merrimack River Initiative
MRWC	Merrimack River Watershed Council
MW	megawatt
MWh	megawatt hours
NAI	Normandeau Associates, Inc.
NEPA	National Environmental Policy Act
New Hampshire NHB	New Hampshire Natural Heritage Bureau
NGO	non-governmental organizations
NGVD 1929	National Geodetic Vertical Datum of 1929
NH GRANIT	New Hampshire statewide geographic information system clearing house
NHDES	New Hampshire Department of Environmental Services
NHDHR	New Hampshire Division of Historical Resources
NHDNC	New Hampshire Department of Natural and Cultural Resources
NHDRED	New Hampshire Department of Resources and Economic Development
NHDFG	New Hampshire Department of Fish and Game
NHOEP	New Hampshire Office of Energy and Planning
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NTUs	Nephelometric Turbidity Units
NWI	National Wetlands Inventory
PAD	Pre-Application Document
PSP	Proposed Study Plan
RM	river mile
ROR	run-of-river
RSA	Revised Statues Annotated
RSP	Revised Study Plan
RTE	Rare, threatened, and endangered
SCORP	Statewide Comprehensive Outdoor Recreation Plan
SD1	Scoping Document 1
SD2	Scoping Document 2

SHPO .....State Historic Preservation Officer
STORET.....USEPA storage and retrieval data warehouse
SWQS .....Surface Water Quality Standards
TMDL.....Total Maximum Daily Load
USACE.....U.S. Army Corps of Engineers
USDA .....U.S. Department of Agriculture
USEPA.....U.S. Environmental Protection Agency
USFWS .....U.S. Fish and Wildlife Service
USGS .....U.S. Geological Survey
WPA .....Wetlands Protection Act

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1.0 Introduction and Background

Boott Hydropower, LLC (Boott), owns and operates the Lowell Hydroelectric Project ("Project" or "Lowell Project") (FERC No. 2790), located at river mile (RM) 41 on the Merrimack River within the City of Lowell, Massachusetts, with an impoundment extending upstream approximately 23 miles almost to the City of Manchester, New Hampshire. The Lowell Project has an authorized Project capacity of 24.8 megawatts (MW). The major Project features include: the 1,093-foot-long, stone-masonry gravity Pawtucket Dam, topped by a 5-foot-high, pneumatic crest gate system[1]; a canal system within downtown Lowell that provides flow to several small hydroelectric units; a main powerhouse containing two 8.6 MW horizontal Kaplan turbine-generator units; a fish lift system at the powerhouse; and a fish ladder adjacent to the Pawtucket Dam. The Project operates in a run-of-river (ROR) mode and has no useable storage capacity. The Lowell Project includes a two-tiered network of man-made canals, totaling approximately 5.5 miles in length, which run throughout downtown Lowell. Flow enters the canal system upstream of the Pawtucket Dam via the Pawtucket Canal and is controlled by the Guard Lock and Gates Facility (Boott 2017).

The site of the Lowell Project was historically used for hydromechanical and hydroelectric power for various mill operations and is operated today to produce hydroelectric power for sale into the regional power grid (Boott 2015). The existing license was issued by the Federal Energy Regulatory Commission ("FERC" or "Commission") on April 13, 1983, and expires on April 30, 2023. In accordance with the Commission's regulations at 18 Code of Federal Regulations (CFR) § 16.9(b), Boott must file an application for a new license for the Project with FERC no later than April 30, 2021.

As described in this Pre-Application Document (PAD) and the associated Notice of Intent (NOI), Boott has elected to pursue a new license for the Project using the Commission's default Integrated Licensing Process (ILP), as defined in 18 CFR Part 5. Based upon an analysis of available resources, Boott believes that the ILP will be the most effective process for this relicensing and will provide a structured framework to evaluate resources that may be of interest to stakeholders that are relevant to this relicensing proceeding.

Pursuant to 18 CFR § 5.8 of the Commission's regulations, following FERC's review this PAD and associated NOI, FERC will issue notice of the commencement of the licensing proceeding and request comments on the PAD within 60 days of the PAD and NOI being filed. Within 30 days of that notice, FERC will conduct a scoping meeting and site visit of the Lowell Project.

[1] On April 18, 2013, the Commission amended the project license authorizing Boott to replace the wooden flashboards on the Pawtucket Dam with a pneumatic crest gate system (143 FERC ¶ 61,048). Installation of the crest gate system is currently in progress.

2.0 Purpose of the Pre-Application Document

The filing of this PAD and the associated NOI by Boott marks the formal start of the relicensing process for the Lowell Project. The purpose of the PAD is to provide a description of the Project and existing and reasonably available information relevant to the Project. The information presented in the PAD is intended to assist the Commission, resource agencies, federally recognized Native American tribes, non-governmental organizations (NGOs), members of the public, and other stakeholders in identifying issues, determining information needs, preparing study requests, and analyzing the license application (18 CFR § 5.6(b)).

2.1 Search for Existing Relevant, and Reasonably Available Information

Boott has undertaken an extensive search to identify and review information potentially relevant to the relicensing of the Lowell Project. This search consisted of four primary activities:

1. A comprehensive search of Boott's files and available documentation;
2. A survey questionnaire sent to 130 parties, requesting identification of any information related to the Project, the Project area, and the region;
3. Searches and reviews of the internet, university databases, and reasonably available public reference sources; and
4. Outreach to select parties [(e.g., Massachusetts Office of Coastal Zone Management, U.S. Fish and Wildlife Service (USFWS), Massachusetts Division of Fisheries & Wildlife (MADFW), and the New Hampshire Department of Environmental Services (NHDES)].

A copy of the PAD information questionnaire and a list of the parties who received the document is provided in Appendices A and B, respectively. A total of 14 parties responded to the questionnaire. Copies of the completed questionnaires and additional consultation correspondence are included in Appendix C of this PAD. Boott reviewed each of the returned questionnaires and identified documents believed to be potentially relevant to the Lowell Project. These documents have been acquired and/or reviewed and their relevance determined. Relevant information has been summarized in the pertinent resource-specific sections of this document, and a bibliography of relevant literature is provided in Section 8 of this PAD.

2.2 Description of Consultation Process Undertaken by Boott Prior to the Submittal of the PAD

Boott has undertaken initial stakeholder consultation in advance of filing this PAD. The purposes of these outreach activities were to: (1) notify the Project's potential stakeholders of the upcoming relicensing activities, (2) determine the relicensing process to be used, (3) identify available information, (4) determine the relationship, if any,

between stakeholder issues and Project operations, and (5) identify likely study needs in advance of the start of the formal licensing process.

Boott's preliminary consultation began with the identification of parties potentially interested in the relicensing of the Lowell Project. Boott mailed a PAD questionnaire to 130 potentially interested parties in an attempt to solicit any existing, relevant, and reasonably available information regarding the Project and the surrounding environment, and to obtain a better understanding of the parties' interest in the relicensing process. Appendix B to this PAD presents the list of stakeholders who received a copy of the PAD questionnaire, as well as this PAD and the associated NOI. Outreach to select parties was conducted to obtain additional information related to rare, threatened, and endangered (RTE) species and coastal zone management. Copies of these letters are included in Appendix C.

3.0 Process Plan and Schedule (18 CFR § 5.6(d)(1))

Boott has elected to use FERC's ILP in support of obtaining a new license for the Lowell Project. In accordance with the regulations governing the ILP and current Tribal Policy Statement (18 CFR §2.1c), FERC staff will hold, if desired by the affected tribes, an initial tribal consultation meeting within 30 days of submittal of Boott's PAD and NOI. In addition, FERC will issue, within 60 days of PAD submittal, a public notice of the commencement of the relicensing proceeding and Scoping Document 1 (SD1). FERC will then hold a public scoping meeting and site visit within 30 days of FERC's notice, which will be within approximately 90 days of Boott's PAD and NOI filing. The scoping meeting is, therefore, anticipated to occur by the end of July 2018.

3.1 Process Plan and Schedule

Boott has prepared a Process Plan and Schedule, which incorporates FERC's ILP schedule as established in 18 CFR §5.6. Table 3.1-1 depicts Boott's Process Plan and Schedule for the relicensing of the Lowell Project.

Table 3.1-1. Proposed Integrated Licensing Process Plan and Schedule.

Milestone	Responsible Party	Time Frame	Estimated Date
File PAD and NOI PAD (18 CFR §5.5(d))	Boott	As early as five and one half years but no later than five years prior to license expiration	April 30, 2018
Initial Tribal Consultation Meeting (18 CFR §5.7)	FERC	No later than 30 days of filing PAD/NOI	May 30, 2018
Issue Notice of PAD/NOI and SD1 (18 CFR §5.8(a))	FERC	Within 60 days of filing PAD/NOI	June 29, 2018
Conduct Scoping Meetings and Site Visit (18 CFR §5.8(b) (viii))	FERC	Within 30 days of PAD/NOI notice and SD1 issuance	July 17-19, 2018

Milestone	Responsible Party	Time Frame	Estimated Date
Comments on PAD, SD1, and Study Requests (18 CFR §5.9(a))	Stakeholders	Within 60 days of PAD/NOI notice and issuance of SD1	August 28, 2018
File Proposed Study Plan (PSP) (18 CFR §5.11)	Boott	Within 45 days of deadline for filing comments on PAD	October 12, 2018
Issuance of Scoping Document 2 (SD2) (18 CFR §5.10) (if necessary)	FERC	Within 45 days of deadline for filing comments on SD1	October 12, 2018
Study Plan Meeting(s) (18 CFR §5.11(e))	Boott	Meeting to be held within 30 days of filing PSP	November 11, 2018
Comments on PSP (18 CFR §5.12)	Stakeholders	Within 90 days of filing PSP	January 10, 2019
File Revised Study Plan (RSP) (18 CFR §5.13(a))	Boott	Within 30 days of deadline for comments on PSP	February 9, 2019
Comments on RSP (18 CFR §5.13(b))	Stakeholders	Within 15 days following RSP	February 24, 2019
Issuance of Study Plan Determination (18 CFR §5.13(c))	FERC Director	Within 30 days of RSP	March 11, 2019
Formal Study Dispute Resolution Process (18 CFR §5.14(a)) (if necessary)	Agencies and Tribes with mandatory conditioning authority	Within 20 days of study plan determination	March 31, 2019
Dispute Resolution Panel Convenes (18 CFR §5.14(d)) (if necessary)	Dispute Resolution Panel	Within 20 days of a notice of study dispute	April 20, 2019
Comments on Study Plan Disputes (18 CFR §5.14(i)) (if necessary)	Boott	Within 25 days of notice of study dispute	April 25, 2019
Third Panel Member Selection Due (18 CFR §5.14(d)(3)) (if necessary)	Dispute Resolution Panel	Within 15 days of when Dispute Resolution Panel convenes	May 5, 2019
Dispute Resolution Panel Technical Conference (18 CFR §5.14(j)) (if necessary)	Dispute Resolution Panel, Boott, Stakeholders	-	Prior to engaging in deliberative meetings
Dispute Resolution Panel Findings and Recommendations (18 CFR §5.14(k)) (if necessary)	Dispute Resolution Panel	No later than 50 days after notice of dispute	May 20, 2019

Milestone	Responsible Party	Time Frame	Estimated Date
Study Dispute Determination (18 CFR §5.14(1)) (if necessary)	FERC Director	No later than 70 days after notice of dispute	June 9, 2019
Conduct First Season of Studies (18 CFR §5.15)	Boott	-	Summer/Fall 2019
Study Progress Report (18 CFR §5.15(b))	Boott	Boott will provide summary updates every three months	Various dates
Initial Study Report (18 CFR §5.15(c))	Boott	Pursuant to the Commission-approved study plan or no later than 1 year after Commission approval of the study plan, whichever comes first	March 11, 2020
Initial Study Report Meeting (18 CFR §5.15(c)(2))	Boott and Stakeholders	Within 15 days of filing the initial study report	March 26, 2020
File Initial Study Report Meeting Summary (18 CFR §5.15(c)(3))	Boott	Within 15 days of initial study report meeting	April 10, 2020
File Meeting Summary Disagreements (18 CFR §5.15(c)(4))	Stakeholders	Within 30 days of study results meeting summary	May 10, 2020
File Responses to Meeting Summary Disagreements (18 CFR §5.15(c)(5))	Boott	Within 30 days of filing meeting summary disagreements	June 9, 2020
Resolution of Disagreements (18 CFR §5.15(c)(6)) (if necessary)	FERC Director	Within 30 days of filing responses to disagreements	July 9, 2020
Conduct Second Season of Studies (if necessary)	Boott	-	Summer/Fall 2020
File Preliminary Licensing Proposal or Draft License Application (18 CFR §5.16(a))	Boott	No later than 150 days prior to the deadline for filing the Final License Application	December 1, 2020
Comments on Preliminary Licensing Proposal or Draft License Application Due (18 CFR §5.16(e))	Stakeholders	Within 90 days of filing Preliminary Licensing Proposal or Draft License Application	March 1, 2021

Milestone	Responsible Party	Time Frame	Estimated Date
File Updated Study Report (18 CFR §5.15(f)) (if necessary)	Boott	Pursuant to the approved study plan or no later than two years after Commission approval, whichever comes first	March 11, 2021
Updated Study Report Meeting (18 CFR §5.15(f)) (if necessary)	Boott and Stakeholders	Within 15 days of updated study report	March 26, 2021
File Updated Study Report Meeting Summary (18 CFR §5.15(f)) (if necessary)	Boott	Within 15 days of study report meeting	April 10, 2021
File License Application (18 CFR §5.17)	Boott	By April 30, 2021 – No later than 24 months before the existing license expires	April 30, 2021

3.2 Scoping Meeting and Site Visit

Pursuant to 18 CFR §5.8(b), FERC will hold a Scoping Meeting on or before July 29, 2018, in accordance with its responsibilities under the National Environmental Policy Act (NEPA). The Scoping Meeting will be held at a location to be selected by FERC in the general vicinity of the Project. FERC will issue a public notice regarding the Scoping Meeting that will include the meeting date, meeting location, and additional instructions for attending the meeting. Additional information may also be obtained by contacting Stephen Kartalia of FERC at 202-502-6131 or stephen.kartalia@ferc.gov.

4.0 Project Location, Facilities, and Operations (18 CFR § 5.6 (d)(2))

The exact name, business address, and telephone number of each person authorized to act as an agent for the applicant is listed below:

Kevin Webb, Hydro Licensing Manager
Enel Green Power North America, Inc.
100 Brickstone Square, Suite 300
Andover, MA 01810
(978) 935-6039

The principal facilities of the Lowell Project are located in the City of Lowell in Middlesex County, Massachusetts, with an impoundment extending upstream to Hillsborough County, New Hampshire (Figure 4.0-1). The Project dam is located at RM 41 on the Merrimack River. The Project is located approximately 11 miles upstream of the Lawrence Project (FERC No. 2800) and approximately 30 miles downstream of the Amoskeag Dam (a development of the Merrimack River Project, FERC No. 1893) in New Hampshire. The 116-mile-long Merrimack River begins at the confluence of the

Winnipesaukee and Pemigewasset Rivers in Franklin, New Hampshire; flows southward into Massachusetts; and then travels northeast until it discharges into the Atlantic Ocean.

Figure 4.0-1. Lowell Hydroelectric Project Location Map.

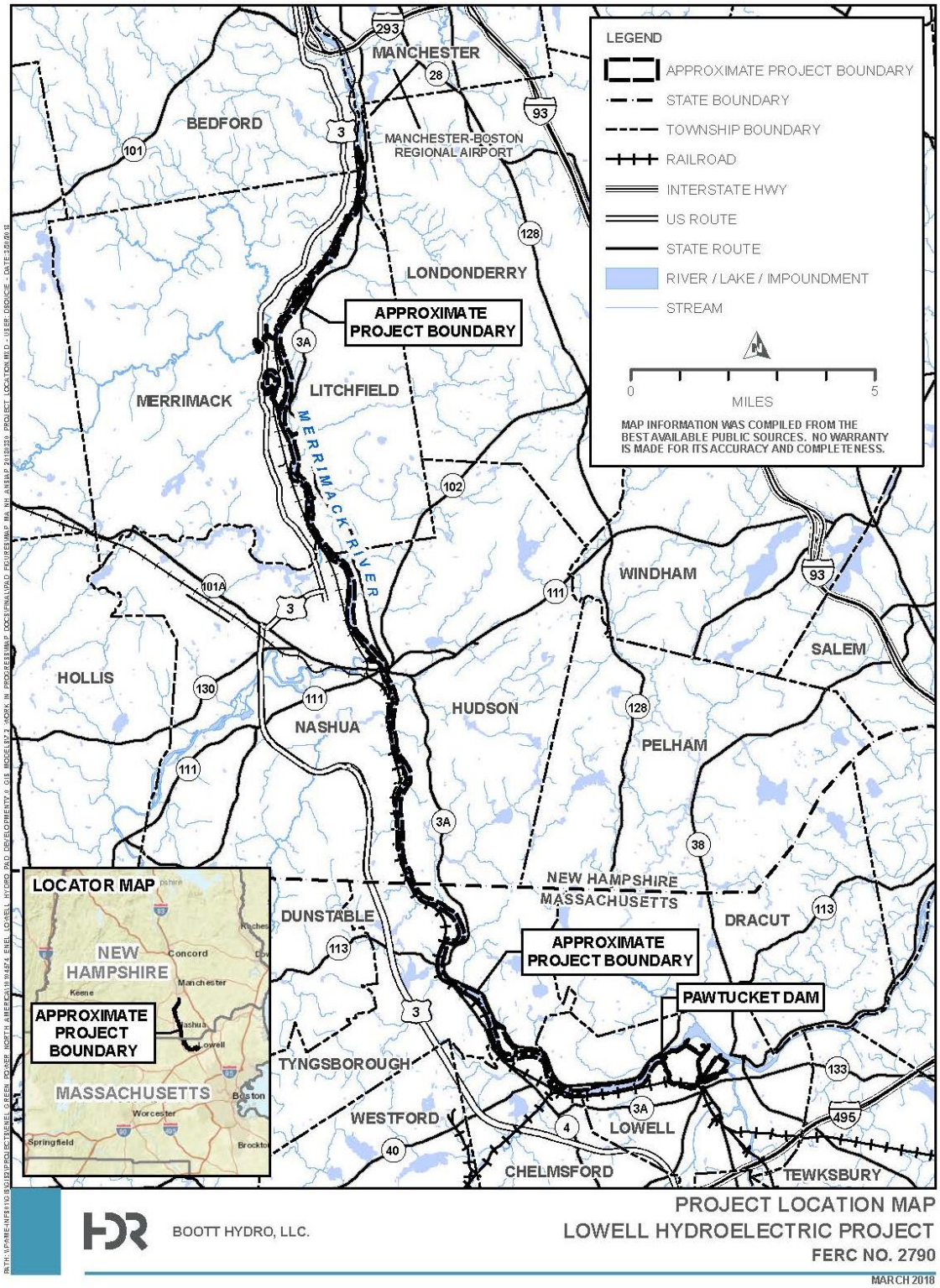
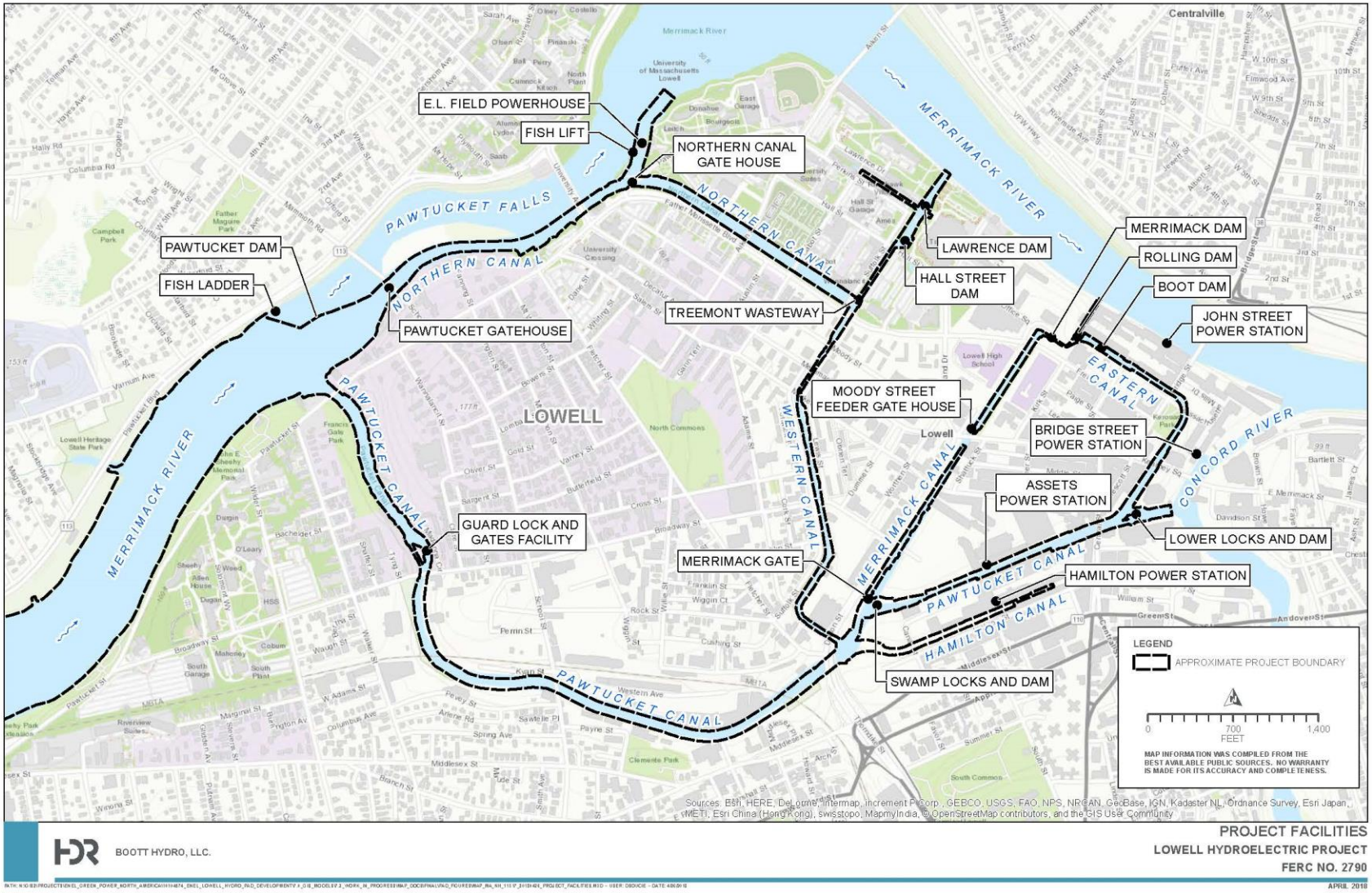


Figure 4.0-2. Lowell Hydroelectric Project Canal System Map.



The Lowell Project operates in a ROR mode and has no useable storage capacity. The existing Lowell Project consists of: (1) a 1,093-foot-long, 15-foot-high masonry gravity dam (Pawtucket dam) that includes a 980.5-foot-long spillway with a crest elevation of 92.2 feet National Geodetic Vertical Datum 1929 (NGVD 29) and five 5-foot-high pneumatically-operated crest gates; (2) a 720-acre impoundment with a normal maximum water surface elevation of 92.2 feet NGVD 29; (3) a 5.5-mile-long canal system (Northern and Pawtucket Canal System) that includes several small dams and a gatehouse; (4) two intake facilities; (5) a powerhouse (E.L. Field) that uses water from the Northern Canal and contains two turbine-generator units with a total installed capacity of 17.3 megawatts (MW); (6) a 1,000-foot-long tailrace channel; (7) four powerhouses (Assets, Bridge Street, Hamilton, and John Street) housed in nineteenth century mill buildings along the Northern and Pawtucket Canal System containing nineteen turbine-generator units with a total installed capacity of 7.5 MW; (8) a 4.5-mile long, 13.8-kilovolt transmission line connecting the powerhouses to the regional distribution grid; (9) upstream and downstream fish passage facilities including a fish elevator and downstream fish bypass at the E.L. Field powerhouse, and a vertical-slot fish ladder at the Pawtucket dam; and (10) appurtenant facilities. The FERC-approved Exhibit G maps are attached as Appendix D.

4.1 Civil Works

The primary facilities, Pawtucket Dam and E.L. Field Powerhouse, of the 24.8 MW[2] Lowell Project are located on the Merrimack River in Lowell, Massachusetts. The Project includes a two-tiered network of man-made canals totaling 5.5 miles in length, which run throughout downtown Lowell. River flow enters the canal system upstream of the Pawtucket Dam via the Pawtucket Canal and is controlled by the Guard Lock and Gates facility. The total capacity of Project features are listed in Table 4.1-1. The location of the following primary project features is shown in Figure 4.0-2.

Table 4.1-1. Current Project Capacity.

Name	Number of Units	Total Capacity (MW)
Mainstem Facility		
E.L. Field Powerhouse	2 units	17.3 MW
Canal Facilities		
Hamilton Power Station	5 units	1.18 MW
Assets Power Station	3 units	0.795 MW
Bridge Street[3]	7 units	3.44 MW
John Street	4 units	2.10 MW

[2] Boott Hydro, LLC submitted an Application for Amendment of License to FERC on March 16, 2017. The amendment of license proposes the removal of four of the Project's currently authorized generating units, also known as "Main Power," from the license. If approved, the authorized capacity of the Project would be reduced from 24.823 MW to 22.463 MW.

[3] Four of these units (2.36 MW) are the "Main Power" units which Boott has requested to be removed from the license.

The Project's civil works are discussed in further detail below.

4.1.1 Pawtucket Dam

The existing Pawtucket Dam is of dressed masonry gravity construction with a length of 1,093 feet, a spillway crest length of 982.5 feet and an average height of 15 feet (Figure 4.1-1 and 4.1-2). Original drawings show the masonry was ashlar, laid dry with a mortared masonry upstream face at a 1:1 slope, a two-foot-thick capstone, and the bed course laid in mortar. It was built in two sections in 1847 and 1875, the latter being grouted during construction. The dam foundation rests on bedrock, except for a short section on hardpan. A fishway ladder is located at the left dam abutment (looking downstream), and the intake structure for the Northern Canal is at the right abutment (Boott 2017).

A pneumatically-operated crest gate system[4] is mounted on the spillway crest to maintain the headpond at its normal level of 92.2 feet National Geodetic Vertical Datum of 1929 (NGVD 1929). The pneumatic crest gate system consists of 20-feet-long, hinged steel panels supported on their downstream side by tubular rubber air bladders. The crest gate system is installed in five independently-controllable zones. Air compressors, which supply system inflation and deflation pressure, and the crest gate control system are housed in a building located near the fish ladder and the left (northerly) abutment of the dam (Boott 2017).

Figure 4.1-1. Pawtucket Dam (prior to the installation of the pneumatic crest gate system).

[4] The pneumatic crest gate system is currently under construction and is expected to be completed and commissioned by summer 2019.

Figure 4.1-2. Pawtucket Dam and concrete fish ladder with partially installed pneumatic crest gate system adjacent to the fish ladder.

4.1.2 Northern Canal

The Northern Canal is approximately 2,200 feet long, with masonry or bedrock lining its complete length. The first 1,000 feet combines masonry walls and an earth dike (with masonry core) as the river wall. The second length is a dressed masonry gravity structure to the site of the E.L. Field Powerhouse. This structure is approximately 30 feet in height (Boott 2017).

4.1.3 Pawtucket Gatehouse

The Pawtucket Gatehouse is located at the southern abutment of the Pawtucket Dam and controls flow into the Northern Canal. It is principally constructed of dressed masonry with concrete over lintels and contains ten 8-foot-wide by 15-foot-high, motor-operated, timber sliding gates which feed the Northern Canal. Another small intake opening feeds a presently unused wheel, which formerly powered the gate mechanisms through a line shaft. The structure's water passages are nearly 80 feet in length. A small navigation lock located at the southerly end of the Pawtucket Gatehouse is used by National Park Service (NPS) tour boats (Boott 2017).

4.1.4 The Pawtucket and Downtown Canals

The Licensee’s four downtown power stations (Hamilton Power Station, Assets Power Station, Bridge Street, and John Street) are fed by the 5.5-mile two-tiered canal system in Lowell. The principal canals in the system are the Pawtucket Canal and the Northern Canal. Smaller canals lead off these two major canals. The canals vary in width from 40

to 120 feet. The walls are of granite, ledge, or concrete. The canal beds are of ledge, concrete, or wood-planked virgin soil (Boott 2017).

4.1.5 Miscellaneous Canal Structures

4.1.5.1 Guard Lock and Gates Facility

The Guard Lock and Gates facility consists of a five-bay gatehouse located on the Pawtucket Canal and an adjacent boat lock facility. The substructure of the gatehouse on the Pawtucket Canal is of dressed masonry, and the superstructure is of brick masonry and wood frame. Adjacent to this structure is a lock facility consisting of the upper locking gate, Great Guard Gate (or Francis Gate), and lower locking gate. The gates span a lock chamber 24 feet wide with masonry walls. The upper locking gate and Great Guard Gate are housed in frame buildings (Boott 2017).

4.1.5.2 Moody Street Feeder Gatehouse

The Moody Street Feeder Gatehouse is located on the Moody Street Feeder Canal adjacent to the Merrimack Canal at the intersection of Dutton Street and Merrimack Street. Three 10-foot-wide gates allow closure of the three separate arched canal passages. The gates are housed in a brick building measuring 62.5 feet long by 22.5 feet wide (Boott 2017).

4.1.5.3 Lawrence Dam

The Lawrence Dam is a rock-filled, timber-crib substructure with a three-tiered apron. The upper apron is composed of timbers overlaying rubble masonry. The second and third aprons consist of massive masonry. The superstructure is made of cast-iron frames, fitted with wood bay boards. The structure is 100 feet long by 12 feet high and is located at the head of the Lawrence Wasteway, which leads to the Merrimack River (Boott 2017).

4.1.5.4 Hall Street Dam

The Hall Street Dam consists of a rubble masonry structure with an upper protective timber deck and stepped massive ashlar masonry apron. The length of the structure is 115 feet with a maximum height of 15 feet. The dam is fitted with 1.5-foot flashboards (Boott 2017).

4.1.5.5 Tremont Wasteway

The Tremont Wasteway is 30 feet wide by 600 feet long and is adjacent to Suffolk Street. The wasteway forms the water passageway between the Northern Canal and the Hall Street Dam. At the head of the wasteway is the Tremont Gatehouse. Two 9-foot-wide gates control the flow of water into the wasteway and are housed in a gatehouse building consisting of brick superstructure with masonry substructure (Boott 2017).

4.1.5.6 Lower Locks and Dam

The Lower Locks and Dam are on the Lower Pawtucket Canal and empty into the Concord River. The dam, with a maximum height of 12 feet, consists of a rubble masonry

structure with a sloping timber apron. Energy dissipation is accomplished by large rubble masonry located downstream of the dam. The superstructure is constructed of cast-iron frames, fitted with wood bay boards. A gated sluiceway is also provided. The lock structure contains two chambers that are 30.5 feet wide by 85 feet long. The width at the gate passageway is 12.5 feet. The lock walls are of hand-laid masonry (Boott 2017).

4.1.5.7 Swamp Locks and Dam

The Swamp Locks and Dam are at the head of the Lower Pawtucket Canal. The dam consists of a concrete apron overlaying a rubble masonry structure. The superstructure is made of cast-iron frames, fitted with wood bay boards. The maximum height of the dam is 15 feet. A sluiceway similar to the Lower Locks and Dam is also provided. A two-chamber lock, with narrowest width of 12.5 feet, allows passage by the Swamp Locks and Dam. The lock is constructed of rubble masonry (Boott 2017).

4.1.5.8 Merrimack Dam and Merrimack Gate

The Merrimack Dam consists of a sloping apron rubble masonry structure. The apron is protected with timber planks. The maximum height of the dam is 8 feet, and it acts as a submerged weir, no longer used to control water elevations (Boott 2017).

The Merrimack Gate consists of a concrete dam structure with sloping upstream face and vertical downstream face. The center portion of the structure is fitted with a 10-foot-wide by 6-foot-high timber gate. The maximum height of the dam is 9 feet (Boott 2017).

4.1.5.9 Rolling Dam

The Rolling Dam consists of a masonry structure with a curved apron protected by wood planks. The maximum height of the dam is 19 feet. The masonry construction is carried downstream of the dam to provide scour protection. The Rolling Dam is located downstream of the Merrimack Dam (Boott 2017).

4.1.5.10 Boott Dam

The Boott Dam is located 80 feet southeast of the Merrimack Wasteway, adjacent to Boott Mills. It consists of a masonry structure 40 feet long with a maximum height of 7 feet and a gated sluiceway (Boott 2017).

4.1.6 Mill Buildings

The Hamilton, Assets, Bridge Street, and John Street power stations and turbines are housed in large old mill buildings. The buildings, not included in the Project, are exceptionally sturdy structures used principally as space for small industrial manufacturers, storage space, or apartment/condominium units. The Project boundary include only the turbines and associated equipment at these downtown mill sites (Boott 2017).

4.1.7 Tailrace Channel

A 1,000-foot-long tailrace channel for the E.L. Field Powerhouse was excavated in bedrock in the river. The channel excavation is approximately 60 feet wide by 20 feet

deep. The tailrace is protected from high river flows by a five-foot-high, concrete training wall, which directs bypassed river flows away from the tailrace (Boott 2017).

4.1.8 Bypass Reach

The bypass reach extends from the top of the Pawtucket Dam to the E.L. Field Powerhouse tailrace and is approximately 0.7 miles long (Cleantech Analytics 2017).

4.1.9 Control Structures

A concrete control structure exists on the Northern Canal immediately below the Pawtucket Street Bridge, and was constructed as part of the construction of the E.L. Filed Powerhouse in the 1980's. The control structure maintains effective net head at the E.L. Field Powerhouse in comparison with subjecting plant operation to limitations of the whole canal system. A navigation lock for vessel transit through the control structure has been provided (Boott 2017).

4.1.10 Fish Passage Facilities

Upstream and downstream fish passage facilities include a fish lift (Figure 4.1-3) and downstream fish bypass at the E.L. Field Powerhouse and a vertical-slot fish ladder at the Pawtucket Dam (Figure 4.1-4). All fish passage facilities were designed in consultation with the USFWS. Passage operations are supervised by state and federal fishery agencies.

The reinforced-concrete fish ladder at the Pawtucket Dam is designed to allow for controlled fish passage at river flows up to 25,000 cubic feet per second (cfs). The fishway operates at 500 cfs, including supplemental attraction flow. The fish ladder is a vertical-slot design with 13-foot-wide by 10-foot-long pools. A counting station and fish trap area is provided. The Pawtucket Dam has been modified by removing ashlar masonry to allow the exit channel to penetrate the dam (Boott 2017).

The upstream fishway at the powerhouse is of the elevator type. The design discharge capacity is 200 cfs. A fish-collection gallery with two openings spans the downstream wall of the powerhouse to collect fish migrating through the tailrace channel.[5] The fish are attracted into the 30-foot crowding pool, trapped, and crowded. From the crowding pool, they enter the elevator and are lifted in a hopper to the exit channel. From the elevator area, the fish enter a holding pool 10 feet wide by 50 feet long. Fish next enter the fish trap area where they can be counted. A 10-foot by 12-foot fish counting station is provided. Passage of fish through the trap area allows fish to enter the exit channel, passing into the Northern Canal and then upriver (Boott 2017).

The downstream fishway at the powerhouse consists of an adjustable-flow sluiceway and bypass adjacent to the intake headwall. Downstream emigrants entering the bypass are quickly sluiced into an enlarged and deepened plunge pool located in the bypassed river reach next to the powerhouse. Natural channel braids in the riverbed allow

[5] In the early 1990's Boott and the fishery agencies agreed that only the northern or "river-side" fish lift entrance would be used because studies showed that the southern or "street-side" entrance resulted in a net loss of fish from the entrance gallery.

emigrants to move downstream to the mainstem river at the confluence of the river reach and tailrace (Boott 2017).

4.1.11 Eldred L. Field Powerhouse

The E.L. Field Powerhouse incorporates a separate conventional intake structure for each of the station's two identical units (Figure 4.1-5). Each intake is equipped with trashracks; intake and draft tube gate slots with permanent or bulkhead style gates for emergency shutdown and dewatering purposes are also provided (Boott 2017).

The powerhouse is equipped with a traversing trash rake to remove debris at the intake. Both mobile and on-site cranes are used for heavy equipment movement at the facility. A surge gate upstream of the powerhouse alleviates Northern Canal elevation changes caused by sudden flow fluctuations. The surge gate can be operated in manual or automatic mode (Boott 2017).

Figure 4.1-3. Fish lift entrance at the E.L. Field Powerhouse tailrace.

Figure 4.1-4. Fish Ladder at the Pawtucket Dam.

Figure 4.1-5. E.L. Field Powerhouse.

4.2 Impoundment Data

The impoundment formed by the Pawtucket Dam extends approximately 23 miles upstream to Moore's Falls in Litchfield and Merrimack, New Hampshire. At the normal pond elevation of 92.2 feet NGVD 1929 (crest of the pneumatic flashboards), the surface area of the impoundment encompasses an area of approximately 720 acres. The gross storage capacity between the normal surface elevation of 92.2 feet and the minimum

pond level of 87.2 feet is approximately 3,600 acre-feet. The Project operates essentially in a ROR mode and has no usable storage capacity.

4.3 Turbines and Generators

Turbine and generator data for each of the five power stations (including the E.L. Field Powerhouse) are provided in Tables 4.3-1 and 4.3-2, respectively.

Table 4.3-1. Lowell Hydroelectric Project Turbine Data.

Powerhouse	Unit #	Type	Size Inches	Speed RPM	Net Head Feet	Flow Rate cfs	Power HP
E. L. Field	1	Fuji Horizontal Full Kaplan	152.4	120	39	3,300	11,540 †
E. L. Field	2	Fuji Horizontal Full Kaplan	152.4	120	39	3,300	11,540 †
Assets	1	Hercules Double Runner Styles C & D	33 and 31	150	13	376	444
Assets	2	Hercules Double Runner Styles C & D	33 and 31	150	13	376	444
Assets	3	Hercules Double Runner Styles C & D	33 and 31	150	13	376	444
Bridge Street	1*	Hercules Type C Double Runner	48	133	22	595	1010
Bridge Street	2*	Hercules Type C Double Runner	48	133	22	595	1010
Bridge Street	3*	Hercules Type C Double Runner	48	133	22	595	1010
Bridge Street	4	Hercules Type D Single Runner	42	138.5	22	333	655
Bridge Street	5	Hercules Type D Single Runner	42	138.5	22	333	655
Bridge Street	6	Hercules Type D Single Runner	42	138.5	22	333	655
Bridge Street	12 *	Morgan Smith Type S Single Runner	46.5	138.5	17	357	55
Hamilton	1	Leffel Type Z Single Runner	45	120	13	374	459
Hamilton	2	Leffel Type Z Single Runner	39	133	13	279	341
Hamilton	3	Leffel Type Z Single Runner	36	150	13	237	287
Hamilton	4	Leffel Type Z Single Runner	45	120	13	374	459
Hamilton	5	Leffel Type Z Single Runner	45	120	13	374	459

Powerhouse	Unit #	Type	Size Inches	Speed RPM	Net Head Feet	Flow Rate cfs	Power HP
John Street	3	Leffel Single Runner	33	200	21	250	482
John Street	4	Leffel Single Runner	33	200	21	250	482
John Street	5	Leffel Single Runner	33	200	21	250	482
John Street	6	Allis Chalmers Single Runner	72	100	21	1,000	1,925

† - 8,654 kilowatts (kW)

* Boott Hydro, LLC submitted an Application for Amendment of License to FERC on March 16, 2017. The amendment of license proposes the removal of four of the Project's currently authorized generating units from the license. These units include Bridge Street 1, 2, 3, and 12 and are also known as the "Main Power" units.

Table 4.3-2. Lowell Hydroelectric Project Generator Data.

Powerhouse	Unit #	Type	Power kW	Voltage Volts	Speed RPM
E.L. Field	1	Fuji Electric	7,506 ††	4,160	120
E.L. Field	2	Fuji Electric	7,506 ††	4,160	120
Assets	1	General Electric Type ATB 48-332-150	265	600	150
Assets	2	General Electric Type ATB 48-332-150	265	600	150
Assets	3	General Electric Type ATB 48-332-150	265	600	150
Bridge Street	1&2*	General Electric Co. Type ATB	1250	600	133
Bridge Street	3*	General Electric Co. Type ATB	180	600	133
Bridge Street	4	General Electric Co. Type ATB	360	600	138.5
Bridge Street	5	General Electric Co. Type ATB	360	600	138.5
Bridge Street	6	General Electric Co. Type ATB	360	600	138.5
Bridge Street	12*	G.E. Co. Type PRC	360	600	138.5
Hamilton	1	Westinghouse Electric Co.	280	600	120
Hamilton	2	Electric Machinery Co.	190	600	133
Hamilton	3	Electric Machinery Co.	160	600	150
Hamilton	4	Electric Machinery Corporation	280	600	120
Hamilton	5	Electric Machinery Corporation	280	600	120
John Street	3	General Electric Co. Type ATI	300	600	200
John Street	4	General Electric Co. Type ATI	300	600	200

Powerhouse	Unit #	Type	Power kW	Voltage Volts	Speed RPM
John Street	5	General Electric Co. Type ATI	300	600	200
John Street	6	Allis-Chalmers Type AV	1,200	600	100

†† - 8,340 kVA at 0.9 Power Factor

* Boott Hydro, LLC submitted an Application for Amendment of License to FERC on March 16, 2017. The amendment of license proposes the removal of four of the Project's currently authorized generating units from the license. These units include Bridge Street 1, 2, 3, and 12 and are also known as the "Main Power" units.

4.4 Appurtenant Equipment

4.4.1 Electrical and Transmission

4.4.1.1 Electrical

The electrical and station protection equipment are designed to provide completely automatic E.L. Field Powerhouse operation with load control on a float to measure water level at the dam. This equipment controls the two synchronous generators connected via 4.16-kilovolt (kV) circuit breakers to a common bus. One station transformer is connected directly to this bus and delivers power to the system. Protective relaying comprises one overall differential relaying scheme (with harmonic and percent bias) enclosing within its protected zone the generators, 4.16-kV switchgear, and the transformer (Boott 2017).

With the exception of the station transformer and the line circuit breaker, all electrical equipment is housed inside the powerhouse structure. The transformer is located within a fenced enclosure adjacent to the powerhouse. The station transformer has the normal protective devices, such as lightning surge, gas, and winding temperature detectors. Power for station metering is derived from 4.16-kV potential transformers connected to the station bus and current transformers installed in the low-voltage connections to the main transformer (Boott 2017).

4.4.1.2 Transmission

A 13.8-kV submarine cable located within the canal carries energy from the E.L. Field Powerhouse substation to the Bridge Street Powerhouse in Lowell, over a distance of approximately 3 miles. Generator leads from Project's additional powerhouses ties into the submarine cable. The output from the E.L. Field powerhouse and the Project's additional generating stations is metered at Bridge Street, where a utility disconnect is also located. Metered energy then travels on an additional 1.5-mile-long submarine cable up the Concord River to National Grid's Perry Street substation. From the Perry Street substation, project output is delivered to the regional utility grid at 115 kV (Boott 2017).

4.4.2 Mechanical

On-site cranes and hoists can be used to operate the powerhouse head gate and draft tube gates for dewatering. Smaller hoists can be utilized for most other site needs, including activities associated with the Projects smaller powerhouses. When required, mobile cranes sited in the facility driveway can be used to reach and operate within most locations of the powerhouse (Boott 2017).

A shop and garage located next to the powerhouse provides the station with on-site equipment storage and maintenance capabilities.

4.5 Description of Project Operations

The Project is operated in a ROR mode and has no useable storage capacity. The text below describes the operating requirements of the Project. Boott is proposing to continue to operate the Project in the same manner as it is currently operated.

4.5.1.1 General Operations

The Project is remotely operated from the Enel Control Center in Andover, Massachusetts, which is staffed 24 hours per day, seven days a week. Traveling operators visit the Project multiple times per week and can be dispatched to the site at any time, as needed. The Project is operated in a ROR mode using the automatic pond level control capability of the E.L. Field Powerhouse. Boott normally operates the Project to maximize flow through the available units at the E.L. Field Powerhouse, then routes any additional flows through the Pawtucket Canal system. The E.L. Field turbine-generator units are more efficient and operate at a higher head than the older canal units, and are, therefore, the priority first-on, last-off units in the Project operations scheme. When river flows exceed the hydraulic capacity of the E.L. Field units (approximately 4,000 cfs per unit or 8,000 cfs for both units), excess flows up to approximately 2,000 cfs are routed through the downtown canal system and to the canal units. Any flows in excess of approximately 10,000 cfs (8,000 cfs at E.L. Field plus 2,000 cfs via canals) are passed over the Pawtucket Dam spillway. Pursuant to Article 37, the Project maintains a minimum flow of 1,990 cfs or inflow, whichever is less, as measured immediately downstream from the Project (Boott 2017).

4.5.1.2 Canal System Operations

The Lowell Project includes a two-tiered network of man-made canals, as discussed in Section 4.4, totaling 5.5 miles in length. Flow enters the canal system upstream of the Pawtucket Dam via the Pawtucket Canal and is controlled by the Guard Lock and Gates Facility. The nominal flow capacity of the downtown canal system via the Pawtucket Canal and the Guard Lock and Gates Facility is approximately 2,000 cfs.

The Lowell Project includes four power stations located within mill buildings along the downtown canal system. The Hamilton Power Station contains five units and draws water from the Hamilton Canal in the upper canal system and discharges into the Lower Pawtucket Canal in the lower canal system at a head of approximately 13 feet. The Assets Power Station contains three units and draws water from the Merrimack Canal in the upper canal system and discharges into the Lower Pawtucket Canal in the lower canal system at a head of approximately 13 feet. In the lower canal system, the Bridge Street and John Street Power Stations each draw from the Eastern Canal and discharge to the Merrimack River or the Concord River, at a head of approximately 21 feet. The John Street Power Station contains four units and discharges into the Merrimack River. The Bridge Street Power Station has seven units with three units known as “Section 8” discharging into the Concord River and four units known as “Main Power” discharging to the Merrimack River (Boott 2017).

There are a number of specific operation plans and agreements that Boott also follows. These are described in detail below.

4.5.1.3 Pneumatic Crest Gate Operations

On April 18, 2013, FERC authorized Boott to replace the existing wooden flashboard system on the Project’s Pawtucket Dam with a pneumatic crest gate system. FERC approved the amended crest gate system operation plan on March 30, 2015. The plan

describes the operation of the pneumatic crest gate system under normal and high water operations.

The pneumatic crest gate system works in conjunction with the automatic pond level control system at the E.L. Field Powerhouse to maintain consistent headpond level conditions. Under normal operations, the crest gate will be maintained at full elevation, and the E.L. Field control system will adjust the main units' output to match inflow and maintain the impoundment water level at the normal, authorized pond elevation (92.2 feet). When inflows begin to exceed the capacity of the available units, the crest gate control system will automatically adjust the gates to maintain the impoundment elevation no higher than 93.2 feet, or one foot above the normal pond elevation. When under automatic control, the crest gates would all be fully lowered at spillway flows of approximately 35,000 cfs and above (FERC 2015*a*).

Under high-water operations, Boott will fully lower the crest gate system in anticipation of potential flood events in order to minimize the upstream backwater effect of the Pawtucket Dam to the extent possible.

Below (Table 4.5-1) is a tabular description of the operating curve used for operations.

Table 4.5-1. Pneumatic Crest Gate System Operational Scheme.

Approximate Spillway Flow (cfs) †	Crest Gate Status	Target Pond Level (ft NGVD)	Unit Operation
0	Full elevation	92.2 ft (Normal pond)	Pond level control maintained at E.L. Field Powerhouse; additional flow passed through downtown canal system as necessary.
0 – 3,250	Full elevation	Rising to ± 93.2 ft	Full available output
3,250 - ± 23,000 (est.)	Automatic pond level control	± 93.2 ft	Full available output
± 23,000 (est.) – 35,000††	Automatic pond level control if High Water Operations Protocol is not triggered.	± 93.2 ft	Full available output
	Fully lowered if High Water Operations Protocol is triggered	Pond level follows spillway rating curve based on spillway flow.	Full available output
>35,000	Fully lowered	Rises above 93.2 ft as spillway discharge increases.	Fully available output

Source: FERC 2015*a*.

† Flow over the spillway is the inflow to the headpond less any flow through the turbines at the E.L. Field Powerhouse, through the downtown canal system, or through the fish ladder. The maximum combined hydraulic capacity of E.L. Field and the canal system is approximately 10,000 cfs, but may be restricted by unit availability, debris accumulation at the Northern Canal Gatehouse, high tailwater conditions, and other factors.

†† The potential range of spillway flows over which the crest gate may be fully lowered per the High Water Operations Protocol. The estimated flow over the spillway is the flow at the Merrimack River (U.S. Geological Survey [USGS] gage No. 01100000) minus the flow at the Concord River (USGS gage No. 01099500) and minus any flow released through Boott's turbines and the downtown canal system.

4.5.1.4 Fish Passage Operations

The Comprehensive Fish Passage Plan, approved by FERC on November 28, 2000, required operations of a fish ladder at the Pawtucket Dam. The fish ladder has a total operating flow of 500 cfs including attraction flow. The 500 cfs is the primary source of flow in the bypass reach, other than spillage over the Pawtucket Dam spillway. The fish lift system at E.L Field Powerhouse has a total flow capacity of 200 cfs; however, it presently operates at 100-120 cfs. Boott is required to operate both the fish ladder and the fish lift daily during spring of each year when a cumulative total of 50 American Shad or 200 River Herring are passed at the downstream Lawrence Hydroelectric Project. Additionally, Boott is required to operate the downstream bypass facility from April 1 through July 15 and from September 1 through November 15 (Cleantech 2017).

Since 2013, Boott has worked cooperatively with USFWS and other fishery agencies to assess and provide passage for eels moving upstream in the mainstem Merrimack. The efforts have occurred primarily at the fish ladder at the Pawtucket Dam, from mid-July through September, annually.

4.5.1.5 National Park Service Requirements

Although there is no formal flow requirement for the canal system, Boott maintains an operating agreement with the NPS to allow tour boat operations to navigate the canal system. Boott maintains canal water levels within appropriate limits during the May 15 to October 15 tour boat operating season. Operations are maintained through a series of locks and gatehouses along the Canal System (Cleantech 2017).

4.6 Grid Interconnection

As noted above, a 13.8-kV submarine cable within the canal carries energy from the E.L. Field powerhouse to National Grid's Bridge Street substation in Lowell. The output from the E.L. Field powerhouse and other project generating stations is metered at Bridge Street, where a utility disconnect is also located. Metered energy then travels on another 1.5-mile-long submarine cable up the Concord River to National Grid's Perry Street substation. From the Perry Street substation, project output is delivered to the regional utility grid at 115 kV. A single-line diagram for the Project and its interconnection to the grid is provided in Volume II of this PAD and filed as CEII.

4.7 Generation and Outflow Records

The Project operates in a ROR mode and, therefore, experiences seasonal and annual variations in generation based on natural hydrologic conditions in the Merrimack River Watershed. Table 4.7-1 provides Project hydrologic data from 1987-2016. Table 4.7-2 provides a summary of monthly Project generation for a 10-year period from 2008 through 2017 in megawatt-hours (MWh). The average annual Project generation for the period of record was 84,501 MWh.

Table 4.7-1. Lowell Project Hydrologic Data (1987-2016).

Month	Minimum (cfs)	90% Exceedance (cfs)	Average (cfs)	10% Exceedance (cfs)	Maximum (cfs)
January	916	3,462	7,651	12,834	39,710
February	1,478	3,272	6,813	11,415	39,180
March	1,914	4,508	11,484	21,355	50,220
April	2,765	6,558	17,901	31,178	78,890
May	2,034	4,112	10,749	18,657	88,410
June	874	2,279	6,768	13,286	44,660
July	670	1,325	4,207	9,270	29,820
August	569	1,121	3,526	6,852	30,030
September	460	1,008	3,162	6,025	32,264
October	787	1,676	5,938	12,706	50,150
November	1,345	2,888	7,978	14,747	30,990
December	1,839	3,472	9,141	17,243	34,810
Annual	460	1,723	7,941	17,059	88,410

Source: USGS 2018*a*.

Table 4.7-2. Monthly Project Generation.

Month	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
January	10,610	2,574	6,403	7,163	10,272	8,064	10,422	6,624	9,258	9,325
February	10,955	3,851	6,672	5,228	8,928	8,304	5,232	3,216	9,312	6,335
March	11,727	5,088	8,555	10,176	12,432	12,784	10,536	5,820	10,042	9,395
April	10,876	7,341	8,061	11,088	7,872	13,392	10,959	10,128	8,427	8,387
May	7,690	10,147	8,094	11,472	11,712	9,600	9,264	5,219	7,244	8,181
June	4,512	10,464	4,752	8,304	9,792	11,551	3,075	6,563	2,577	9,716
July	5,615	11,252	2,963	3,552	3,216	11,520	4,608	6,432	1,010	6,635
August	4,810	8,026	2,072	4,416	4,560	6,144	5,472	2,412	1,044	2,959
September	4,962	4,012	1,677	10,128	3,696	6,214	4,428	1,898	498	3,462
October	5,287	5,703	8,457	11,136	7,344	3,894	4,314	5,297	1,059	3,332
November	4,726	4,404	10,216	10,272	6,384	5,376	6,880	6,367	3,649	7,380
December	4,656	4,747	9,687	10,272	8,880	7,772	10,700	8,395	9,025	7,946
Annual	86,425	77,609	77,608	103,207	95,088	104,614	85,890	68,371	63,146	83,053

4.8 Dependable Capacity

Dependable capacity is generally defined as the amount of load a hydroelectric plant can carry under adverse hydrologic conditions during a period of peak demand; for example, during the hot, dry conditions typical of August in the Project area. The estimated dependable capacity is also determined by the minimum flow requirements included in the existing license. Under the current license, the Project's estimated dependable capacity is approximately 4.9 MW, based on the August median flow of 1,940 cfs at the project site.

4.9 Current License Requirements and Compliance History

The Lowell Project received its FERC license on April 13, 1983, and commenced operations of the E.L. Field Powerhouse in 1986. The four additional power stations included under the Project license were previously in operation. The Assets Power Station was constructed in 1911 and additional capacity was installed in 1913. The Bridge Street Power Station was constructed in 1910 and additional capacity was installed in 1918, 1920, and 1921. The Hamilton Power Station was constructed in 1918 and additional capacity was installed in 1919, 1920, and 1922. The John Street Power Station was constructed in 1919 and additional capacity was installed in 1923 and 1949.

Since issuance of the original license in 1983, various articles have been revised. The major milestones related to the Lowell Project license are listed in Table 4.9-1.

Table 4.9-1 Lowell Project License Major Milestones.

Date	Title	Notes
April 13, 1983	Order Issuing License (Major)	
December 15, 1983	Order Approving Transfer of License	Transfer from Boott Mills & Proprietors to Boott Hydropower, Inc. & General Electric Credit Corporation
December 23, 1985	Order Approving Transfer of License	Adds Barclay's American Leasing, Inc., as a co-licensee (never consummated)
June 28, 1991	Order Revising License Article	Revised authorized capacity at Bridge Street and John Street facilities and E.L. Field Powerhouse
April 1, 2005	Order Approving Transfer of License	Transfers license to Boott Hydropower, LLC and Eldred L. Field Hydroelectric Family Trust
April 18, 2013	Order Amending License	Approves installation of pneumatic crest gate system

Date	Title	Notes
December 8, 2015	Order Approving Partial Transfer of License	Transfers license to Boott Hydropower, LLC as sole Licensee

Boott submitted an Application for Amendment of License to FERC on March 16, 2017. The amendment of license proposes the removal of four of the Project's currently authorized generating units from the license. If approved, the authorized capacity of the Project would be reduced from 24.823 MW to 22.463 MW.

4.9.1 Current License Requirements

The articles of the 1983 license (as modified by the 2013 Commission order amending the license) represent the applicable license terms under which Boott now operates the Project. A summary of the most applicable of these articles related to Project operations and environmental measures is provided below. A complete set of the articles of the license are presented in Appendix E.

Article 33 (amended April 18, 2013 and approved May 18, 2016): Requires the Licensee, prior to the commencement of any construction activities, to cooperate with the Massachusetts State Historic Preservation Officer (SHPO) and the NPS to carry out a mitigation program for avoiding or minimizing adverse effects on the Locks and Canals Historic District and the Lowell National Historic Park (The license was amended to replace wooden flashboards on Pawtucket Dam with pneumatic crest gate system and mitigation measures were required).

Article 34 (approved September 24, 1984): Requires the Licensee to file functional design drawings of the upstream and downstream fish passage facilities.

Article 35 (approved November 28, 2000): Requires the Licensee to conduct an operational study to determine the effectiveness of the fish passage facilities.

Article 36 (approved November 27, 1984; November 28, 2000; July 11, 2001): Requires the Licensee to develop (1) an instream flow study plan to determine the relationship between Project discharges and downstream aquatic habitat, and (2) a fishery study plan to determine Project discharges necessary to provide for the migration of anadromous fish.

Article 37 (ordered November 27, 1984): Requires the Licensee to discharge an interim continuous minimum flow of 1,990 cfs or inflow, whichever is less, for the purpose of protection fish and wildlife resources, as measured immediately downstream from the Project.

Article 38 (ordered September 12, 1984): Requires the Licensee to file a revised Report on Recreational Resources to include: (1) functional plans for certain repairs and improvements to the Northern Canal and a visitor facility at the E.L. Field Powerhouse; (2) a canal system water level agreement with the NPS.

Boott is also required to adhere to the following operations-related plan:

Crest Gate Operation Plan (approved March 30, 2015): Requires the Licensee to adhere to the detailed plan for operation of the pneumatic crest gate system filed on July 16,

2013, and revised on July 30, 2014. The details of this plan are discussed in further detail above in Section 4.5.

4.9.2 Compliance History

Boott has continued to operate the Project in compliance with the Project license with the exception of one violation. FERC issued a letter on December 2, 1994, stating a violation of Article 38 had occurred. In accordance with the license, the Project visitor center was to open to the public by May 30, 1993; however, the opening was delayed by design changes to the powerhouse and development of display signage. The visitor center was opened to the public on July 21, 1994. FERC did not issue any penalties related to this violation. The visitor facilities are discussed in Section 5.8.1.3 and are shown in Figure 5.8-5 of this document.

Following record flooding events on the Merrimack River in May 2006 and April 2007, FERC initiated an investigation of the performance of the project's wooden flashboards during these events. The investigation was initiated in response to complaints from residents in low-lying areas upstream of the Pawtucket Dam. While it did not designate the issue as a violation or non-compliance, FERC staff concluded that the flashboards had not performed as designed, and on May 28, 2008, ordered the licensee to remove the flashboards and to submit a new design for the flashboards that would fail as originally designed. FERC approved Boott's updated flashboard design on June 4, 2008, and the flashboards were fully reinstalled per the approved design on June 20, 2008. On September 25, 2008, FERC issued a letter ordering Boott to work with the NPS and other stakeholders to determine options for a flashboard system that "can be ensured to be completely down during high flows in the Merrimack River." Accordingly, Boott held a number of meetings with the stakeholders and on March 26, 2010, submitted a letter to FERC indicating that a pneumatic crest gate system had been selected as the best option. On July 6, 2010, Boott submitted an application to amend the project license to replace the existing five-foot wooden flashboards with an pneumatic crest gate system of equal height. FERC issued an amendment order authorizing the crest gate system on April 18, 2013. As stated in Section 4.0, the crest gate system is currently under construction and expected to be completed September, 2018.

4.10 Current Net Investment

The current net investment in the Lowell Project is $49,225,665. This should not be interpreted to be the fair market value of the Project.

4.11 Potential for New Project Facilities

Boott is not proposing any new Project facilities or modifications to Project operations at this time. However, as economic conditions continue to change, Boott periodically performs evaluations of Project facilities for potential upgrades and will continue to do so into the future.

5.0 Description of Existing Environment and Resource Impacts (18 CFR § 5.6(D)(3))

5.1 Description of the River Basin (18 CFR § 5.6(d)(3)(xiii)

5.1.1 Drainage Area and Length of River

The Merrimack River watershed (Figure 5.1-1) encompasses approximately 5,010 square miles within the states of New Hampshire and Massachusetts. It is the fourth largest watershed in New England. The Merrimack River is formed by the confluence of two major rivers, the Pemigewasset and Winnipesaukee, in Franklin, New Hampshire. From the confluence, it flows approximately 115 miles to the Atlantic Ocean (MEOEEA 2001).

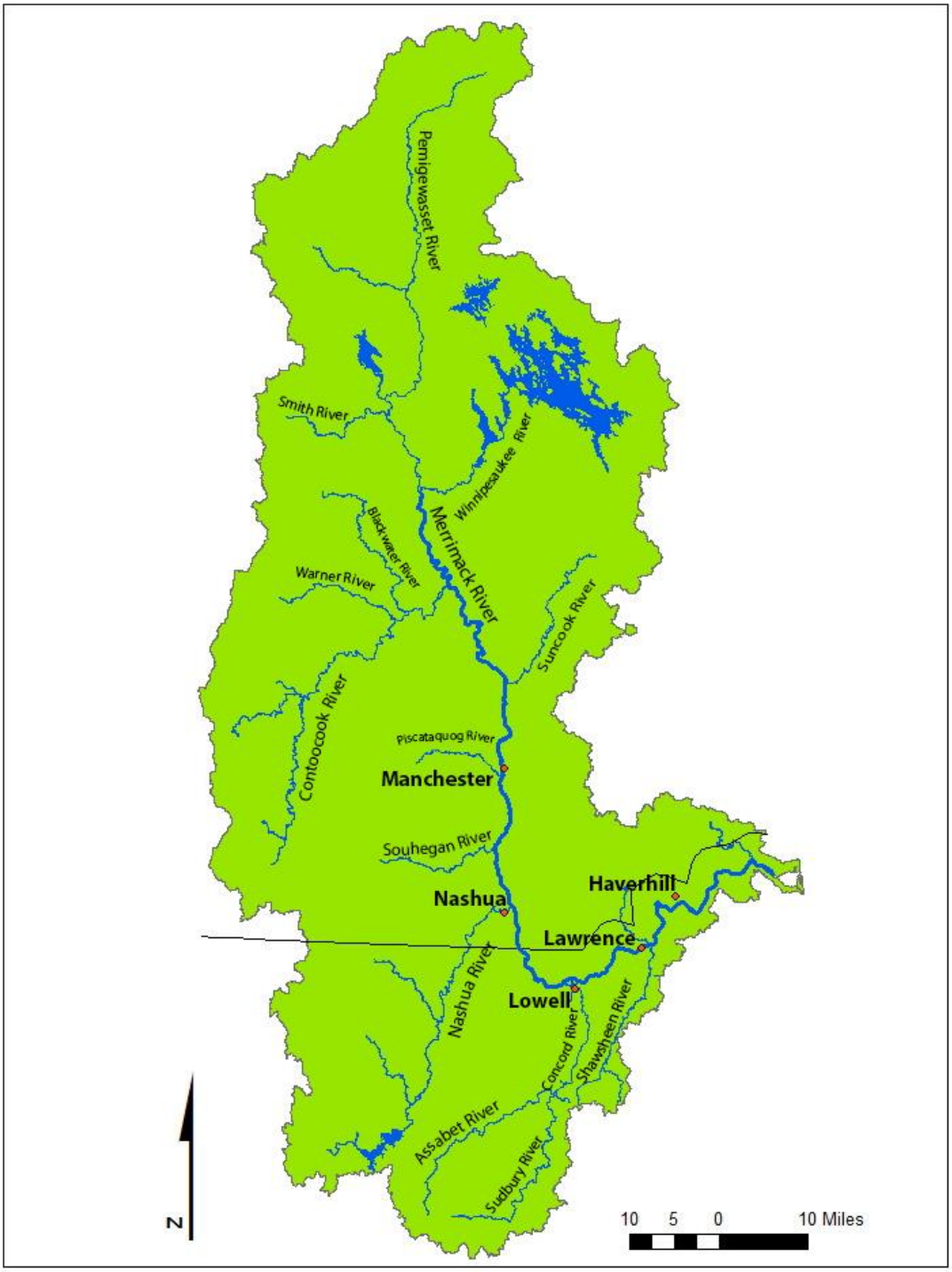
5.1.2 Major Land and Water Uses

The Merrimack River supports multiple uses due to its proximity to a large human population. It is the fourth largest watershed in New England and within its watershed lie approximately 200 communities with a total population of two million people. Historically, the immediate shoreline and adjacent lands to the river were developed to support the Industrial Revolution in the United States. The lower Merrimack River is intensely urbanized as a result of the historic and continued human development. The upper Merrimack River is less developed and is a mix of rural and suburban areas that includes open space, agricultural fields, and woodlands (MEOEEA 2001).

5.1.2.1 Major Land Uses

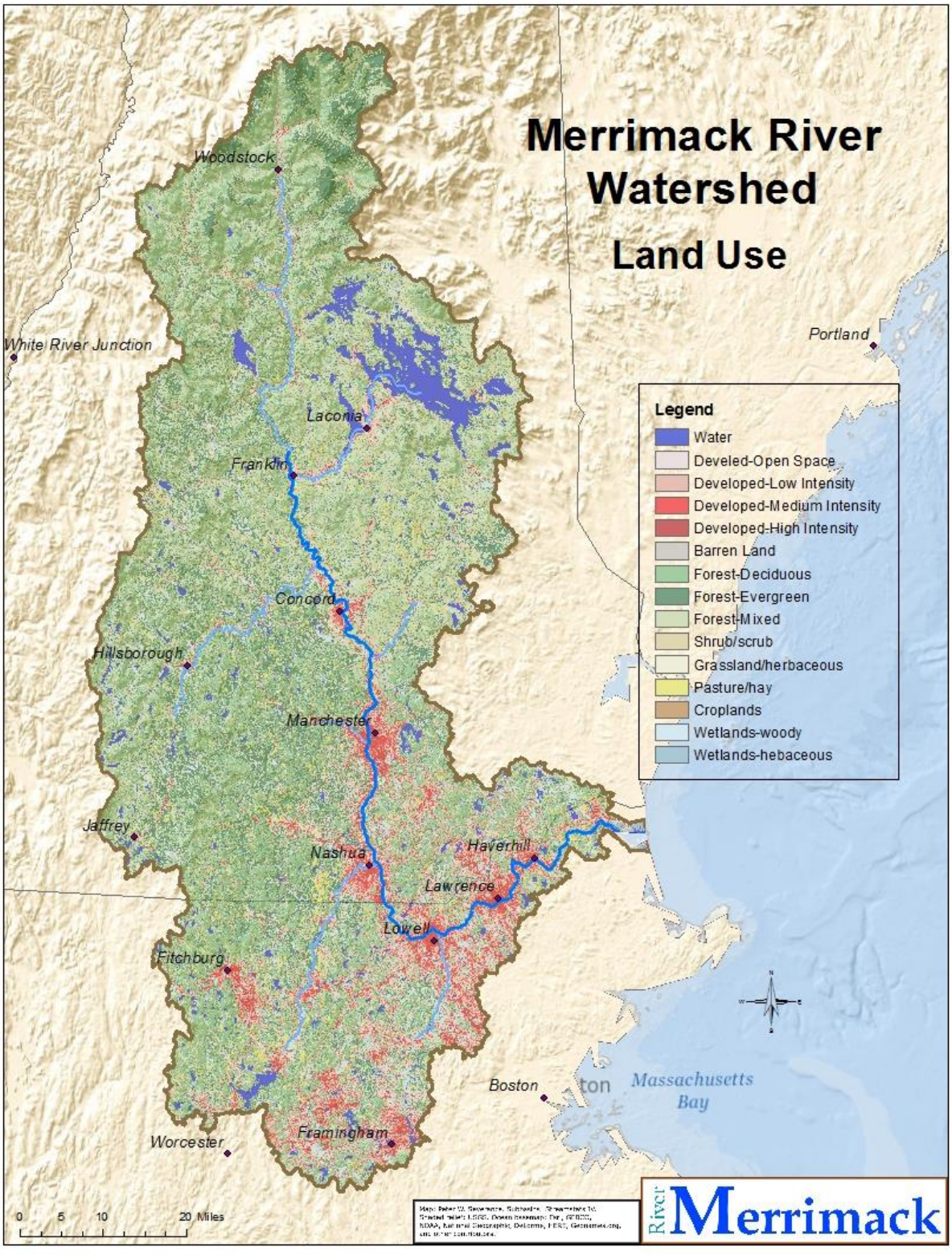
The headwater reaches of the major tributaries and the upper mainstem corridor of the Merrimack River are primarily rural with suburban developments. There are large tracts of open land bordering the river that are used for agricultural production or are undeveloped woodlots. Over 75 percent of the Merrimack River watershed area is a mix of deciduous and evergreen forest and woodland (USACE 2003). Upon reaching Concord, New Hampshire, the mainstem corridor becomes increasingly more urbanized with remnant historic millworks marking the centers of historic development throughout the length of the river mainstem. Downstream of Concord, the Merrimack River basin is more urbanized with a mix of industrial users, residential and commercial developments, and small to medium-sized cities (USACE 2003). As the river continues to flow south, the development becomes more medium intensity to high intensity (Figure 5.1-2) (Merrimack River Watershed Council [MRWC] 2018*a*). The historic use of the Merrimack River in the vicinity of the Lowell Project for navigation, transportation, and industrial applications remain as the primary feature guiding its current use as a tourism attraction, municipal and industrial infrastructural element, and recreational asset.

Figure 5.1-1. Merrimack River Watershed.



Source: USACE 2003.

Figure 5.1-2. Land Use of the Merrimack River Watershed.



Source: Merrimack River Watershed 2018.

5.1.2.2 Major Water Uses

Consumptive users of the Merrimack River water are primarily municipal and industrial. Many of the municipalities bordering the Merrimack River, or within its watershed, use the river as a potable water source as well as a wastewater discharge point. The Merrimack River is the only major New England River used as a drinking water supply and is used as such by the communities of Lowell, Lawrence, Tewksbury, Methuen, and Andover in Massachusetts and Nashua, New Hampshire. Two more cities in New Hampshire, Manchester and Concord, plan to use the river for drinking water supply in the near future (MRWC 2018*b*).

5.1.3 Dams and Diversion Structures within the Basin

There are six FERC-regulated hydroelectric projects on the Merrimack River (Table 5.1-1) as well as four U.S. Army Corps of Engineers (USACE) flood storage dams within the Merrimack River basin in New Hampshire. Boott helps to support the operational costs of these flood storage projects through the payment of Headwater Benefits payments assessed by FERC.

The USACE flood storage system in the Merrimack River basin consists of the following:

Franklin Falls Dam, is located in Franklin, New Hampshire, on the Pemigewasset River. The dam is three miles upstream of the confluence of the Pemigewasset and Winnipesaukee rivers where the Merrimack River originates. The dam is the key unit in the flood risk management for the Merrimack River basin. It provides flood protection for principal industrial and residential centers along the entire length of the Merrimack River. The construction of Franklin Falls Dam was completed in 1943, and it can store up to 50.2 billion gallons of water for flood control purposes (USACE 2016*a*).

The Hopkinton-Everett Lakes Flood Risk Management Project consists of two dams, the dam at Hopkinton Lake, located on the Contoocook River in Hopkinton, NH, and the dam at Everett Lake, located on the Piscataquog River in Weare, NH. The two dams are connected by a two-mile-long canal and in moderate to severe flooding are operated as a single flood risk management project. Construction of the project was completed in 1963. Together, the flood storage areas behind both dams can hold 52.6 billion gallons of water, which would cover approximately 8,000 acres (12.5 square miles). This is equivalent to 6.8 inches of water covering its drainage area of 446 square miles (USACE 2016*b*).

The Blackwater Dam is located on the Blackwater River in Webster, New Hampshire. There is no lake at Blackwater Dam. The flood storage area of the project covers approximately 3,280 acres and extends upstream about seven miles through Salisbury, having a maximum width of one mile. Blackwater Dam can store up to 15 billion gallons of water for flood control purposes (USACE 2016*c*).

Table 5.1-1. Hydroelectric Projects on the Merrimack River.

Facility	FERC Project #	Licensee[1]	River Mile	Generation Capacity (MW)
Eastman Falls	2457	Public Service Company of NH	116	6.4
Garvins Falls	1893	Public Service Company of NH	87	12.3
Hooksett	1893	Public Service Company of NH	81	1.6
Amoskeag	1893	Public Service Company of NH	73	16
Lowell	2790	Boott	40	24.8
Lawrence	2800	Essex Company, LLC	29	16.8

1. The Public Service Company (PSC) of NH facilities are current the subject of a FERC transfer proceeding between PSC of NH (Eversource) and subsidiaries of HSE Hydro NH AC, LLC.

5.1.4 Tributary Rivers and Streams

The Merrimack River watershed is comprised of numerous sub-watersheds of varying size. These sub-watersheds are listed below in Table 5.1-2 including the drainage area and length of each tributary stream. These sub-watersheds are also depicted in Figure 5.1-3.

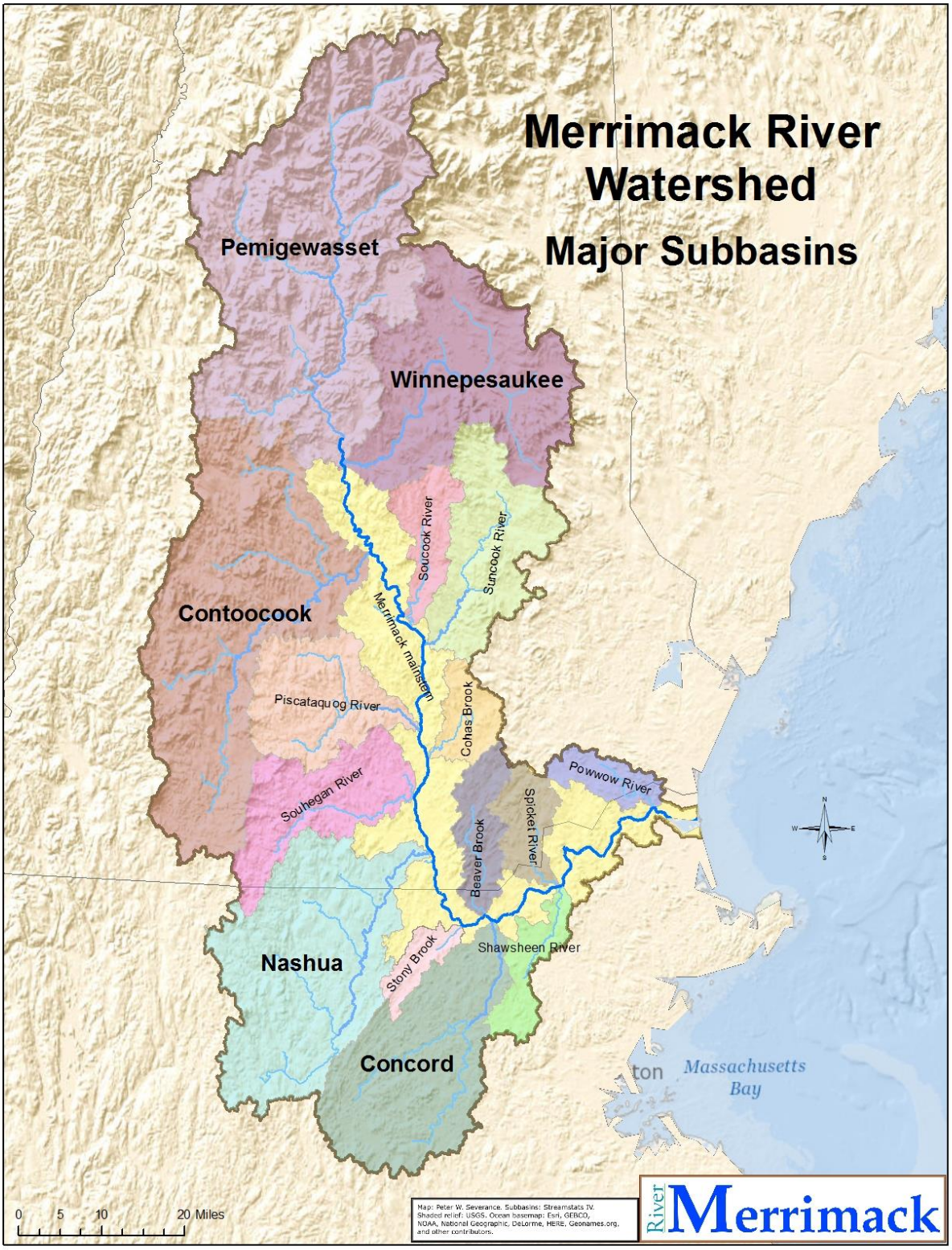
Table 5.1-2. Summary of Major Tributaries.

Location of Headwaters	Tributary	Drainage Area (mi^2)	Length (mi)
New Hampshire	Pemigewasset River	1021	64
	Winnipesaukee River	486	23
	Contoocook River	766	66
	Soucook River	91	28
	Suncook River	260	39
	Piscataquog River	220	24
	Cohas Brook	68	7
	Souhegan River	219	34
	Beaver Brook	91	12
	Spicket River	75	15
	Powwow River	49	23

Location of Headwaters	Tributary	Drainage Area (mi^2)	Length (mi)
	Merrimack River mainstem	577	
Massachusetts	Nashua River	530	34
	Salmon River	32	NA
	Stony Brook	46	NA
	Shawsheen River	74	24
	Assabet / Sudbury / Concord Rivers	400	16

Source: USACE 2003.

Figure 5.1-3. Subbasins of the Merrimack River Watershed.



Source: The Merrimack River Watershed 2018.

5.2 Geology (18 CFR § 5.6(d)(3)(ii)

5.2.1 Physiography and Topography

The Lowell Project is located in the New England Physiographic Province. This broad physiographic section is characterized as a mountainous area of significant relief. The area is made up of highly deformed Precambrian and Paleozoic metamorphic rocks, including gneiss, schist, slate, quartzite, and marble. The province was glaciated during the Pleistocene and shows both depositional and erosional effects of glacial ice. The Taconic, Green, and White Mountain ranges are distinct features of the New England Physiographic Province. The Taconic Mountains are a north-south trending mountain range along the western edge of the province and are thought to be formed by erosion of an upper block of a large thrust fault. Also north-south trending, the Green Mountains exist primarily in Vermont and are made of Precambrian gneisses. The White Mountains are an exhumed mass of Paleozoic granite and include Mt Washington in New Hampshire, the tallest mountain in the region at 6,288 feet. The province is valued for its mineral resources, both industrial and as building materials. Marble, granite, and slate are all widely distributed and quarried within the province (NPS undated*a*).

The Merrimack River watershed traverses each of the three major sections of the New England Physiographic Province: the White Mountains, New England Uplands, and Seaboard Lowlands (Flanagan et al. 1999 as cited in USACE 2002). The majority of the basin falls within the New England Uplands region, which is characterized by rolling hills and has a local relief ranging from a few hundred feet to 1,000 feet in more mountainous regions. The watershed elevation ranges from a high of 5,249 feet on Mount Lafayette in the White Mountain region to mean sea level along the northeastern Massachusetts coast (USACE 2002).

Within this broad physiographic section, the U.S. Environmental Protection Agency (USEPA) has defined distinct ecoregions that share similarities in ecosystems and in the type, quality, and quantity of environmental resources (Griffith et al. 2009). The physiographic setting of the Lowell Project corresponds to the Gulf of Maine Coastal Plain Level IV Ecoregion defined by Griffith et al. (2009).

The Gulf of Maine Coastal Plain consists of rolling plains with hills and some high hills. Glacial drumlins are common, as well as ponds, small lakes, and wetlands. Low and moderate gradient streams and large rivers with sand, gravel, boulder, and bedrock substrates are common in the ecoregion. Natural vegetation in the ecoregion consists of mesic to dry Appalachian oak-pine forests with various combinations of red oak (*Quercus rubra*), white oak (*Q. alba*), and black oaks (*Q. velutina*), some scarlet (*Q. coccinea*) or chestnut oaks (*Q. prinus*) to the south, white pine (*Pinus strobus*), sugar maple (*Acer saccharum*), red maple *(A. rubrum*), hickories (*Carya spp.*), and other central or northern hardwoods. Floodplain forests are typically dominated with silver maple (*A. saccharinum*), American elm (*Ulmus americana*), and green ash (*Fraxinus pennsylvanica*) (Griffith et al. 2009).

5.2.2 Bedrock Geology

Bedrock in the Merrimack River watershed is generally of similar age and genesis. Intrusive igneous rocks, primarily Granitoid Plutonic rocks, dominate the northeastern

portion of the river basin. Large deposits of metamorphic mixed and sulfide-bearing granofels cover the north-central and northwestern portion of the basin. A strip of metamorphic grade rocks, including mixed schist and gneiss deposits, cuts across the Massachusetts-New Hampshire border in a northeasterly direction (USACE 2002).

The Merrimack Quartzite is the principal bedrock unit underlying the Project. Although the rock is cut by abundant fractures, it is hard and relatively unweathered. The low-grade metasedimentary rock is of Silurian or Devonian age, approximately 400 million years old. Lithologically, the rock is a fine-grained, impure, bedded quartzite with minor schist. In places, quartzite consists of alternating coarse-grained sandy beds with silty beds (Boott 2015).

The Project is also nearby the mapped contact between the Merrimack Quartzite and the Ayer Granite. The Ayer Granite is a late Paleozoic intrusion. It is a complex igneous rock with an average composition of granodiorite. It is a light- to medium-gray, medium- to coarse-grained rock, commonly porphyritic, gneissic or migmatitic (Boott 2015).

5.2.3 Surficial Geology

The Merrimack River basin is generally covered by a sheet of glacial till, with areas of large fine- and large-grained, glacial-lake deposits along the river mainstem and major tributaries (Flanagan et al. 1999 as cited in USACE 2002). According to the USACE (1977), the till cover within the Merrimack River basin is composed of variable, unstratified, silty, gravelly, sand and clays. The cover is generally thin on the hilltops and in the deep valleys, with exposed bedrock typically visible in the hilly upland regions. Large glacial melt-water lakes formed throughout the basin during glacial retreat (USACE 2002).

5.2.4 Mineral Resources

As mentioned above, the New England Physiographic Province is valued for its mineral resources, both industrial and as building materials. Marble, granite, and slate are all widely distributed and quarried within the province (NPS undated*a*). There are no mapped oil, gas, or mineral resources in the Lowell Project boundary. According to the USGS (USGS undated*a*), there are two active mines in the Project vicinity, including the Westford Quarry located approximately 4.5 miles southwest of Pawtucket Dam and Litchfield Sand and Gravel located approximately 17 miles northwest of Pawtucket Dam.

5.2.5 Project Area Soils

Soil types in the vicinity of the Lowell Project are variable and reflect the diversity of parent materials, the local topography, and the physiographic position of landforms. The Project vicinity is composed of soil series formed primarily in glacial and glaciofluvial deposits, sandy outwash or eolian deposits, and recent alluvium. Additionally, a large portion of the soils mapped in the Project vicinity are classified as Udorthents. There are many types of Udorthent soils, but in general they include areas of human altered soil and non-soil areas that are mapped based on their surface texture, type of alteration, depth to water table, and geologic setting. Some human-altered map units include sand, gravel, till, quarry pits, areas of excavated (cut and fill) geologic material, and areas used for the disposal of refuse.

Mapped soils in the vicinity of the Project are presented in Figure 5.2-1. A 100-foot buffer has been applied to the Project boundary to develop this figure. Map unit delineation on a soil map represents an area that is dominated by one or more major kinds of soil or miscellaneous area. Each map unit is identified and names are in accordance with the taxonomic classification of the dominant soils. The U.S. Department of Agriculture's (USDA) Official Soil Series Descriptions for mapped soil series in Figure 5.2-1 are presented in Appendix F of this PAD (USDA undated).

5.2.6 Impoundment Shoreline and Stream Banks

The shoreline surrounding the Merrimack River within the Project area typically consists of low-to-moderate slopes dominated by urban, commercial, industrial, and residential development. Some areas along the shoreline within the Project vicinity consist of agricultural areas and some areas consist of forest canopy vegetation underlain by established shrub and herbaceous layers. Large boulders, cobbles, or exposed bedrock are uncommon along the shoreline of the Merrimack River within the Project area. A portion of the shoreline is bordered by walking trails, which are used by the public and the majority of the southern shoreline is bordered by a railroad. A topographic map of the Project area is included in Appendix G.

There is no evidence of erosion, slumping, or slope instability around the shoreline of the Project.

5.2.7 Seismicity

The northeast United States lies within the relatively tectonically stable and geologically old North American plate, where a great deal of the tectonic action took place over 200 million years ago when the Atlantic basin began to form due to the separation of Africa from North America. However, based on instrumental seismic records, earth scientists believe that the tectonic activity in the northeast is still ongoing (Ebel 1987).

The Project is located in Seismic Zone 2 and is subject to earthquakes of moderate intensity. The Clinton-Newbury fault zone forms an important regional crustal plate boundary and is located roughly 1.5 miles southeast of the Project area. No recent large-scale earth movements are known along the Clinton-Newbury fault and it is considered inactive (Boott 2015).

Regarding historic seismicity, the USGS National Earthquake Information Center Database was searched regarding earthquakes within the Project region from 1970 to present day. The most significant (largest and closest) events were indicated by the USGS to be a magnitude (M) of 3.7 on October 2, 1994, 54 miles from the Project, and a M of 3.1 on January 10, 1999, 22.3 miles from the Project (USGS undated*b*).

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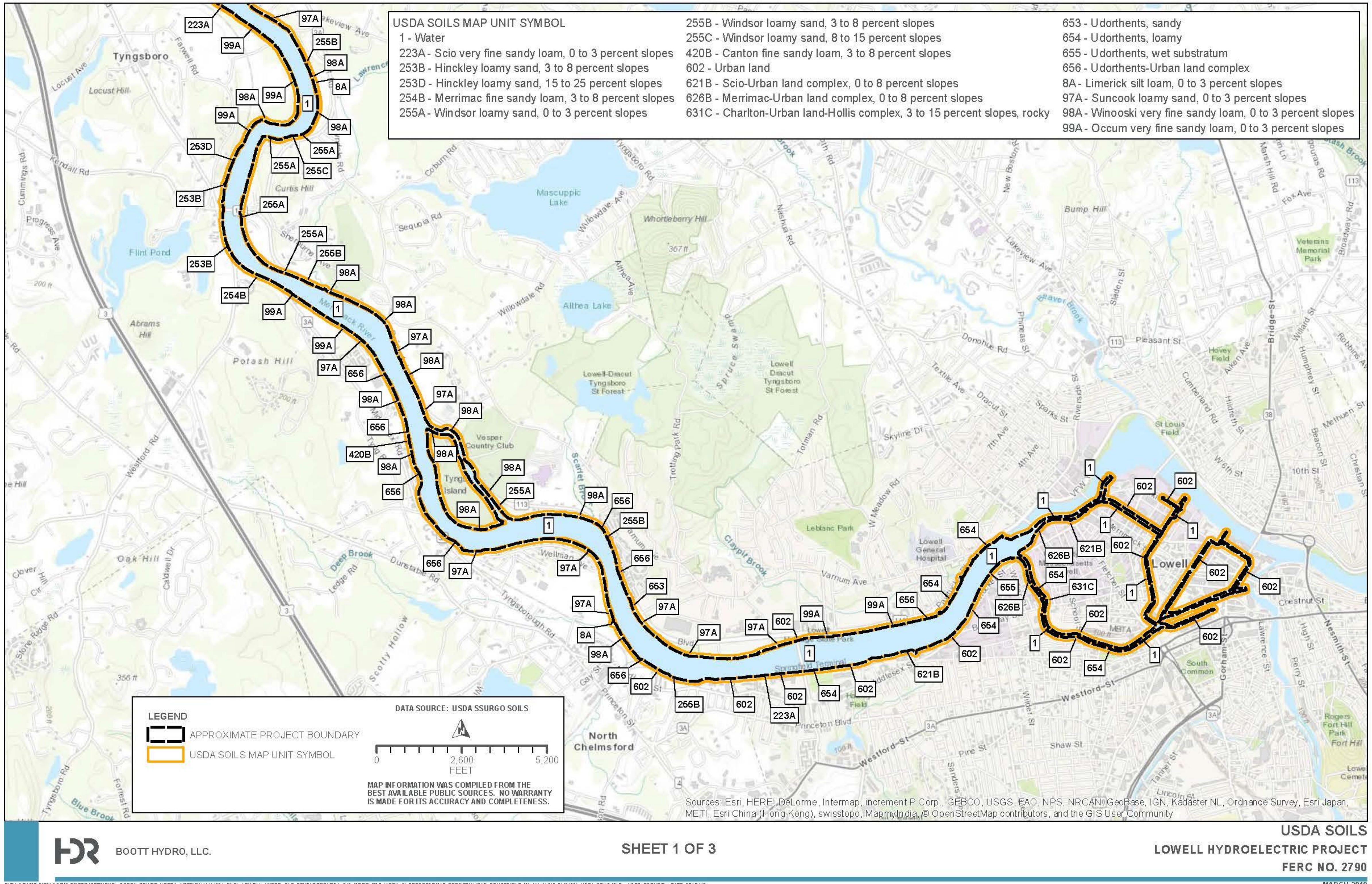
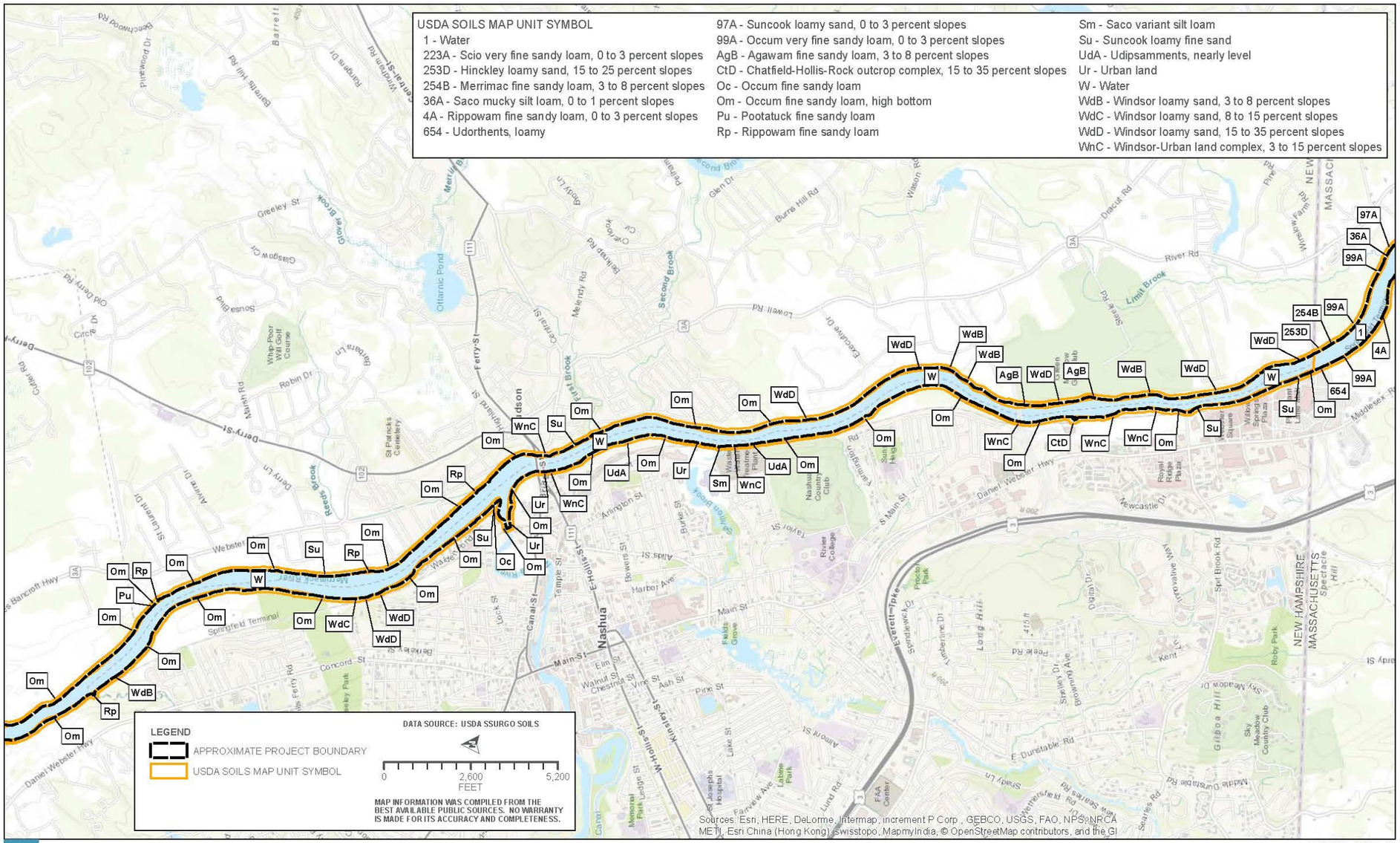
Figure 5.2-1. Soils in the Vicinity of the Lowell Hydroelectric Project.

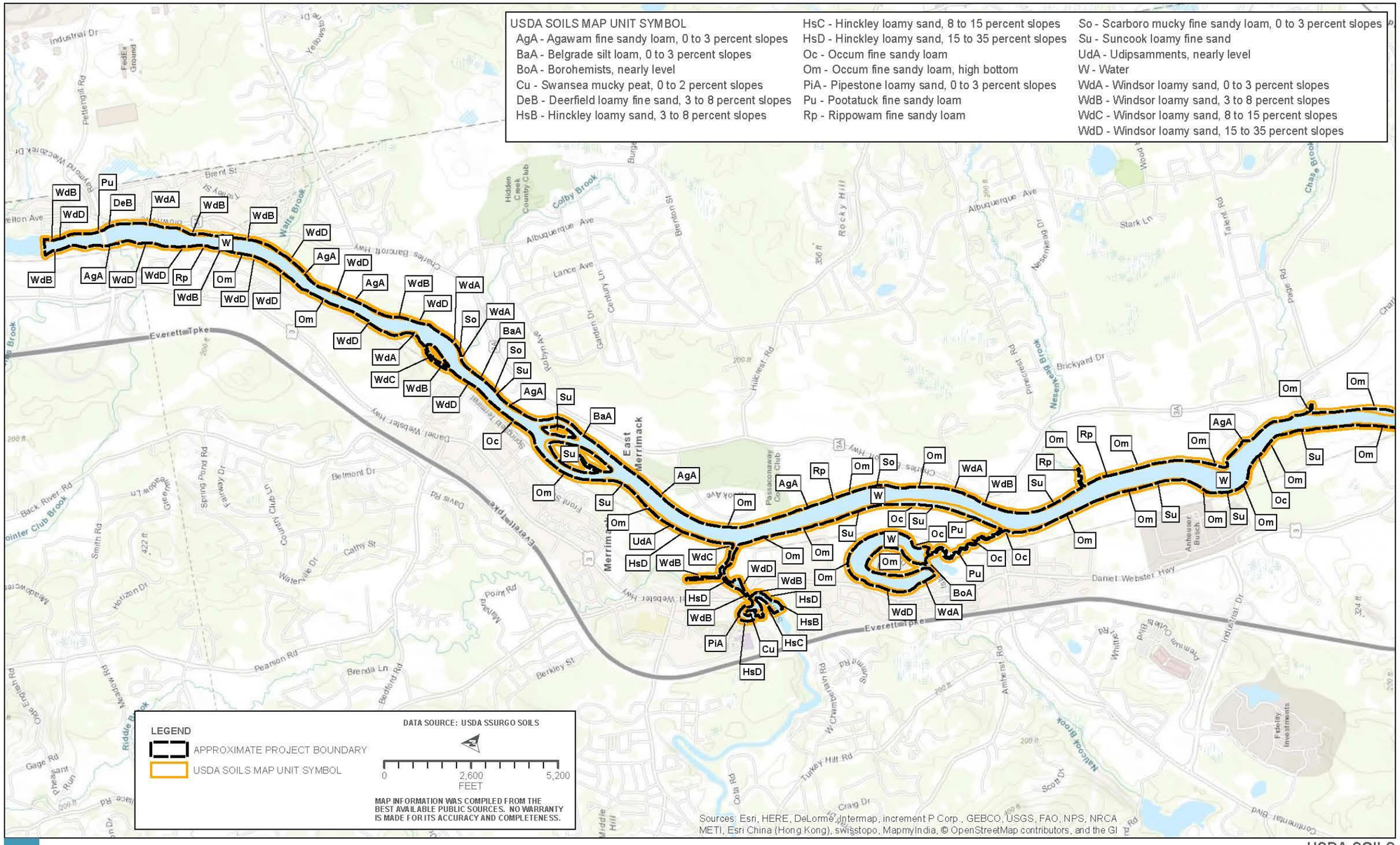




BOOTT HYDRO, LLC.

SHEET 2 OF 3

USDA SOILS
LOWELL HYDROELECTRIC PROJECT
FERC NO. 2790
MARCH 2018



BOOTT HYDRO, LLC.

SHEET 3 OF 3

USDA SOILS
LOWELL HYDROELECTRIC PROJECT
FERC NO. 2790
MARCH 2018

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5.3 Water Resources (18 CFR § 5.6(d)(3)(iii))

5.3.1 Drainage Area

The Merrimack River watershed has a total drainage area of approximately 5,010 square miles within the states of New Hampshire and Massachusetts (MEOEEA 2002). The Lowell Project is located at RM 41 on the Merrimack River. The drainage area of the Lowell Project is approximately 3,979 square miles.

5.3.2 River Flows

The majority of the flows through the Lowell Project are a direct result of the annual hydrologic cycle. The river receives higher inflows during the annual spring runoff and the wetter fall and winter months.

Two USGS Gages were reviewed to establish Project hydrology:

- USGS Gage No. 01099500 *Concord River Below Meadow Brook, at Lowell, MA*; and
- USGS Gage No. 01100000 *right Bank at Lowell, 1,100 feet downstream from the Concord River*.

Flows from USGS Gage No. 01099500 *Concord River Below Meadow Brook, at Lowell, MA* was subtracted from flows at USGS Gage No. 01100000 *right Bank at Lowell, 1,100 feet downstream from the Concord River* to calculate the hydrologic data tabulated in Table 5.3-1, presenting data at the Project from the past 30 years (water years 1987-2016).

Table 5.3-1. Lowell Project Hydrologic Data (Water Years 1987-2016).

Month	Minimum (cfs)	90% Exceedance (cfs)	Average (cfs)	10% Exceedance (cfs)	Maximum (cfs)
January	916	3,462	7,651	12,834	39,710
February	1,478	3,272	6,813	11,415	39,180
March	1,914	4,508	11,484	21,355	50,220
April	2,765	6,558	17,901	31,178	78,890
May	2,034	4,112	10,749	18,657	88,410
June	874	2,279	6,768	13,286	44,660
July	670	1,325	4,207	9,270	29,820
August	569	1,121	3,526	6,852	30,030
September	460	1,008	3,162	6,025	32,264
October	787	1,676	5,938	12,706	50,150
November	1,345	2,888	7,978	14,747	30,990
December	1,839	3,472	9,141	17,243	34,810
Annual	460	1,723	7,941	17,059	88,410

Source: USGS 2018*a*.

5.3.3 Flow Duration Curves

Monthly flow duration curves have been developed for the Lowell Project using water years 1987-2016. These curves can be found in Appendix H to this PAD.

5.3.4 Existing and Proposed Uses of Project Waters

In Massachusetts, the Massachusetts Department of Environmental Protection (MADEP) regulates the quantity of water withdrawn from both surface and groundwater supplies to ensure adequate water supplies for current and future water needs pursuant the Massachusetts Water Management Act (MADEP 2018*a*). Available registrations and permits were reviewed. Two regulated water withdrawals were identified in Lowell. These withdrawal users were identified as Lowell Water Treatment Facility (Permit #9P231316003) and Western Avenue Dyers (Permit #9P131316001). Based on the 2017 Annual Water Quality Report by the Lowell Regional Water Utility (LRWU), the utility withdrew 3.9 billion gallons of water from the Merrimack River to provide drinking water for Lowell and the surrounding communities (LRWU 2017). In 2016, the LRWU withdrew 4.2 billion gallons from the Merrimack River (LRWU 2016).

In New Hampshire, Pennichuck Water Works supplies water for the City of Nashua and 10 surrounding New Hampshire municipalities located in southern New Hampshire, using both surface water and groundwater sources. The Nashua Core water system derives its water supply from the Pennichuck Brook and the Merrimack River watersheds (Pennichuck Water Works 2018). The city of Manchester currently does not utilize the Merrimack River as a drinking water source, but it is anticipated to by year 2022 (Manchester Water Works 2017).

In New Hampshire, the NHDES regulates large groundwater withdrawals under the state's Groundwater Protection Act to ensure that no adverse impacts to water users or natural resources occur as a result of a withdrawals (NHDES 2018*a*). Only one groundwater withdrawal permit was located within the Project vicinity, which was issued to the Merrimack Village District Water Works in New Hampshire (Permittee Number LGWP-2017-0001) (NHDES 2018*b*).

The USEPA is the permitting authority in Massachusetts and New Hampshire for issuing National Pollutant Discharge Elimination System (NPDES) permits, which are required whenever a municipality, industry, or other entity wishes to discharge pollutants to a surface water of the United States (MADEP 2018*b*). In Massachusetts, NPDES permits are typically co-issued by the USEPA and MADEP (MADEP 2018*b*). Available NPDES permits were reviewed for the Project vicinity in Massachusetts (Commonwealth of Massachusetts 2018*a*, USEPA 2018*a*); however, no active permits were found. Two NPDES permits were identified within the Project vicinity in New Hampshire, which were issued for wastewater treatment facilities and combined sewer overflows to the city of Manchester (Permit Number NH0100447) and the city of Nashua (Permit Number NH0100170) (USEPA 2018*d*).

The Lowell Project has four NPDES permits issued under the Massachusetts General Permit no. MAG360000. These are: Permit No. MAG360024 for the Eldred L. Field Powerhouse; No. MAG360026 for the Hamilton powerhouse; No. MAG360025 for the John St. powerhouse; and No. MAG360027 for the Section 8 powerhouse.

5.3.5 Existing Instream Flow Uses

Existing instream flow uses of the Merrimack River within the Project vicinity include a wide variety of uses, including waste assimilation, drinking water, hydropower production, and recreation (e.g., fishing and boating). No other existing instream flow uses of the Project waters have been identified.

5.3.6 Federally Approved Water Quality Standards

5.3.6.1 Massachusetts

Water quality standards for the Commonwealth are contained in the Code of Massachusetts Regulations (CMR) at 314 CMR 4.00: Massachusetts Surface Water Quality Standards (SWQS). Inland surface waters of the Commonwealth are classified by appropriate use Class (A, B, or C) as defined in 314 CMR 4.05. Qualifiers applied to these classifications indicate special considerations and uses applicable to a segment that may affect the application of criteria or antidegradation provisions. The classification of surface water in Massachusetts is provided in 314 CMR 4.06.

The MADEP's Division of Water Pollution Control has classified waters within the Project vicinity as Class B with specific qualifiers (Table 5.3-2). As defined in 314 CMR 4.05(3)(b), Class B waters are designated as:

> [A] habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth, and other critical functions, and for primary and secondary contact recreation. Where designated in 314 CMR 4.06, Class B waters shall be suitable as a source of public water supply with appropriate treatment ("Treated Water Supply"). Class B waters shall be suitable for irrigation and other agricultural uses and for compatible industrial cooling and process uses. These waters shall have consistently good aesthetic value.

A summary of the standards applicable to Class B waters with the Warm Water qualifier is provided in Table 5.3-3.

Table 5.3-2. Water Quality Classification Applicable to the Lowell Project.

Boundary	Mile Points	Class	Qualifiers
State line to Pawtucket Dam	49.8 – 40.6	B	Warm Water[1] Treated Water Supply[2] CSO[3]
Pawtucket Dam to Essex Dam, Lawrence	40.6 – 29.0	B	Warm Water[1] Treated Water Supply[2] CSO[3]

Source: 314 CMR 4.06.

[1] In these waters, dissolved oxygen and temperature criteria for warm water fisheries apply.

[2] Denotes those Class B waters that are used as a source of public water supply after appropriate treatment. These waters may be subject to more stringent site-specific criteria established by the Department as appropriate to protect and maintain the use. See, also, 310 CMR 22.00.

[3] These waters are identified as impacted by the discharge of combined sewer overflows (CSO); however, a long-term control plan has not been approved or fully implemented for CSO discharges.

Table 5.3-3. Water Quality Standards for Class B Waters with the Warm Water Qualifier in Massachusetts.

Parameter	Class B Warm Water Standards
Dissolved Oxygen (DO)	Shall not be less than 5.0 milligrams per liter (mg/L) in warm water fisheries. Where natural background conditions are lower, DO shall not be less than natural background conditions. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.
Temperature	Shall not exceed 83 degrees Fahrenheit (°F) (28.3 degrees Celsius [°C]) in warm water fisheries. The rise in temperature due to a discharge shall not exceed 5°F (2.8°C) in rivers and streams designated as warm water fisheries (based on the minimum expected flow for the month); in lakes and ponds the rise shall not exceed 3°F (1.7°C) in the epilimnion (based on the monthly average of maximum daily temperature). Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. There shall be no changes from natural background conditions that would impair any use assigned to this Class, including those conditions necessary to protect normal species diversity, successful migration, reproductive functions, or growth of aquatic organisms.
pH	Shall be in the range of 6.5 through 8.3 standard units and not more than 0.5 units outside of the natural background range. There shall be no change from natural background conditions that would impair any use assigned to this Class.
Solids	These waters shall be free from floating, suspended, and settleable solids in concentrations and combinations that would impair any use assigned to this Class that would cause aesthetically objectionable conditions, or that would impair the benthic biota or degrade the chemical composition of the bottom.
Color and Turbidity	These waters shall be free from color and turbidity in concentrations or combinations that are aesthetically objectionable or would impair any use assigned to this Class.

Source: 314 CMR 4.05.

5.3.6.2 New Hampshire

Water quality standards in New Hampshire are contained in New Hampshire's Revised Statutes Annotated (RSA) 485A:8, Standards for Classification of Surface Waters of the State, and in Env-Wq 1700, the Surface Water Quality Standards. RSA 485A:8 establishes that all New Hampshire surface waters must be classified as either Class A or Class B waters, and establishes certain minimum surface water quality criteria for each classification (NHDES 2012*a*). The Merrimack River is designated as a Class B in New Hampshire, which pursuant RSA 485A:8 shall be considered as being acceptable for fishing, swimming, and other recreational purposes and, after adequate treatment, for use as water supplies. A summary of the standards applicable to Class B is provided in Table 5.3-4.

Table 5.3 4. Water Quality Standards for Class B Waters in New Hampshire.

Parameter	Class B Warm Water Standards
DO	Except as naturally occurs, waters shall have a DO concentration of at least 75% of saturation based on a daily average and an instantaneous minimum DO concentration of at least 5 mg/L.
Temperature	Any stream temperature increase associated with the discharge of treated sewage, waste or cooling water, water diversions, or releases shall not be such as to appreciably interfere with the uses assigned to this class.
pH	Shall be 6.5 to 8.0 unless due to natural causes.
Turbidity	Shall not exceed naturally occurring conditions by more than 10 Nephelometric Turbidity Units (NTUs).
Color	Shall contain no color in such concentrations that would impair any existing or designated uses, unless naturally occurring.

Source: Env-Wq 1700, RSA 485A:8.

5.3.7 Existing Water Quality Data

Historically, the Merrimack River was among the top ten most polluted rivers in the country in the 1970s. After the Clean Water Act (CWA) was passed in 1972, the point source pollution from factories along the Merrimack River was tackled and the river's water quality dramatically improved. Water quality data have been previously collected along the Merrimack River. Data collected within the Project vicinity are presented here, which includes water temperature, DO, pH, and specific conductance data collected: (1) at a USGS gage approximately 1.6 RM downstream from the Project (2) at numerous sites from RM 29.6 to 55.9 by a volunteer monitoring program established by the Merrimack River Watershed Council, and (3) at three NHDES monitoring sites obtained from the USEPA's storage and retrieval (STORET) data warehouse.

The USGS periodically collected water quality data approximately 1.6 RM downstream from the Project powerhouse at gage 01100000 (Merrimack River BL Concord River at Lowell, MA) between 1953 and 2004 (USGS 2018*a*), Figure 5.3-1. The most recent data are presented below, which consists of water temperature, DO, pH, and specific conductance data collected between 1998 – 2004 (Figure 5.3-2 to Figure 5.3-6). Water temperatures were seasonal and were below the state maximum temperature criterion. DO concentrations were often well above the state minimum criterion of 5.0 mg/L and were near saturation, except on one occasion in August 1999. The pH was within the acceptable range, except on a single sampling event in December 2003 when it was 6.3 units. Specific conductance ranged from 83 to 328 microsiemens per centimeter (µS/cm) (USGS 2018*a*).

A volunteer monitoring program established by the MRWC collected water quality data at 41 monitoring stations located along the mainstem of the Merrimack River in 2009 (MRWC 2010). Results were grouped into one of the five river segments identified during the study. Results from three sections, including from the Essex Dam to the Pawtucket Dam in Lowell (Section 3), from the Pawtucket Dam to the Massachusetts/New Hampshire state border (Section 4), and from the state border to Greeley Park in Nashua (Section 5) are presented here in Tables 5.3-5 through 5.3-7. Nine sites were sampled in

Section 3, eight sites were sampled in Section 4, and seven sites were sampled in Section 5. Monitoring occurred periodically between May and October in 2009. Water temperatures ranged from 8.1 to 25.7°C and were well below the maximum temperature criterion of 28.3°C. DO concentrations ranged from 7.2 mg/L to 12.1 mg/L and were well above the state minimum state criterion of 5.0 mg/L. The pH was frequently below the acceptable minimum criterion and ranged from 3.3 to 6.8 units. However, according to the MRWC (2010) these data could be erroneous and could not be confirmed by the USEPA. Specific conductance ranged from 99 to 211 µS/cm.

A search was conducted using the USEPA's STORET database for water quality data within the Project vicinity in Massachusetts and New Hampshire. Water temperature, DO, pH, and specific conductance data were available for the following three sites, all of which were collected by the NHDES (Figure 5.3-1):

1. Bridge Connecting RTE 3 & 3A (Station ID 11113300-02-MER)
2. RTE 111 BRIDGE, EAST HOLLIS ST (Station ID 11113300-03-MER)
3. RR BRIDGE D.S. OF MANCHESTER WWTF (Station ID 11113300-08-MER)

Data collected over the past 20 years are presented in Figures 5.3-7 through 5.3-11. Water temperatures ranged up to 28°C. DO concentrations ranged from 6.6 to 10.8 mg/L, which were well above the minimum state criterion of 5.0 mg/L, and waters were 82.1 to 121.0 percent saturated. The pH ranged from 5.7 to 7.5 units and levels were frequently below the minimum criterion of the state range. Specific conductance ranged from 64 to 180 µS/cm.

DO concentrations were also monitored during the Merrimack River Watershed Assessment Study, which was a joint effort between federal, state, and local communities to develop a comprehensive watershed management plan for the Merrimack River (USACE 2018). During the study, water quality sampling was conducted along the mainstem of the Merrimack River from Concord, New Hampshire, to its estuary in Newburyport, Massachusetts. From 2003 to 2005, three dry-weather surveys and four wet-weather surveys were conducted. Additionally, a continuous survey of DO and temperature was conducted at two locations for a one-month period during low-flow conditions in August and September 2003. These data were not available, but the study summary indicated DO along the mainstem of the Merrimack River from Manchester, New Hampshire, to the Atlantic Ocean were well above the minimum criterion of 5 mg/L (USACE 2018).

Figure 5.3-1. USGS and STORET Water Quality Sample Locations.

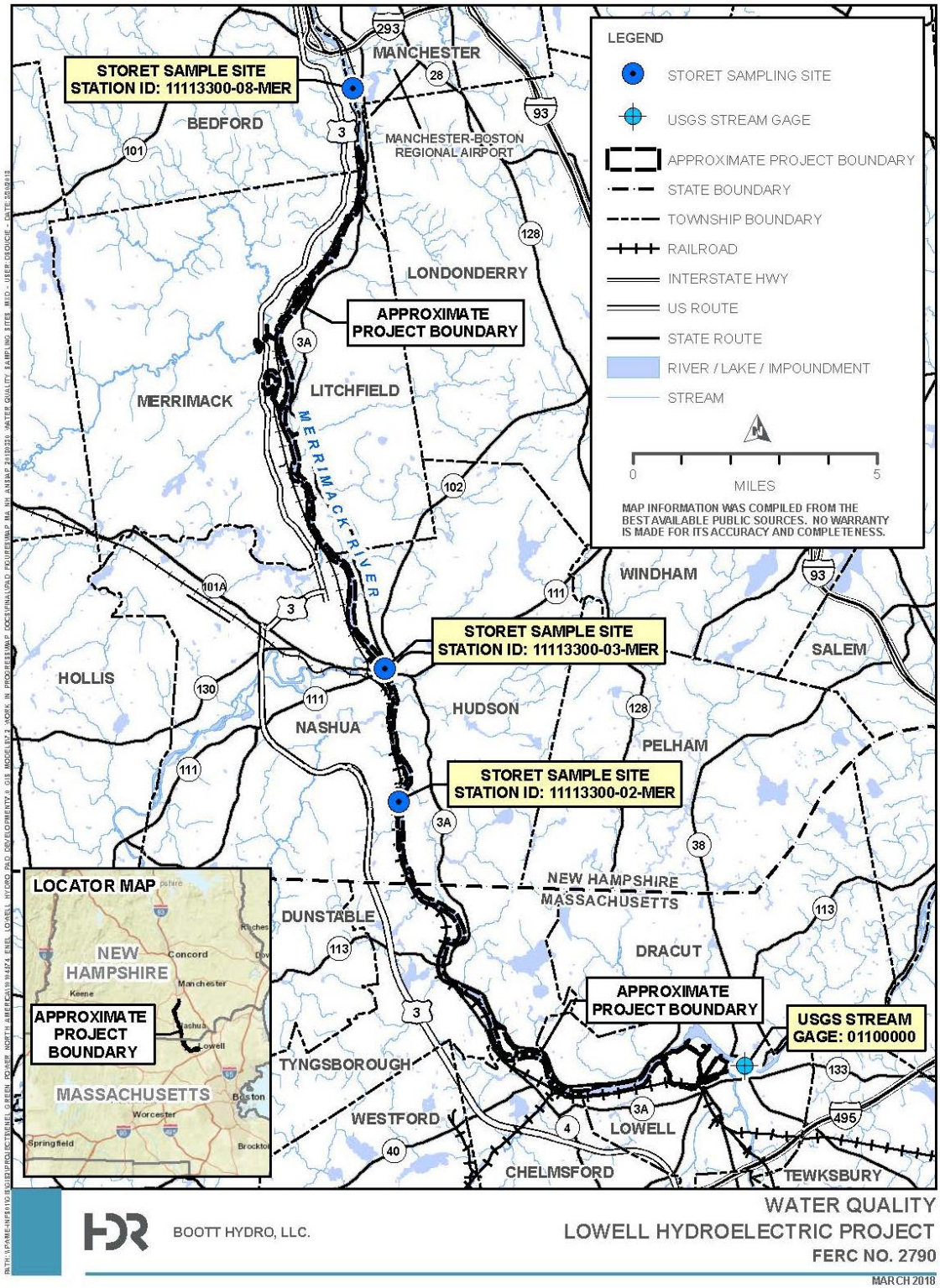

Figure 5.3-2. Water Temperature Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004.

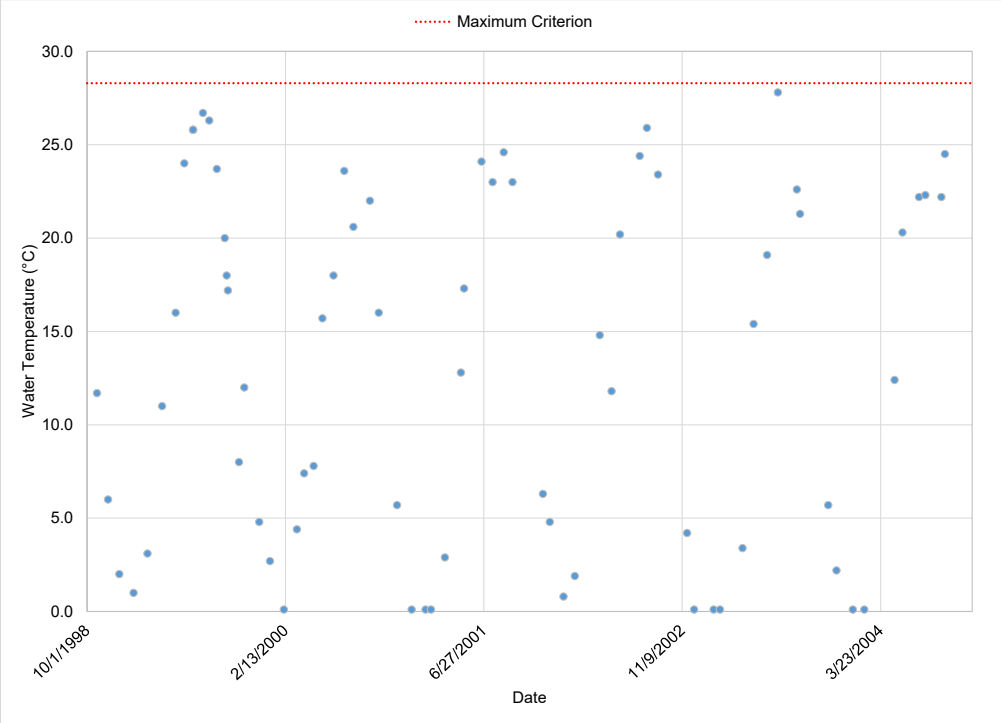

Figure 5.3-3. Dissolved Oxygen Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004.

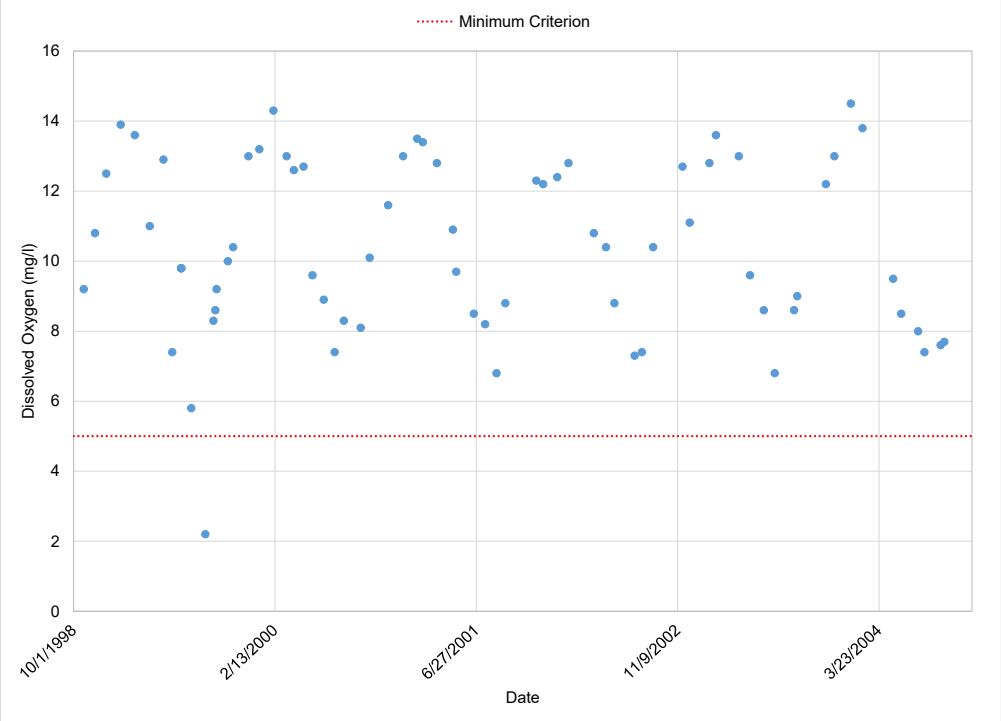

Figure 5.3-4. Dissolved Oxygen Percent Saturation Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004.

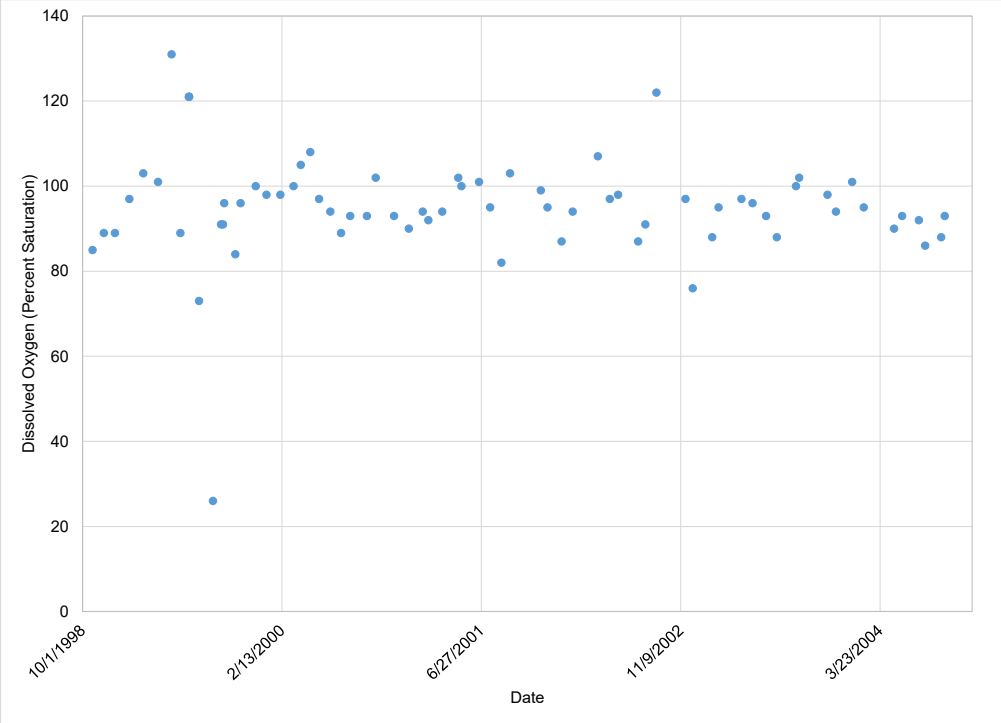

Figure 5.3-5. PH Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004.

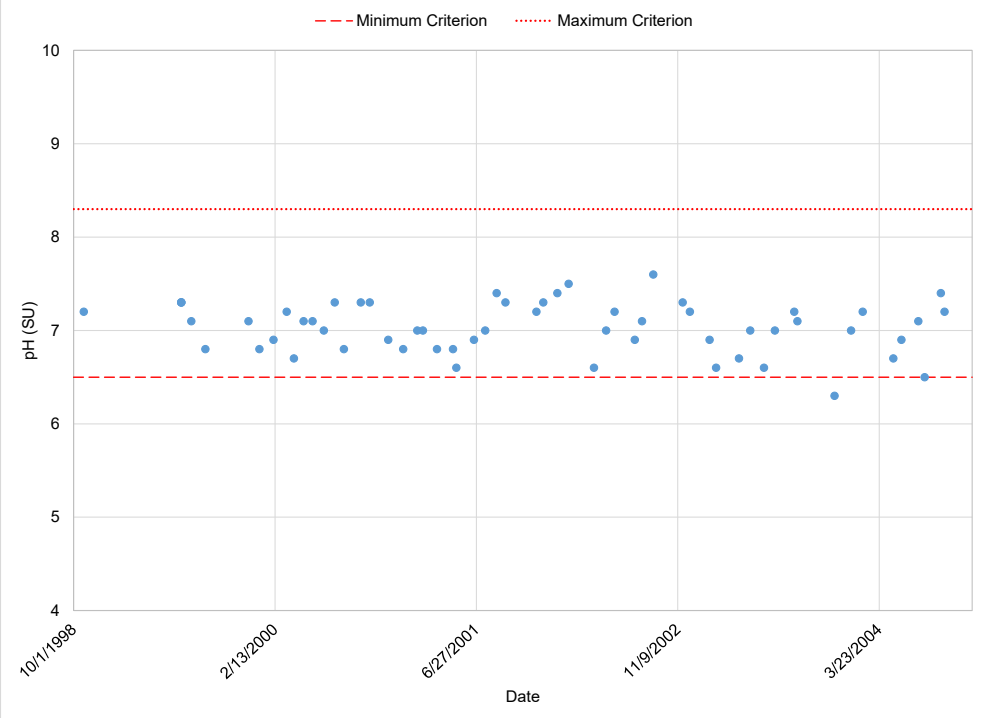

Figure 5.3-6. Specific Conductance Data Collected at USGS Gage 01100000 *Merrimack River BL Concord River at Lowell, MA* on the Merrimack River, 1998 – 2004.

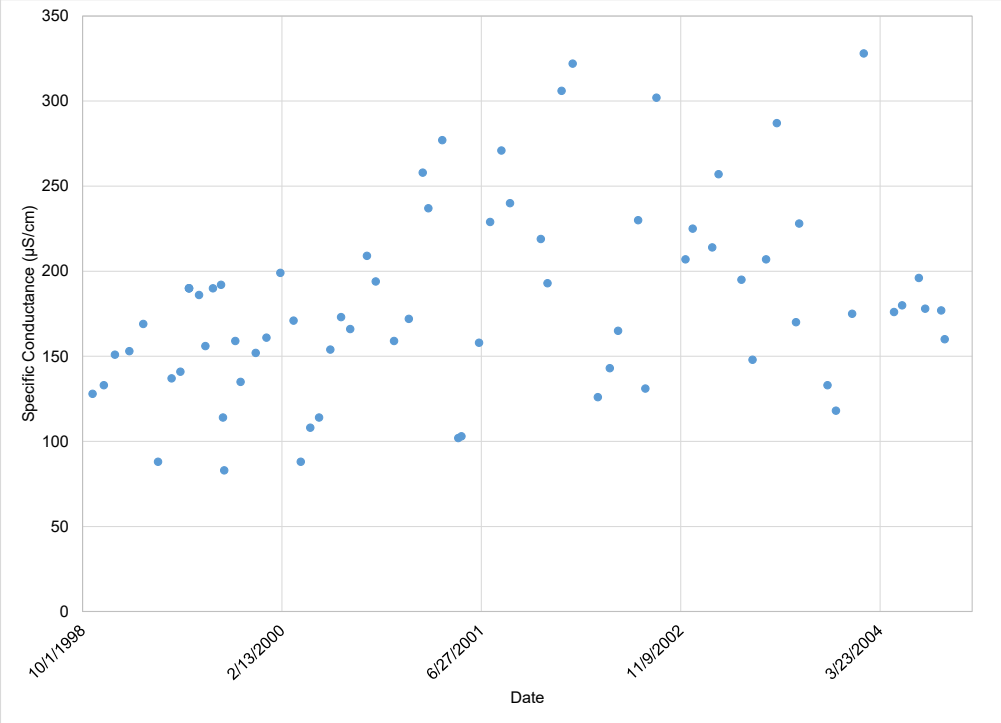

Table 5.3-5. Water quality data collected by a volunteer monitoring program established by the MRWC at 9 sites along the Merrimack River from Essex Dam to the Pawtucket Dam in Lowell, 2009.

River Mile	Description	Water Temperature (°C)						DO (mg/L)						pH (SU)						Specific Conductance (µS/cm)					
		14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug	14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug	14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug	14-May	30-May	11-Jun	23-Jul	1-Aug	13-Aug
29.6	Above Essex Dam	15.6	16.6	19.2	22.5	23.3	23.4	11.1	10.5	8.5	7.9	9.9	8.0	6.5	4.8	6.6	6.3	4.2	-	117	169	189	178	109	160
31.4	Methuen Water Intake	15.4	16.6	19.4	22.3	23.3	23.2	11.2	8.5	8.5	7.6	10.0	7.8	6.4	6.0	6.7	6.4	5.6	-	119	159	190	169	106	147
32.2	Bartlett Brook	15.4	16.5	19.3	22.4	23.3	23.1	11.6	8.2	8.5	7.6	10.0	7.8	6.4	6.1	6.6	6.4	4.6	-	118	157	194	169	103	144
33.4	Fish Brook	15.6	16.5	19.2	22.4	23.2	23.2	12.1	7.8	8.3	7.5	10.0	7.7	6.5	4.1	6.6	6.4	5.5	-	124	161	195	187	119	170
35.1	Gravel Pit	15.6	16.7	19.1	22.4	23.1	23	11.7	7.7	8.1	7.5	10.1	8.0	6.5	4.6	6.5	6.4	6.0	-	122	152	176	155	104	142
36.3	Trull Brook	15.4	16.9	19.2	22.5	23.0	23.2	11.6	7.8	8.7	7.9	10.2	7.9	6.4	4.3	6.7	6.4	6.0	-	111	170	211	177	99	166
37.9	Duck Island	15.4	16.8	19.2	22.4	-	23.1	11.7	7.6	8.6	7.7	-	7.9	6.2	5.8	6.6	6.3	-	6.5	106	135	176	151	-	133
38.9	Concord River	-	-	-	-	-	23.3	-	-	-	-	-	7.2	-	-	-	-	-	6.6	-	-	-	-	-	196
40.0	Oulette Bridge	-	-	-	-	-	23.2	-	-	-	-	-	7.7	-	-	-	-	-	6.5	-	-	-	-	-	122
Minimum		15.4	16.5	19.1	22.3	23	23	11.1	7.6	8.1	7.5	9.9	7.2	6.2	4.1	6.5	6.3	4.2	6.5	106	135	176	151	99	122
Maximum		15.6	16.9	19.4	22.5	23.3	23.4	12.1	10.5	8.7	7.9	10.2	8.0	6.5	6.1	6.7	6.4	6.0	6.6	124	170	211	187	119	196

Note: dash (-) indicates no data collected.

Table 5.3-6. Water quality data collected by a volunteer monitoring program established by the MRWC at 8 sites along the Merrimack River from Pawtucket Dam to the Massachusetts/New Hampshire border, 2009.

River Mile	Description	Water Temperature (°C)								DO (mg/L)								pH (SU)								Specific Conductance (µS/cm)							
		12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct	12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct	12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct	12-May	10-Jun	24-Jun	14-Jul	11-Aug	19-Aug	8-Sep	20-Oct
41.1	Pawtucket Dam	15.7	19.9	18.3	21.3	22.3	25.7	20.8	8.4	9.6	9.4	8.8	8.8	8.4	7.9	8.0	-	6.1	6.4	6.0	6.0	6.6	3.3	6.3	6.0	108	143	102	119	121	130	132	128
42.4	Rourke Bridge	15.6	19.8	-	21.4	22.3	-	20.5	8.1	9.4	8.4	-	8.8	8.4	-	8.0	-	6.2	6.4	-	6.1	6.7	-	6.3	5.9	104	145	-	118	120	-	132	121
43.4	Stony Brook	15.6	19.7	-	21.4	22.4	-	20.4	8.1	9.4	8.2	-	8.8	8.5	-	8.0	-	6.2	6.4	-	6.1	6.7	-	6.3	5.8	103	143	-	114	118	-	129	118
44.6	Vesper Country Club	15.5	19.7	-	21.4	22.4	-	20.2	8.2	9.3	8.0	-	8.8	8.3	-	8.0	-	6.2	6.5	-	6.2	6.6	-	6.3	5.9	103	141	-	114	119	-	127	120
46.4	Lawrence Brook	15.4	19.7	-	21.2	22.4	-	20.4	8.3	9.3	7.8	-	8.8	8.4	-	8.2	-	6.2	6.4	-	6.2	6.7	-	6.4	6.0	102	145	-	113	116	-	135	138
47.3	Tyngsborough (Rte. 113) bridge	15.3	19.6	-	21.2	22.4	-	20.5	8.3	9.3	7.8	-	8.8	8.3	-	8.2	11.9	6.2	6.4	-	6.2	6.7	-	6.4	5.9	100	144	-	113	116	-	133	131
48.9	Limit Brook	15.3	19.3	-	21.1	22.5	-	20.5	8.3	9.3	7.7	-	8.7	8.5	-	8.3	11.6	6.2	6.4	-	6.1	6.7	-	6.3	5.9	102	144	-	112	111	-	128	123
49.6	MA/NH border	15.3	19.2	18.2	21.1	22.4	-	20.4	8.3	9.4	7.7	9.8	8.8	8.3	-	8.0	11.6	6.3	6.4	6.0	6.0	6.8	-	6.3	5.9	99	142	99	114	114	-	129	129
	Minimum	15.3	19.2	18.2	21.1	22.3	25.7	20.2	8.1	9.3	7.7	8.8	8.7	8.3	7.9	8.0	11.6	6.1	6.4	6.0	6.0	6.6	3.3	6.3	5.8	99	141	99	112	111	130	127	118
	Maximum	15.7	19.9	18.3	21.4	22.5	25.7	20.8	8.4	9.6	9.4	9.8	8.8	8.5	7.9	8.3	11.9	6.3	6.5	6.0	6.2	6.8	3.3	6.4	6.0	108	145	102	119	121	130	135	138

Note: dash (-) indicates no data collected.

Table 5.3-7. Water quality data collected by a volunteer monitoring program established by the MRWC at 7 sites along the Merrimack River from Massachusetts/New Hampshire border to Greeley Park in Nashua, 2009.

River Mile	Description	Water temperature (°C)					DO (mg/L)					pH (SU)					Specific conductance (µS/cm)				
		12-May	13-Jul	11-Aug	8-Sep	20-Oct	12-May	13-Jul	11-Aug	8-Sep	20-Oct	12-May	13-Jul	11-Aug	8-Sep	20-Oct	12-May	13-Jul	11-Aug	8-Sep	20-Oct
49.9	**Pheasant Lane Mall**	-	21.0	22.4	20.3	8.3	-	8.3	8.4	8.0	11.3	-	6.3	6.7	6.4	5.9	-	117	121	132	127
50.9	**Spit Brook**	15.5	21.1	22.4	20.3	8.3	9.3	8.4	8.3	8.2	11.3	6.3	6.3	6.8	6.4	5.9	103	128	116	133	126
51.8	**Unnamed stream**	-	20.9	-	-	-	-	8.7	-	-	-	-	6.0	-	-	-	-	97	-	-	-
52.5	**Nashua Country Club**	-	20.9	-	-	-	-	8.6	-	-	-	-	6.3	-	-	-	-	139	-	-	-
53.1	**Nashua WWTP**	-	20.9	-	-	-	-	8.6	-	-	-	-	6.5	-	-	-	-	199	-	-	-
54.4	**Nashua River**	-	20.8	-	-	-	-	8.6	-	-	-	-	6.2	-	-	-	-	164	-	-	-
55.9	**Greeley Park**	-	21.2	-	-	-	-	8.9	-	-	-	-	6.2	-	-	-	-	96	-	-	-
	Minimum	15.5	20.8	22.4	20.3	8.3	9.3	8.3	8.3	8.0	11.3	6.3	6.0	6.7	6.4	5.9	103	96	116	132	126
	Maximum	15.5	21.2	22.4	20.3	8.3	9.3	8.9	8.4	8.2	11.3	6.3	6.5	6.8	6.4	5.9	103	199	121	133	127

Note: dash (-) indicates no data collected.

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Figure 5.3-7. Water Temperature STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015.

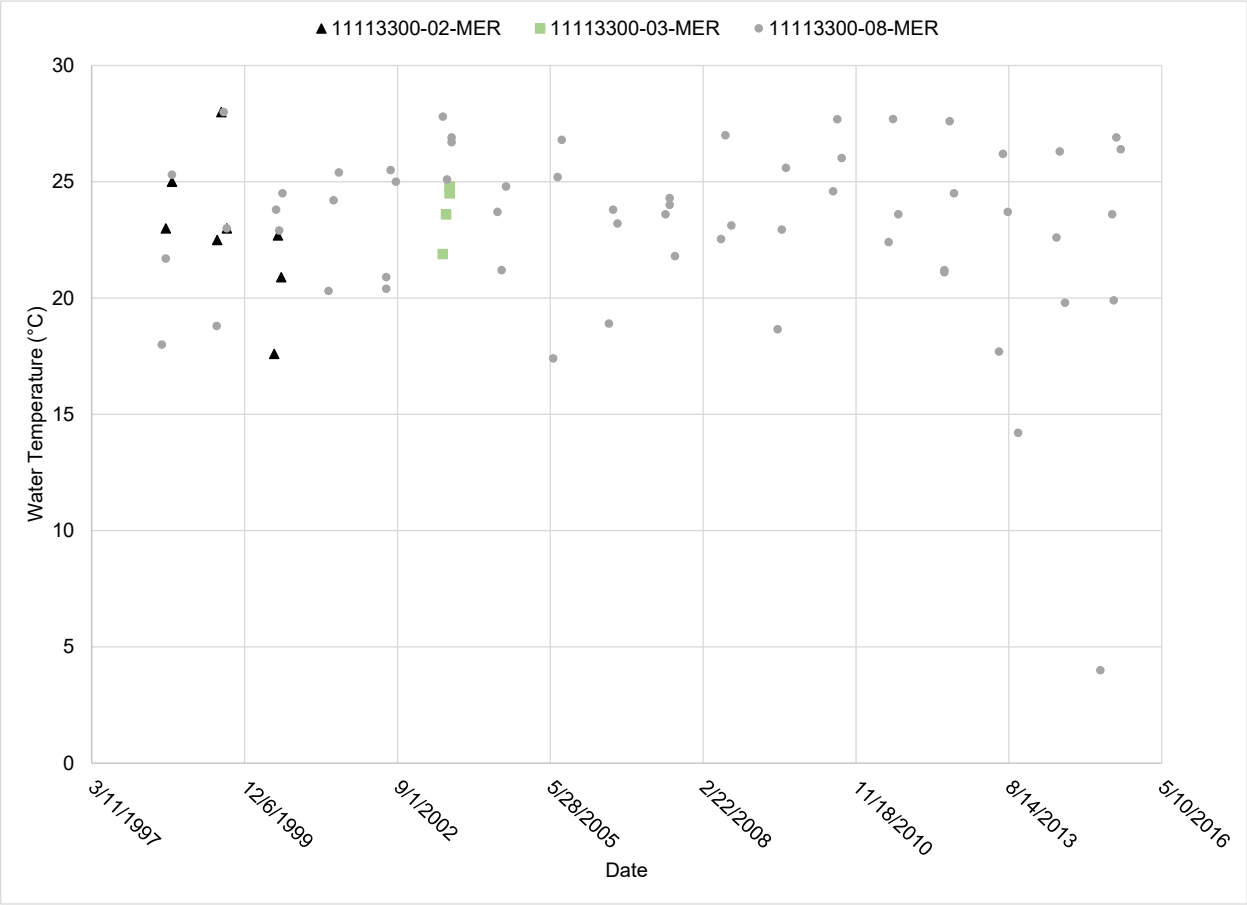


Figure 5.3-8. Dissolved Oxygen STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015.

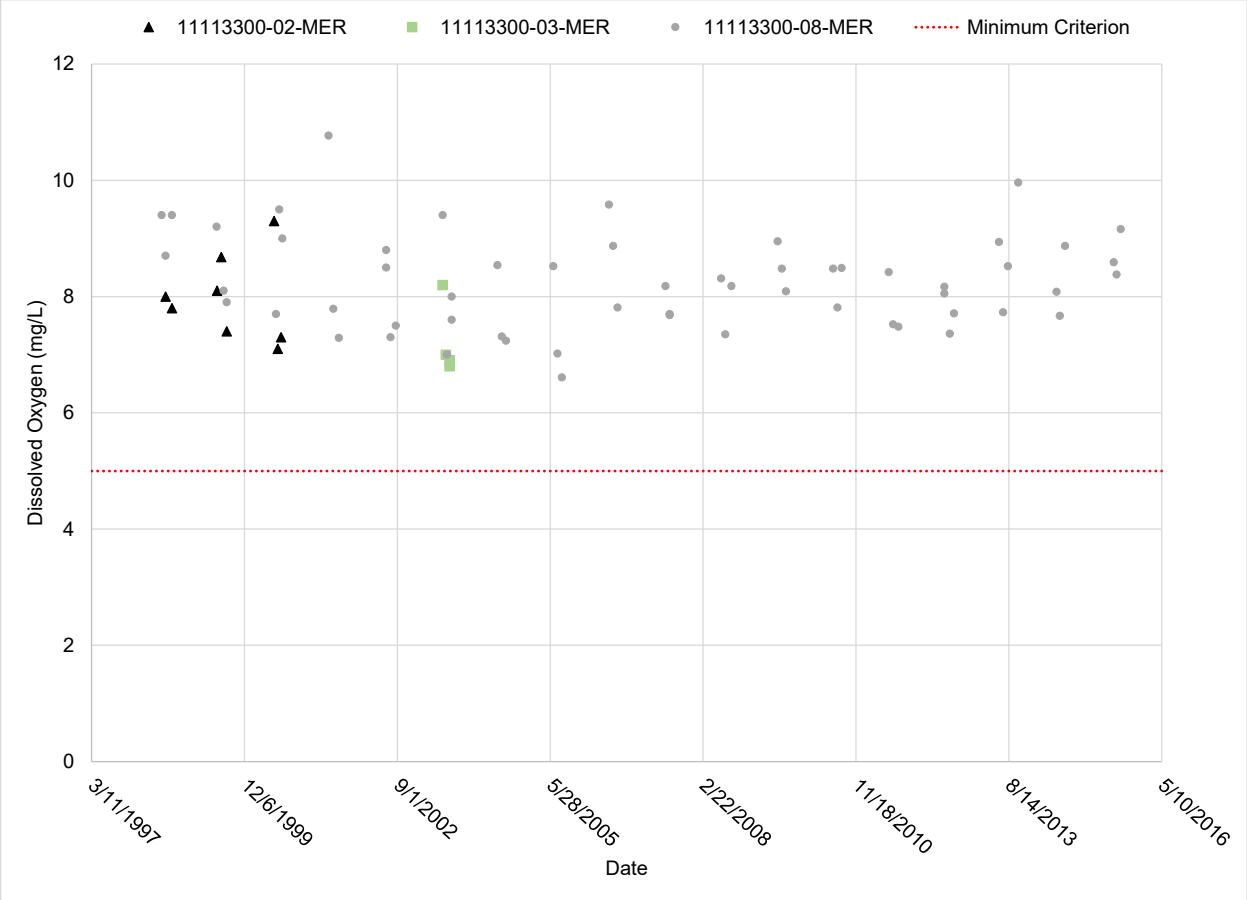


Figure 5.3-9. Dissolved Oxygen Percent Saturation STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015.

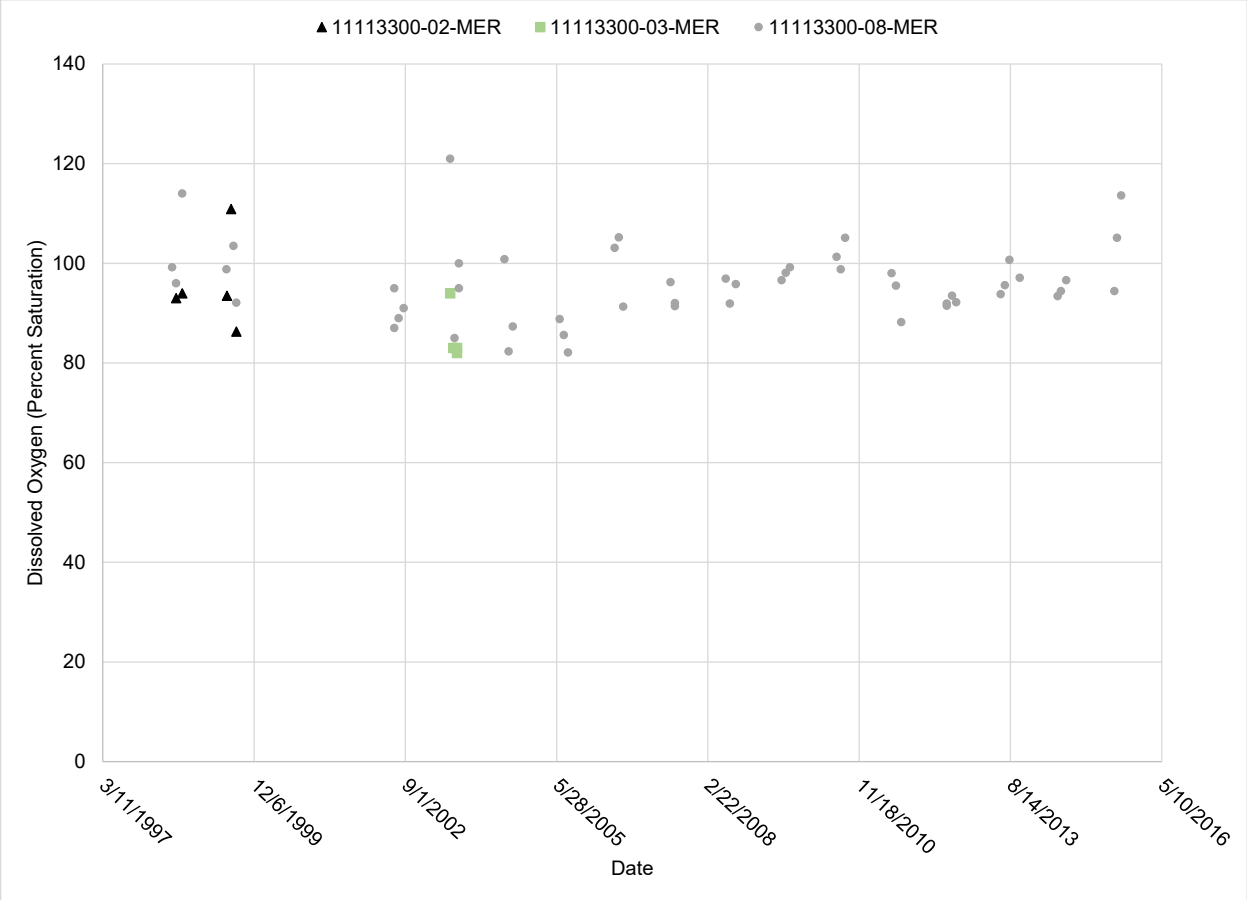


Figure 5.3-10. PH STORET Data Collected at three sites by the NHDES in the Merrimack River, 1998 – 2015.

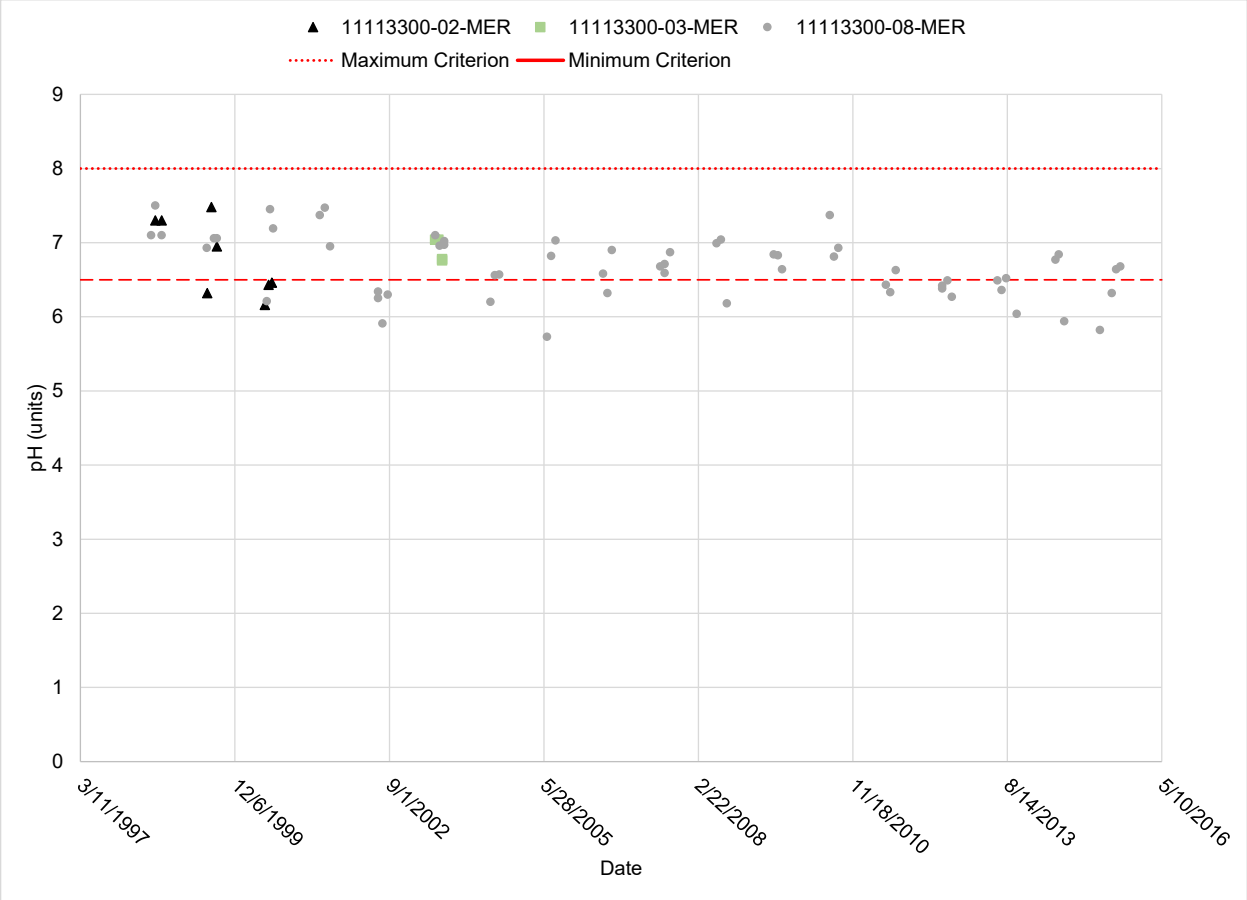
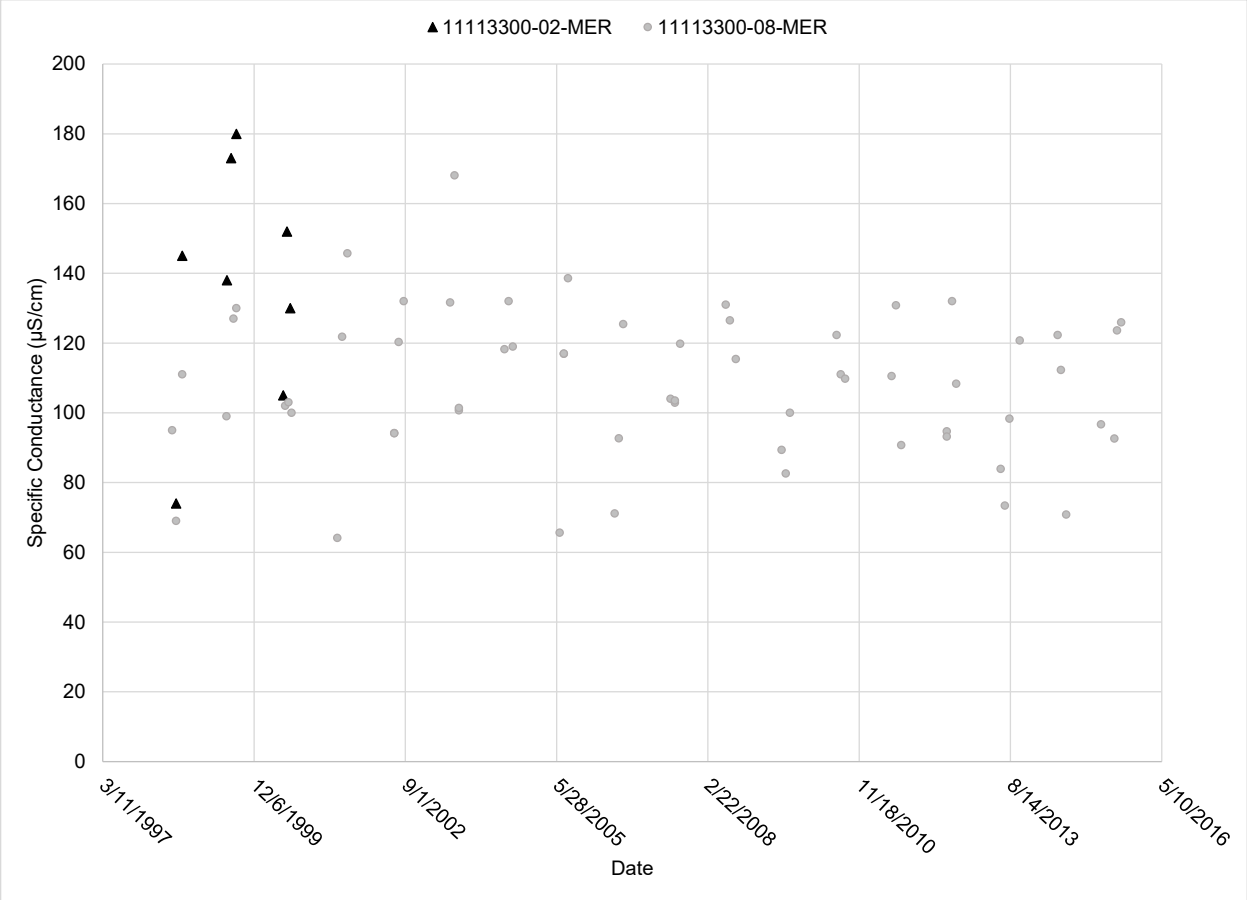


Figure 5.3-11. Specific Conductance STORET Data Collected at two sites by the NHDES in the Merrimack River, 1998 – 2015.



5.3.7.1 Use Impairment

An Integrated List of Waters (Integrated List) for Massachusetts and New Hampshire is submitted to the USEPA in fulfillment of reporting requirements under the CWA. Section 303(d) of the CWA requires states to identify those water bodies that are not expected to meet surface water quality standards after the implementation of technology-based controls and to prioritize and schedule them for the derivation of total maximum daily loads (TMDLs).

Massachusetts

The Integrated List in Massachusetts assigns waterbody segments to one of five categories, depending upon their status with respect to designated use support (Table 5.3-8). The Merrimack River is listed as Category 5 impaired waters in Massachusetts, which includes portions within the Project vicinity (Table 5.3-9) (MADEP 2015). Probable sources contributing to impairment for the reporting year 2014 included atmospheric deposition, CSOs from municipal discharges, impacts from hydrostructure flow regulation/modification, wet weather discharges from municipal discharges/sewage, municipal point source discharges of municipal discharges/sewage, and urban-related runoff/stormwater (USEPA 2018*b*, 2018*c*).

A draft Pathogen TMDL has been drafted for the Merrimack River Watershed (MADEP et al. undated). No other TMDLs were located for the Merrimack River Watershed (Commonwealth of Massachusetts 2018*b*).

Table 5.3-8. Description of Integrated Report Categories in Massachusetts.

Category	Description
1	Unimpaired and not threatened for all designated uses
2	Unimpaired for some uses and not assessed for others
3	Insufficient information to make assessments for any uses
4	Impaired or threatened for one or more uses, but not requiring the calculation of a TMDL
5	Impaired or threatened for one or more uses requiring a TMDL

Table 5.3-9. Impaired Water Segments within the Lowell Project vicinity (MADEP 2015, USEPA 2018*b*,*c*).

Name	Segment ID	Description	Length (miles)	Designated Use(s) (Group[s]) Impaired	Impairment Cause
Merrimack River	MA84A-01	State line at Hudson, NH/Tyngsborough, MA to Pawtucket Dam, Lowell	9	Fish Consumption (Aquatic Life Harvesting), Primary Contact Recreation (Recreation)	Fecal coliform, mercury in fish tissue
Merrimack River	MA84A-02	Pawtucket Dam, Lowell to Lowell Regional Wastewater Utilities outfall at Duck Island, Lowell	3.2	Fish Consumption (Aquatic Life Harvesting), Fish, Other Aquatic Life and Wildlife (Fish, Shellfish, and Wildlife Protection and Propagation), Primary Contact Recreation (Recreation)	Low flow alterations*, *Escherichia coli*, mercury in fish tissue, total phosphorus

*TMDL not required (non-pollutant).

New Hampshire

The Section 305(b) and 303(d) consolidated list in New Hampshire assigns waterbody segments to various categories (Table 5.3-10). Portions of the Merrimack River in New Hampshire are identified as Category 5 waters and are included in the 2016 303(d) list (Table 5.3-11) (NHDES 2016*b*). Sources of impairment in these sections are unknown.

Table 5.3-10. Description of Integrated Report Categories in New Hampshire.

Category	Description
1	Attaining all designated uses and no use is threatened.
2	Attaining some of the designated uses; no use is threatened; and insufficient or no data and information is available to determine if the remaining uses are attained or threated (i.e., more data is needed to assess some of the uses).
3	Insufficient or no data and information are available to determine if any designated use is attained, impaired, or threatened (i.e., more monitoring is needed to assess any use).
4	Impaired or threatened for one or more designated uses but does not require development of a TMDL because:
4A	A TMDL has been completed, or
4B	Other pollution control requirements are reasonably expected to result in attainment of the water quality standard in the near future, or
4C	The impairment is not caused by a pollutant.
5	Impaired or threatened for one or more designated uses by a pollutant(s), and requires a TMDL, which is the 303(d) list.

Table 5.3-11. Impaired Water Segments within Project vicinity in New Hampshire (NHDES 2016*b*).

Assessment Unit ID	Water Name	Primary Town	Water Size (miles)	Use Description	Impairment Name	DES Category	TMDL Priority	Source Name
NHRIV700061206-24	Merrimack River	Nashua	5.2	Aquatic Life	Aluminum	5-M	Low	Unknown
					pH	5-M	Low	Unknown
				Primary Contact Recreation	Chlorophyll-a	5-M	Low	Unknown
NHRIV700061002-14	Merrimack River	Nashua	3.7	Aquatic Life	pH	5-M	Low	Unknown
				Primary Contact Recreation	Creosote	5-M	Low	Contaminated Groundwater
								RCRA Hazardous Waste Sites

5.3.8 Downstream Reach Gradients

The gradient of the Merrimack River from the Pawtucket Dam to just downstream of USGS Gage No. 01100000 *right Bank at Lowell, 1,100 feet downstream from the Concord River* is approximately 13 feet per mile.

5.4 Fish and Aquatic Resources (18 CFR § 5.6(d)(3)(iv))

5.4.1 Overview

The Merrimack River is home to a diverse assemblage of fishes, including from cold water and warm water species. During the last 150 years, over 15 non-indigenous species such as largemouth bass (*Micropterus salmoides*), smallmouth bass (*M. dolomieu*), walleye (*Sander vitreus*), common carp (*Cyprinus carpio*), rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), various catfish species (*Ictalurus* spp.) and goldfish (*Carassius auratus*) have successfully established themselves through human introduction within the Merrimack River. The Merrimack River basin is home to approximately 50 species of fish; nine of which are anadromous (Stolte 1982 as cited in Technical Committee for Anadromous Fishery Management of the Merrimack River Basin [Technical Committee] 1997). The slower-moving, ponded reaches within the basin contain the majority of the warm water species, while those areas having steeper gradients contain the majority of the cold water species (Technical Committee 1997).

Aquatic habitat found in the Project vicinity consists of habitat types typical of most northeastern large rivers, which support a variety of cool and warm water species. Shallow water, littoral, and riparian habitat types exist along the shoreline of the Project's impoundment, as well as along the several islands scattered in the Project's impoundment. At low river flows, the habitat in the Project's bypass reach is generally broad, relatively shallow, and rocky with numerous areas of exposed bedrock.

Historically, the Merrimack River served as a major resource for fisheries. However, the increase in industrial and urban pollution and construction of numerous dams along its length during the past two hundred years resulted in lowering the value of the river as an important aquatic habitat. The most affected fish populations have been the sensitive migrating species: anadromous fish that live in salt water and spawn in fresh water, and catadromous species that inhabit the river and spawn in the ocean. The changes in water quality of the Merrimack River combined with impoundments created by dams has increased the warm water fisheries habitat and resulted in the demise or severe reductions of migratory fish species (Massachusetts Department of Transportation Federal Highway Administration [FHA] and The Commonwealth of Massachusetts Department of Public Works [MDPW] 1985).

In more recent years, the quality of the Merrimack River has improved, and today there is a concerted effort on the part of state and federal fish and wildlife agencies to restore anadromous fish populations in the Merrimack River. These restoration efforts have included stocking the headwaters of the river with adult American shad (*Alosa sapidissima*) and juvenile Atlantic salmon (*Salmo salar*), and building fish ladders at dams to allow fish access to the upper reaches of the Merrimack River. Other anadromous fish that are returning to the Merrimack River include the alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and sea lamprey (*Petromyzon marinus*). According to the FHA and MDPW (1985), the only catadromous species in the Lowell portion of the Merrimack River is the American eel (*Anguilla rostrata*).

In 1969 the State of New Hampshire, the Commonwealth of Massachusetts, USFWS, and the National Marine Fisheries Service (NMFS) combined their efforts and formed Policy and Technical Committees for the Anadromous Fishery Management of the

Merrimack River. Largely through the efforts of these committees, much progress has recently been made (Boott Mills 1980).

The Technical Committee was formed to address the restoration of anadromous fish in the Merrimack River watershed and includes representatives from the following government organizations: New Hampshire Department of Fish and Game (NHDFG), Massachusetts Division of Fish and Wildlife (MADFW), MADMF, USFWS, United States Forest Service (USFS), and NMFS (Technical Committee 2010). The Technical Committee coordinates restoration activities such as installation, evaluation, operation, and maintenance of fish passage and capture facilities at hydroelectric facilities along the Merrimack River. Boott collaborates with the Technical Committee under an adaptive management framework regarding all activities related to managing the fishery resources impacted by the Lowell Project.

Efforts to restore Atlantic salmon were abandoned in 2013 for the Merrimack River after consistently low return numbers were observed. Efforts shifted towards the restoration of the remaining migratory fish species, notably river herring and shad (Cleantech 2017). American shad and striped bass (*Morone saxitilis*) are marine species regulated as inland recreational fisheries managed jointly by the representative agencies that form the Technical Committee.

The Technical Committee oversees the management of the Lowell Project fisheries as directed by the Project's Comprehensive Fish Passage Plan (CFPP) which was filed pursuant to articles 35 and 36 of the Project's existing license and approved by FERC in November 2000. The CFPP includes details of operational measures undertaken by Boott to protect upstream and downstream migrating anadromous fish. Upstream and downstream fish passage facilities at the Project include a fish lift and downstream fish bypass at the E.L. Field Powerhouse and a vertical-slot fish ladder at the Pawtucket Dam. The fish passage facilities at the Project were designed in consultation with the USFWS and current fish passage operations are supervised by both state and federal fishery agencies per the CFPP.

In accordance with the CFPP, Boott is required to begin operating the fish passage facilities at the Lowell Project when a cumulative total of 50 American shad or 200 river herring are passed at the downstream Lawrence Hydroelectric Project. Termination of upstream fish passage operations at the end of the upstream passage season is determined each year in consultation with the Technical Committee, and typically occurs in early to mid-July. Additionally, in accordance with the CFPP, Boott is required to operate the downstream bypass facility from April 1 through July 15 and from September 1 through November 15 (Cleantech 2017). Under the CFPP, Boott is required to provide annual post-season updates to the Technical Committee. Fish are capable of bypassing the Project's entire canal system via the Merrimack River and use the existing upstream and downstream fish passage facilities at the Pawtucket Dam and E.L. Field Powerhouse. There are no exclusionary measures at the entrance of the Project's canal system. However, in the CFPP, Boott included an operational protocol to pass additional flows through the canal system in the rare instance where the Northern Canal needs to be dewatered to conduct repairs or maintenance on the main powerhouse during downstream fish passage season (Cleantech 2017). This provision has been implemented only once during the term of the license, to facilitate repairs to the Northern Canal wall in 1996.

As currently provided in the CFPP, the fish lift historically has been the primary route of upstream passage at the project, whereas the ladder has typically been operated only during periods of higher flow when spillage at the dam may attract upstream migrants toward the bypass reach. In recent years, Boott and the Technical Committee have tested the success of passage through the ladder under normal, non-spill conditions with very favorable results. Beginning in 2018 Boott has agreed to operate both the lift and the ladder throughout the fish passage season, in exchange for agency support of Low Impact Hydropower Institute (LIHI) certification of the project.

As a component of the CFPP, Boott collects information regarding the abundance of diadromous fishes using the upstream fishways annually. This activity is a joint monitoring effort to inform the Technical Committee that manages these fishery resources. MADFW and Boott staff work cooperatively to record diadromous fish counts at the E. L. Field Powerhouse fish lift throughout the upstream migration season. Beginning in 2017, fish count records also were kept at the Pawtucket Dam fish ladder. Boott provides a summary of these counts as part of its annual fishway operations report to the Technical Committee.

The CFPP is based on several fisheries studies conducted at the Project (see Section 5.4.5) and experience gained at the Project since the installation of the Project's fish lift and fish bypass facilities. The CFPP was developed in consultation with the resource agencies, and many of the agencies' recommendations have been incorporated into the CFPP. Currently, Boott is coordinating with the USFWS and University of Massachusetts, Amherst, in upstream and downstream American eel (*Anguilla rostrata*) passage studies at the Project. Since 2013 Boott has actively worked with USFWS to assess and improve upstream eel passage at the Pawtucket Dam. In 2016, Boott purchased new radio telemetry equipment to assist the USFWS monitoring at three sites to assess the downstream movement of radio tagged adult eels released at the Merrimack River Project upstream (Cleantech 2017). In 2017 Boott deployed telemetry equipment at six locations at the Lowell Project and two locations at the Lawrence Project to again track the movement of radio-tagged eels released at the Merrimack River Project through the Lowell Project facilities.

5.4.2 Existing Fish and Aquatic Resources

Common freshwater game species currently found in the in the Lower Merrimack River include yellow perch (*Perca flavescens*), chain pickerel (*Esox niger*), northern pike (*E. lucius*), brown bullhead (*Ameiurus nebulosus*), smallmouth and largemouth bass, walleye, common carp and Centrarchid sunfishes (Lower Merrimack River Local Advisory Committee [LMRLAC] 2008). There are 43 fish species potentially residing in the Lowell Project reach of the Merrimack River (Table 5.4-1) (Hartel et al. 2002; Technical Committee 1997). The fisheries and aquatic resources of the Merrimack River in the vicinity of Lowell Project are managed jointly by MADFW, NHDFG, and the USFWS. These agencies jointly manage the Merrimack River, including the Lowell Project, as a warm water recreational fishery, as well as for conservation of diadromous species. Alewife, American eel, American shad, sea lamprey, and striped bass are currently managed diadromous species that are found at the Lowell Project during certain life stages.

Table 5.4-1. List of Fish Species in the Vicinity of the Lowell Project.

Common Name	Scientific Name
Alewife	*Alosa pseudoharengus*
American eel	*Anguilla rostrata*
American shad	*Alosa sapidissima*
Atlantic salmon	*Salmo salar*
Banded killifish	*Fundulus diaphanus*
Banded sunfish	*Enneacanthus obesus*
Black crappie	*Pomoxis nigromaculatus*
Blacknose dace	*Rhinichthys atratulus*
Blueback herring	*Alosa* aestivalis
Bluegill	*Lepomis macrochirus*
Bridle shiner	*Notropis bifrenatus*
Brook trout	*Salvelinus fontinalis*
Brown bullhead	*Ameiurus nebulosus*
Brown trout	*Salmo trutta*
Chain pickerel	*Esox niger*
Common carp	*Cyprinus carpio*
Common shiner	*Luxilus cornutus*
Creek chubsucker	*Erimyson oblongus*
Fallfish	*Semotilus corporalis*
Gizzard shad	*Dorosoma cepedianum*
Golden shiner	*Notemigonus crysoleucas*
Goldfish	*Carassius auratus*
Largemouth bass	*Micropteris salmoides*
Longnose dace	*Rhinichthys cataractae*
Margined madtom	*Notorus insignis*
Northern pike	*Esox lucius*
Pumpkinseed	*Lepomis gibbosus*
Redbreast sunfish	*Lepomis auritus*

Common Name	Scientific Name
Redfin pickerel	*Esox americanus*
Rock bass	*Ambloplites rupestris*
Sea lamprey	*Petromyzon marinus*
Slimy sculpin	*Cottus cognatus*
Smallmouth bass	*Micropterus dolomieu*
Spottail shiner	*Notropis hudsonius*
Striped bass	*Morone saxatilis*
Swamp darter	*Etheostoma fusiforme*
Tessellated darter	*Etheostoma olmstedi*
Walleye	*Sander vitreus*
White catfish	*Ameiurus catus*
White perch	*Morone americana*
White sucker	*Catostomus commersoni*
Yellow bullhead	*Ameiurus natalis*
Yellow perch	*Perca flavescens*

Sources: Hartel et al. 2002; Technical Committee 1997.

5.4.3 Essential Fish Habitat

Based on a review of the NMFS online database, the Lowell Project reach of the Merrimack River is designated essential fish habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act for Atlantic salmon (National Oceanic and Atmospheric Administration [NOAA] undated). Essential fish habitat was defined as “all waters currently or historically accessible to Atlantic salmon within the streams, rivers, lakes, ponds, wetlands, and other water bodies of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut” (New England Fishery Management Council [NEFMC] 1998).

5.4.4 Temporal and Spatial Distribution of Fish Communities

The priority species for management at the Lowell Project are the catadromous American eel and three anadromous Alosidae species, American shad, blueback herring, and alewife. Juvenile and adult American eel upstream and downstream migration periods overlap. Juveniles ascend beginning in May and continue through October. The adult outmigration period begins in late summer and lasts through November. The peak outmigration period is October through mid-November.

Adult American shad and river herring ascend the Merrimack River from May through early July. The peak period is highly dependent on water temperature and total river discharge. The juvenile outmigration period is in the fall (September through November) and is also highly dependent on ambient water temperature and river discharge conditions.

5.4.4.1 Abundance (Standing Crop)

As discussed above, the CFPP details the facilities and operational measures that are implemented by Boott to provide protection to upstream and downstream migrating anadromous fish (FERC 2000). As a component of the CFPP, Boott collects information regarding the abundance of diadromous fishes using the upstream fishways annually. This activity is a joint monitoring effort to inform the Technical Committee that manages these fishery resources. MADFW and Boott staff work cooperatively to record diadromous fish counts at the E. L. Field Powerhouse fish lift throughout the upstream migration season. Beginning in 2017, fish count records also were kept at the Pawtucket Dam fish ladder. Boott provides a summary of these counts as part of its annual fishway operations report to the Technical Committee. The diadromous fish counts for river herring, (blueback herring and alewife), American shad, Atlantic salmon, striped bass, sea lamprey, and American eel from the Lowell and Lawrence fish lifts since 1983 are presented in Table 5.4-2. In addition, the Pawtucket Dam fish ladder counts from 2017 are 2,080 for river herring and 1,387 for American shad (K. Webb, EGP North America, personal communication, March 19, 2018). In addition, the Pawtucket Dam fish ladder counts from 2016 are 145,256 for river herring and 5,922 for American shad; and for 2017, the counts are 2,080 for river herring and 1,387 for American shad (K. Webb, EGP North America, personal communication, March 19, 2018).

Table 5.4-2. Lowell and Lawrence Diadromous Fish Passage Counts Since 1983.

Year	River Herring[1] (Lawrence)	River Herring[1] (Lowell)[2]	American Shad (Lawrence)	American Shad (Lowell)[2]	Atlantic Salmon (Lawrence)	American Eel (Lowell)	American Eel (Lawrence)
1983	4,794		5,629		114		
1984	1,769		5,497		115		
1985	23,112		12,793		213		
1986	16,265		18,173	1,630	103		
1987	77,209		16,909	3,926	139		
1988	361,012	56,739	12,359	1,289	65		
1989	387,973	137,296	7,875	940	84		
1990	254,242	9,888[3]	6,013	443	248		
1991	379,588	6,920[3]	16,098	428	332		
1992	102,166	32,501	20,796	6,491	199		
1993	14,027	4,315	8,599	1,679	61		
1994	88,913	33,735	4,349	383	21		
1995	33,425	11,848	13,861	5,255	34		
1996	51	51	11,322	400	76		

Year	River Herring[1] (Lawrence)	River Herring[1] (Lowell)[2]	American Shad (Lawrence)	American Shad (Lowell)[2]	Atlantic Salmon (Lawrence)	American Eel (Lowell)	American Eel (Lawrence)
1997	403	403	22,661	4,446	71		
1998	1,362	13	27,891	4,159	123		
1999	7,898	2,930	56,461	16,347	185		
2000	19,405	673	72,800	12,716	82		
2001	1,550	58	76,717	7,740	83		
2002	526		54,586	5,283	56		
2003	10,866	194	55,620	6,580	147		
2004	15,051	7,448	36,593	11,028	129		
2005	99	201	6,382	716	34		
2006	1,257	27	1,205		91		
2007	1,169		15,876	1,653	74		
2008	108		25,116	4,050	119		
2009	1,456	139	23,199	2,267	81		
2010	518	43	10,442	490	85		
2011	740	228	13,835	831	402		
2012	8,992	1,809	21,396	1,728	137		6,969
2013	17,359	13,490	37,149	9,756	22		915
2014	57,213	23,610	38,107	3,357	75	166	1,788
2015	128,692	31,323	89,467	20,937	13	2,647	8,124
2016	417,240	287,343	67,528	11,439	6	328	1,981
2017	91,616	5,656	62,846	5,086	5	1,981	177,738
TOTAL	**2,528,066**	**820,159**	**976,150**	**153,473**	**3,824**	**5,122**	**197,515**

5.4.5 Spawning Run Timing and Extent and Location of Spawning, Rearing, Feeding, and Wintering Habitats

Four diadromous species, American eel, American shad, blueback herring, and alewife are of primary concern for conservation purposes in the Lowell Project vicinity of the Merrimack River. American eel are the single catadromous species. Atlantic salmon are not currently an anadromous species of management concern as large-scale restoration efforts in the Merrimack River basin have ceased. Although not a species of concern, records for an additional anadromous species, sea lamprey, are currently being kept to track its status (see Table 5.4-2). Additionally, there is one resident freshwater species of management concern, bridle shiner (*Notropis bifrenatus*). In Massachusetts the bridle shiner is considered a species of special concern (Commonwealth of Massachusetts 2018*c*), and in New Hampshire the species is listed as state threatened (NHDFG 2017).

5.4.5.1 Atlantic salmon (*Salmo salar*)

Atlantic salmon is a highly migratory, anadromous fish species which were indigenous to suitable riverine habitat from northeastern Labrador south to the Housatonic River which empties into Long Island Sound (Kocik and Friedland 2002). Numerous reviews detailing the life history of Atlantic salmon exist (Kocik and Friedland 2002; Fay et al. 2006; NMFS 2009). Adult Atlantic salmon begin to return to natal freshwater rivers during the spring and continue into October, often producing a spring and a fall run. The majority of fish returning to rivers in New England have been at sea for two years. A lesser component of the run comprises fish having been at sea for one or three years as well as repeat spawners. Fecundity varies with age with a one-sea-winter fish producing an average of 3,040 eggs, a two-sea-winter fish producing an average of 7,560 eggs, a three-sea-winter fish producing an average of 10,200 eggs, and a repeat spawner producing an average of 11,350 eggs (Baum 1997). Redds are constructed by female salmon and eggs are deposited and immediately fertilized by male salmon during the late fall, generally in riffle habitat with coarse gravel substrate. Following the fall spawn, approximately 20 percent of spent adult salmon (called kelts) move back downstream and into the ocean but the majority move back downstream and into the ocean the following spring (Baum 1997).

Juveniles remain in freshwater for 2 to 3 years. Upon reaching 5 to 9 inches in length, they outmigrate to the ocean as smolts during spring. They grow in the ocean for one to two years before returning to their natal streams to spawn during spring. Atlantic salmon were historically abundant in the Merrimack River. Their decline occurred primarily due to overfishing and the loss of habitat due to dams, human development, sedimentation, and pollution. Attempts to restore Atlantic salmon have been unsuccessful to date and are currently discontinued (Hartel et al. 2002).

Atlantic salmon are not currently listed as a threatened or endangered species by the NHDFG and MADFW (NHDFG 2017; Commonwealth of Massachusetts 2018*c*).

5.4.5.2 Sea lamprey (*Petromyzon marinus*)

Sea lamprey are an elongate, eel-like anadromous species found along the Atlantic coast from Labrador to Florida (Smith 1985; Flescher and Martini 2002). Adult sea lamprey reach an average length of 28 inches (72 centimeters [cm]) at the start of spawning with a maximum recorded length of 35 inches (90 cm) (Flescher and Martini 2002).

While at sea, adult sea lamprey parasitize a range of fish species by attaching to them with 11-12 rows of horny, hooked teeth located in an oral hood. Sea lampreys typically attach to the side of their prey and rasp at the flesh until they can feed on blood. Adult sea lampreys return to coastal streams during the spring. Sea lampreys seek out river or stream reaches that contain gravel substrate and swift current velocities, and eggs are deposited in a shallow nest depression constructed on the bottom. The majority of spawning adults are eight years of age (Beamish and Medland 1988) and an average female contains 200,000 eggs. Deposited eggs develop over a 10-13 day period after which the larvae (called an ammocoete) develops gill clefts, an oral hood, and body pigmentation (Flescher and Martini 2002). Ammocoetes travel downstream to low velocity areas with muddy or sand bottom where they construct a shallow burrow.

Ammocoetes are filter feeders and diatoms comprise the majority of their diet. The larval period generally lasts for five years (Beamish and Medland 1988) after which the ammocoetes transform into juveniles over a 4 to 6 month period. During the transformation, eyes and related musculature, oral hood and teeth, salivary glands, new kidneys, and pigmentation develop (Flescher and Martini 2002). Juvenile lamprey move away from the river bottom and downstream where they are capable of entering seawater and adopting a parasitic life style (Flescher and Martini 2002; Hartel et al. 2002).

The sea lamprey is not currently listed as a threatened or endangered species by USFWS, NHDFG, or MADFW.

5.4.5.3 Bridle shiner (*Notropis bifrenatus*)

Bridle shiner is a small freshwater minnow species occurring in the Atlantic drainage of the eastern United States from southern Maine to Virginia and west to New York State (Scott and Crossman 1979). Bridle shiners prefer clear water in the low current sections of streams and rivers. They often associate with moderate levels of submerged aquatic vegetation and bottom substrates of silt and/or sand. Spawning takes place from late-May through July in water depths of 2-3 feet and areas surrounded by dense vegetation. Their eggs adhere to aquatic vegetation and young-of-year rear among aquatic vegetation beds. They are a forage fish and are preyed upon by pickerel, bass, and yellow perch.

In Massachusetts the bridle shiner is considered a species of special concern (Commonwealth of Massachusetts 2018*c*), and in New Hampshire the species is listed as state threatened (NHDFG 2017).

5.4.5.4 American Eel *(Anguilla rostrata)*

The American eel is a catadromous fish species, spending the majority of its life cycle in freshwater and returning to the sea for the purposes of spawning. Various developmental stages of the species occur in freshwater, coastal waters, and the open ocean as far north as Labrador and Greenland along the North American east coast to as far south as the Gulf of Mexico and northern South America (Facey and Van Den Avyle 1987).

American eel can be found from brackish ocean shore habitats to the upper reaches of headwater streams. They prefer moderate-to-slow currents, but do well along gravelly and muddy bottoms in lakes and reservoirs. American eel are prolific carnivores and generally feed during the night or low-light hours on aquatic invertebrates, crustaceans, and small fish.

Juvenile American eels ascend freshwater rivers from estuarine and brackish early rearing habitats during the elver life stage. Subsequent yellow life stages occur as they feed and grow in freshwater habitats. Adult American eels reach sexual maturity at about 5 to 20 years (Werner 1980). Although most of the life cycle of the American eel is now understood, their spawning location and the behaviors leading up to spawning from their exodus from freshwater and brackish habitats still remains mostly a mystery. They are thought to spawn in the Sargasso Sea.

The American eel is not currently listed as a threatened or endangered species by USFWS, NHDFG or MADFW.

5.4.5.5 Striped bass (*Morone saxatilis*)

Striped bass are large predatory fish that are a popular gamefish. The adults migrate to freshwater to feed in the spring. Striped bass use the lifts at the Lawrence Hydroelectric Project to move upstream to the Lowell Project. It is unlikely that striped bass moved upstream of Lawrence prior to the lift operations. Striped bass can spend considerable time in freshwater, potentially their entire lifecycle. The availability of forage is what determines their presence in length of time spent in freshwater. They generally feed heavily on river herring and American shad which they follow inland during their spring migration. They also feed heavily on American eel.

Striped bass is not currently listed as a threatened or endangered species by USFWS, NHDFG or MADFW.

5.4.5.6 Alosine Clupeids

River Herring

River Herring is a collective term used to describe both anadromous alewives and blueback herring. In Massachusetts, more than 100 coastal rivers and streams are home to the anadromous alewife (*Alosa pseudoharengus*) and blueback herring (*A. aestivalis*). These fishes are ecologically important because they are forage for many marine and freshwater fish predators such as striped bass, cod (*Gadus morhua*), and yellow perch as well as birds. In addition, they are a key link in the transfer of nutrients from freshwater to marine systems and vice versa. River herring provide recreational and cultural benefits to citizens who value them for food and bait. In recent years, river herring abundance in several runs throughout Massachusetts have declined to historical low levels. The declines prompted the MADMF in 2005 to establish a three-year moratorium on the sale and harvest of river herring throughout the commonwealth (MADMF 2011). The blueback herring is similar in appearance to alewife and are difficult to differentiate from alewife. Adult blueback herring are 10 to 12 inches in length and reach sexual maturity between 2 to 4 years. Juveniles are less than 3 inches long while in freshwater. Adult blueback herring ascend rivers to spawn in swift-flowing sections with gravel and rocky bottoms in the spring. Alewife spawn in sluggish backwaters of rivers and ponds. Young-of-year river herring juveniles outmigrate in the fall (MADMF 2011).

River herring are not listed as threatened or endangered species by USFWS, MADFW, or the NHDFG. However, according to MADMF (2011), the NMFS has listed blueback herring and alewife as species of concern and recreational harvest of river herring is prohibited.

American Shad (Alosa sapidissima)

American shad is the largest member of the herring family in Massachusetts. American shad spawn in Atlantic coastal rivers from Florida to Eastern Canada. There is a significant difference in size between the sexes, with males usually weighing between 1 and 3 pounds, while the females grow larger and can reach over 8 pounds. Shad may produce up to 600,000 eggs, which are fertilized by the smaller males over a period of days. Spawning takes place over sandy gravel substrate with moderate current. Juvenile shad hatch in about one week and feed on zooplankton in the river until the late summer

or fall, when they migrate downstream to the ocean. In northern rivers, shad will spawn multiple years after about five years at sea. Adult American shad that leave rivers after spawning will follow the younger, non-spawning shad on a counterclockwise loop through the Bay of Fundy and back into the Gulf of Maine. By the end of the summer, shad make their way to wintering areas in relatively close proximity to their home rivers (NHDFG undated*a*).

American shad are not listed as threatened or endangered species by USFWS, MADFW, or NHDFG. The Merrimack River is only one of two rivers in Massachusetts where recreational harvest is allowed (Commonwealth of Massachusetts 2018*c*).

5.4.6 Other Site-Specific Fisheries Information

Multiple studies have been conducted at the Lowell Project to assess the movement behavior, passage route use, and survival of migratory fish species during the past three decades. Use and efficiency studies of the E.L. Field Powerhouse fish lift by American shad were conducted in 1999 and 2000 by Boott and by Alden Research Laboratory in 2011. The earlier studies led to significant modifications and upgrades of those facilities that improved the passage efficiencies of American shad. In addition, a 1988 acoustic telemetry study performed by RMC Environmental Services of adult American shad movement through the Northern Canal demonstrated successful passage through the Pawtucket Gatehouse, as well as incidental information regarding downstream passage routes for post-spawning individuals. In a follow-up study in 1991 by Normandeau Associates, Inc. (NAI), NAI found similar findings as the 1988 adult American shad telemetry study.

Downstream bypass effectiveness studies in 1991 and subsequent studies in 1994 and 1995 by NAI yielded information regarding the use of the Project's bypass. This information led to phased modifications of the bypass which increased its use and efficiency at passing juvenile Alosids downstream. Similar studies were performed for Atlantic salmon smolts in 1996 and 2003 by NAI. A 2005 USFWS radio telemetry study provided information regarding American shad movement behavior between the downstream hydroelectric station, Lawrence, and the Lowell facilities. Most recently, a study performed in 2017 by NAI yielded information regarding the downstream migratory behaviors of American eel in the Lowell Project.

As a means to illustrate the type and amount of studies that have occurred at the Project for migratory fish species, Boott has provided a summary of the studies below in Table 5.4-3. Table 5.4-3 provides the year the final report was published, the title of the study, the major study objectives, and the major findings of each study.

Table 5.4-3. Major Findings of Fish Passage Studies Performed at and/or in the Vicinity of the Lowell Project Since 1988.

Year	Study Title	Author	Major Study Objectives and Findings
1988	Passage of Radio-Tagged American Shad through the Northern Canal Headgate Structure, Lowell Hydroelectric Project	RMC Environmental Services, Inc.	Study Objectives: • Determine if adult American shad released into the Northern Canal pass through the headgate structure located at the upper end of the canal; and • Monitor American shad behavior and route of passage during outmigration. Study Findings: • 24 of the 25 radio-tagged shad (96%) released at fish lift exit passed the Northern Canal headgate structure with little delay. • Upstream passage of American shad through the Northern Canal headgate structure is increased with the boat lock open. Thirteen (52%) of the 25 tagged shad released into the Northern Canal were located downstream of the Eldred L. Field Station during emigration. Eight of these 13 passed through the Eldred Field Station or downstream passage facility. The exact route of the other five shad could not be ascertained. However, they may have passed over the Pawtucket Dam undetected by the continuous monitors. . • The Pawtucket Canal should not entrap emigrating adult shad.
1991	An Assessment of the Effectiveness of a Fish Bypass for Passing Juvenile Alewives at the Lowell Hydroelectric Project, Lowell, Massachusetts	Normandeau Associates, Inc.	Study Objective: • Conduct a mark and recapture study at the Lowell Hydroelectric Project in the fall of 1990 to determine the relative efficiency of its fish bypass system at passing juvenile clupeids. Study Findings: • During the peak of the migration season, large schools of juvenile clupeids were observed swimming in circles in the forebay area. These schools tended to avoid the downstream corners of the forebay area, especially the corner where the bypass is located. When some fish did approach the opening, the turbulence appeared to disorient and scatter them. • Because water depth in the vicinity of the E.L. Field Powerhouse's bypass is greater than 30 feet, the 91-cm-deep bypass opening at the Lowell Project may be too shallow for the majority of fish to locate it. • A total of 7,882 juvenile clupeids were captured in the bypass net between September 25 and October 23. Alewives comprised 95% of the catch, shad 4.5%, and blueback herring less than 0.5%.

Year	Study Title	Author	Major Study Objectives and Findings
1991	Downstream Passage Routes of Radio-tagged Adult American Shad at the Lowell Hydroelectric Project on the Merrimack River, Lowell, Massachusetts	Normandeau Associates, Inc.	Study Objective: • Determine the routes utilized by adult American shad as they pass downstream at the Lowell Hydroelectric Project. Study Findings: • Of the 50 American shad tagged during their upstream migration as part of this study, 23 returned downstream through the Project site. • Thirteen of the tagged American shad (53%) passed through E.L. Field powerhouse, five (22%) used the fish bypass at the E.L. Field powerhouse, two (9%) entered the Pawtucket Canal, and three (13%) spilled over the Pawtucket Dam. • Most of the remaining shad that did not return to the Project site became stationary upriver because of mortality. • The study also indicated that the losses of adult shad upriver from the Lowell Project was consistent with shad runs in other rivers.
1994	Use of the Fish Bypass at Lowell Hydroelectric Facility During Fall 1993	Normandeau Associates, Inc.	Study Objective: • Document the use of a modified fish bypass opening by downstream migrating juvenile clupeids. Study Findings: • During the fall of 1993, the modified fish bypass opening at the E.L. Field Powerhouse was effective in passing 31.8% of the marked fish during the four hours after the release. • The modified bypass opening tested in 1993 was very efficient in passing clupeids; passing more than 47,000 clupeids in only four hours of sampling demonstrated that hydraulic conditions at the newly enlarged bypass opening have improved considerably. • Downstream migrating clupeids that enter the Northern Canal tend to congregate in very large schools in the forebay area.
1995	Use of the Fish Bypass by Juvenile Clupeids at the Lowell Hydroelectric Project During Fall 1994	Normandeau Associates, Inc.	Study Objective: • Document the use of a modified fish bypass opening by downstream migrating juvenile clupeids. Study Findings: • The modified fish bypass system with the bypass flume installed was effective in passing 37% of the marked fish. • Downstream passage efficiency for juvenile clupeids at the Lowell Project has greatly improved since the first bypass efficiency study was conducted in 1991, when passage efficiency was estimated at 7%. • The study also suggested that the wider bypass opening attracts and passes more fish with less bypass discharge.

Year	Study Title	Author	Major Study Objectives and Findings
1996	Lowell Hydroelectric Project Internal Fish Lift Efficiency Monitoring Program, Spring 1996	Normandeau Associates, Inc.	Study Objectives: • Determine the internal efficiency of the Lowell Project fish lift at passing adult American shad upstream to spawn; • Use underwater cameras deployed at each entrance to the fish lift system to determine the number of shad entering and exiting the facility; and • Use video cameras installed in the fish counting room to monitor the fish lift exit channel and record all shad successfully lifted upstream. Study Findings: • Study results indicated that internal fish lift efficiency for shad at the Lowell Project was low for both flows evaluated (50 cfs and 90 cfs), probably due to the low flow velocities inside the fish lift entrance channel, especially upstream of the crowder gates. • With higher flows and velocities inside the fish lift entrance channel, fewer shad dropped out of the system and internal lift efficiency improved. However, even with the increased flow, most of the shad observed approaching the crowder gates did not pass through them. • For both flows tested (50 cfs and 90 cfs), most of the attraction flow (approximately 60%) passed out of the larger, main entrance weir 1 and the rest flowed out weir 2.
1996	Downstream Passage Routes of Radio-Tagged Atlantic Salmon Smolts at the Lowell and Lawrence Hydroelectric Projects on the Merrimack River	Normandeau Associates, Inc.	Study Objective: • Conduct a radio telemetry study to determine the extent to which the Lowell and Lawrence downstream fish bypass systems are used by radio-tagged Atlantic salmon smolts. Study Findings: • The fish bypass systems at both the Lowell and Lawrence Hydroelectric Projects were not very effective at passing radio-tagged Atlantic salmon smolts, and at both sites, most of the downstream passage was through the turbines. • At the Lowell Project, 13% of the radio-tagged salmon used the bypass during this study, a significant increase compared to the 4% bypass usage by radio-tagged salmon in 1990. • At the Lawrence Project, only 1 (5%) of the radio-tagged salmon smolts that passed the site during this study used the bypass - the remainder went through the turbines. • Only four (15%) of the radio-tagged salmon that passed the Lowell Project made it downstream to the Lawrence Project's headpond and of these, none were recorded passing the Lawrence site. • Predation appears to have been a factor in the disappearance of some radio-tagged salmon released upstream of both hydroelectric sites.

Year	Study Title	Author	Major Study Objectives and Findings
2000	An Assessment of Internal Fish Lift Efficiency at the Lowell Hydroelectric Project, Spring 1999	Boott Hydropower, Inc.	Study Objective: • Determine the internal efficiency of the Lowell Project fish lift at passing American shad upstream. Study Findings: • The 1999 fish lifting season at the Lowell Project was by far the most successful in the facilities' history. The total number of shad lifted at Lowell during 1999 (16,209) established a new all-time record for total shad lifted in a season at the Project, an increase of nearly 400% over the 1997 and 1998 totals. • The ratio of total shad lifted at the Lowell Project to the total lifted at the downstream Lawrence facility was nearly doubled, reaching approximately 29% in 1999 compared to a historic ratio of 15% since 1986, and in the preceding two years. • The average internal lift efficiency (42%) achieved at the Lowell Project during the 1999 fish lifting season represents a substantial improvement over the previous results, increasing over seventeen-fold compared to results achieved in 1996.
2000	Assessment of Internal Fish Lift Efficiency at Lowell Hydroelectric Project	Boott Hydropower, Inc.	Study Objectives: • Determine the internal efficiency of the Lowell Project fish lift at passing American shad upstream. Study Findings: • The crowder gate opening has a significant effect on internal fish lift efficiency. • Based on data collected from the brail camera, average efficiency was greatest (72.3%) at the 2-foot opening and lowest (29.0%) at the 4-foot opening. • Although the 2-foot crowder opening resulted in the highest average efficiencies observed in this study, it is possible that a narrower opening could restrict the movement of fish moving into the facility. • Fish Lift system modifications substantially increased internal efficiency by 10%.
2001	An Assessment of Internal Fish Lift Efficiency at the Lowell Hydroelectric Project, Spring 2000	Boott Hydropower, Inc.	Study Objective: • Determine the internal efficiency of the Lowell Project fish lift at passing American shad upstream. Study Findings: • The primary conclusion drawn from the study is that crowder gate opening significantly impacts the internal efficiency of the Lowell fish lift. • The study results indicated that the internal efficiency of the fish lift can be greatly enhanced by fishing the crowder gates at a 2-foot opening. • Brail camera results, which are most comparable to previous studies at Lowell and Lawrence, clearly show that internal efficiency at Lowell has substantially improved and is comparable to efficiencies now realized at Lawrence.

Year	Study Title	Author	Major Study Objectives and Findings
2002	Interdam Movements and Passage Attraction of American Shad in the Lower Merrimack River Main Stem	U.S. Fish and Wildlife Service, Central New England Fishery Resources Office	Study Objectives: • Determine the number of tagged American shad that pass Essex Dam and reach the Boott Station tailrace; and • Monitor American shad movements between Essex and Pawtucket dams. Study Findings: • Sixty-five tagged fish were deemed healthy after release from the Essex Dam fish lift. • From the group of 65 tagged fish, 43 fish (66%) reached the pool immediately downstream of the Boott Station tailrace and 36 fish (55%) entered the tailrace. • Four radio-tagged American shad (6% of 65 fish) versus an estimated 5,283 untagged American shad (10% of 54,450 fish that passed Essex Dam) passed through the Boott Station fish lift in 2002. • The results of the study indicate that American shad passage efficiency at the Boott Station fish lift needs improvement to achieve full American shad restoration upstream of the Pawtucket Dam.
2003	Passage Route Selection and Survival of Atlantic Salmon Smolts Passed through the Lowell Hydroelectric Project	Normandeau Associates, Inc.	Study Objectives: • Assess the effectiveness of the Lowell Project at safely passing downstream migrating Atlantic salmon smolts; and • Conduct a passage routing and turbine survival study during the spring of 2001. Study Findings: • Using twenty radio-tagged salmon smolts to test three bypass flows, fish bypass efficiency at the Lowell Project averaged 32% and ranged from 15% passage with a bypass flow of approximately 2% of turbine flow to 42% passage with approximately 4% bypass flow. • For salmon smolts released as part of the turbine survival study, the results indicate that immediate and delayed assessment survival after turbine passage is 100%. • Overall smolt survival for all smolts choosing turbine passage as an emigration route through the project could approach 100%. • No turbine-passed fish appeared to be injured as a result of turbine passage. • Predatory fish (primarily striped bass) residing in the tailrace and downstream of the Project have a substantial impact on the survival rates of salmon smolts emigrating past the Lowell Project.

Year	Study Title	Author	Major Study Objectives and Findings
2011	Shad Upstream Passage Assessment at Lowell Hydroelectric Project (FERC 2790)	ALDEN Research Laboratory, Inc.	Study Objectives: • Assess the upstream passage of American shad at the Lowell Hydroelectric Project; and • Evaluate adult shad passage success or impediments and overall fish migration patterns from the Lawrence Hydroelectric Project into the Lowell tailrace and into the Lowell project's fish lift hopper. Study Findings: • The acoustic telemetry results of the study indicate that 57% of the shad that pass the Lawrence Hydroelectric Project reach the Lowell tailrace. • Once shad reach the Lowell tailrace, they move along the edges of the tailrace, typically displaying a "U" shaped swimming pattern following the edges of the tailrace and the wall of the powerhouse. • The results of the study indicated that fish avoided the upstream "corners" of the tailrace, but did approach the center of the powerhouse closely when the riverside entrance was in operation. • Only three individual fish were detected as entering the riverside fish lift entrance. • The data from this study indicated that tagged fish detected within 60 feet of the fishway entrance were within the top 15 feet of the water column. • The attraction flow jet from the river side entrance is impacted by both the bedrock of the tailrace wall and the upwelling boil from the turbine discharge. • Observations of the tailrace conditions indicate the turbulent flow conditions extend 50 to 100 feet from the powerhouse and extend the full width of the tailrace. • The flow that exits the turbine draft tubes is apparently directed vertically approximately 60 to 80 feet downstream of the powerhouse and then boils in all directions at the water surface; there is an evident surface backflow towards the powerhouse upstream of the boils.
2013	Additional Analysis of American Shad Three-Dimensional Behavior in the Tailrace of the Lowell Project	Blue Leaf Environmental	Study Objective: • Provide additional analyses for the work conducted by ALDEN Research Laboratory, Inc. conducted in the spring of 2011, which is summarized above. Study Findings: • The results of this analysis demonstrated that shad did not spend long periods of time holding in a specific position within the tailrace or reside in areas outside of the established pattern of movement. • The greatest residence times were associated with cells inside the previously-defined "horseshoe pattern" where the acoustic-tagged shad 3D tracks illustrated movement "back and forth" in the tailrace, along both walls of the tailrace. • The result of this analysis demonstrated that there was not a movement pattern with shad in the tailrace of the Lowell Project. Shad are not swimming in the horseshoe pattern in one particular direction, they are moving in both a clockwise and counter clockwise direction. • Streamtrace particles used during this study were released into the vector field and did not exhibit net movement in any particular direction; particles meandered in all directions.

Year	Study Title	Author	Major Study Objectives and Findings
2018	Downstream Passage Evaluation for Silver-phase American Eels at Lowell Hydroelectric Project	Normandeau Associates, Inc.	Study Objective: • Evaluate downstream passage for silver-phase American eels at Lowell Hydroelectric Project. Study Findings: • Fourteen radio-tagged eels passing downstream of the Amoskeag Project (the next hydroelectric facility upstream of Lowell in New Hampshire) were detected at Pawtucket Dam. • Thirteen of the fourteen study eels arriving at Lowell were subsequently detected downstream at Lawrence. • Transit times between Amoskeag and Pawtucket Dam ranged from 10 – 244 hours. • Passage events occurred primarily between sunset and sunrise via the turbines (eight) and over Pawtucket Dam (five); one individual was not detected at the passage detection fields at Lowell but was detected at the Lawrence Project. • The E.L. Field Powerhouse bypass was not used as a downstream passage route.

5.4.7 Benthic Macroinvertebrates

Benthic macroinvertebrates are small aquatic animals and the aquatic larval stages of insects. They include dragonfly and stonefly larvae, snails, worms, and beetles. They lack a backbone, are visible without the aid of a microscope, and are found in and around water bodies during some period of their lives. Benthic macroinvertebrates are often found attached to rocks, vegetation, logs and sticks or burrowed into the bottom sand and sediments (USEPA undated). These organisms provide a link between a system's primary productivity and its aquatic consumers through the conversion of plant biomass to consumable energy. Benthic macroinvertebrates are useful indicators of water quality because many species have a wide range of tolerances to pollution; Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddis flies) (EPT) species are highly sensitive to pollution. Furthermore, EPT species are high-quality forage for a variety of freshwater fish species.

In recent years, the MADEP, NHDES, the Merrimack River Initiative (MRI), and numerous smaller watershed committees have begun conducting macroinvertebrate biomonitoring studies in the Merrimack River basin (USACE 2003). According to the USACE (2003), benthic macroinvertebrate sampling was conducted at 44 locations throughout the Merrimack River Basin (10 mainstem and 34 tributary). Artificial substrates were deployed in August 1994 and collected seven weeks later after a colonization period. The results of the MRI study were published in November 1996 in a two-part study report titled *Merrimack River Bi-State Water Quality Report, Part One* and the *Merrimack River Bi-State Biomonitoring Report, Part Two*.

Three macroinvertebrate species of management concern that are entirely or semi-aquatic potentially reside in the Lowell Project vicinity of the Merrimack River. These species include the eastern pondmussel (*Ligumia nasuta*), the cobra clubtail (*Gomphus vastus*) and the umber shadowdragon (*Neurocordulia obsoleta*). These species were identified as species of special concern in Massachusetts (Commonwealth of Massachusetts 2018*c*).

5.4.7.1 Eastern Pondmussel

The Eastern pondmussel is a medium-sized to large freshwater mussel that can reach 6 inches in length. It is an aquatic habitat generalist as it exhibits no distinct preference for substrate, depth, or flow conditions. It can be found in all sizes of waterbody, streams and rivers, and lakes or ponds. Eastern pondmussel larvae must attach to the gills or fins of a vertebrate (fish) host to develop into juveniles. This species has a restricted distribution in New England, and many historical populations are either extinct or have declined considerably in recent decades. This is probably the result of habitat degradation and pollution (Nedeau et al. 2000).

5.4.7.2 Cobra Clubtail

The cobra clubtail is a large, semi-aquatic dragonfly, Order Odonata, suborder Anisoptera. This large group of clubtail dragonflies are named because of the swelling at the tip of the abdomen that produces a club-like appearance. All dragonfly nymphs, the juvenile lifestage, are aquatic. They spend at least a year maturing before emerging as a

flying adult during the summer months. The lifecycle repeats as females deposit eggs at water surfaces. The range of the species is identified as the eastern U.S., barely extending into southeastern Canada. The species is considered very local in Massachusetts; known only from the Merrimack River, where its current status is uncertain, and from the Connecticut River, where it is considered common. The habitat of the species consists of medium to large, mud-bottomed rivers; sometimes large streams and lakes. Adults perch in vegetation or on the ground along the shoreline or on sand and gravel bars. They can occasionally be found in meadows and openings away from water. Males fly long patrols with abdomen upturned, a few feet over the river, periodically hovering and clashing with other males. Females oviposit in flight by tapping their abdomens to the surface of the water (MADFW 2003).

5.4.7.3 Umber Shadowdragon (*Neurocordulia obsoleta*)

The umber shadowdragon is a large insect of the Anisoptera (dragonfly) suborder. It belongs to a family known as the emeralds. The umber shadowdragon is chocolate brown in coloration with a yellowish lateral spot; brown abdomen with pale lateral spots. This dragonfly is crepuscular as an adult, actively flying in the evening during the months of May through August. The females deposit eggs at the water surface. Juvenile life stages, nymphs, rear for approximately one year and emerge to repeat the lifecycle as adults. Umber shadowdragons are found on large rivers that have relatively unvegetated shorelines and do well in reservoirs and dammed river sections. This crepuscular species spends the day hanging from twigs and branches in the shade, apparently high in the trees as they are very rarely seen before dusk. Adults forage close to shorelines and over open water, flying very low and erratically for a brief period from sunset until dark. Mating and egg laying also occur at this time. The presence of this species is most easily confirmed by locating their exuviae on bridge abutments, retaining walls, dams, steep embankments, or tree trunks (MADFW 2003).

5.4.8 Invasive Aquatic Species

Invasive species are defined as non-indigenous plant or animal species that aggressively compete with native species. These species often out-compete local native species, impacting biodiversity, recreation, and human health. The Merrimack River supports a relatively large number of invasive species. The Invasive Plant Atlas of New England (IPANE), NHDES, and the MRWC identifies the species listed in Table 5.4-4 as potentially occurring in the general vicinity of the Project.

Table 5.4-4. Aquatic Invasive Species Likely to Occur in the Project Vicinity.

Common Name	Scientific Name
Common reed	*Phragmites australis*
Curly-leaved pondweed	*Potamogeton crispus*
Eurasian water milfoil	*Myriophyllum spicatum*
Carolina fanwort	*Cabomba caroliniana*
Purple loosestrife	*Lythrum salicaria*

Common Name	Scientific Name
Twoleaf milfoil	*Myriophyllum heterophyllum*
European water chestnut	*Trapa natans*
Yellow Iris	*Iris pseudacorus*
European water-clover	*Marsilea quadrifolia*
Watercress	*Nasturtium officinale*
Reed canarygrass	*Phalaris arundinacea*
Yellow iris	*Iris pseudacorus*
Flowering rush	*Butomus umbellatus*
Yellow floating heart	*Nymphoides peltata*
Asian clam	*Corbicula fluminea*

Sources: MRWC 2015; IPANE 2018

5.5 Wildlife and Botanical Resources (18 CFR § 5.6(d)(3)(v))

The lower Merrimack River corridor, including the Lowell Project, provides habitat for a diversity of botanical and wildlife species. Diverse habitats such as wetlands, forests, grasslands, and the river provide essential habitat for a variety of mammals, birds, reptiles, and amphibians in sufficient quantity and quality to ensure sustainable conditions for these species (LMRLAC 2008). The quantity and quality of these habitats has changed over time. Early European settlers changed the lower Merrimack River drastically. Forests were cleared for agricultural lands. Later, the mainstem river was heavily modified for industrial purposes. Eventually, these agricultural lands were abandoned and natural forest succession has replaced much of them (NHDFG 2015). The current resulting botanical resources that provide wildlife habitat along the Merrimack River is a patchwork of forests comprised of vegetation common to the northeast and grasslands that are agricultural remnants or associated with modern development.

The Project itself is located in a more urbanized area with medium to heavy density development along the shores of the Merrimack River. The city of Lowell is heavily urbanized with many businesses capitalizing on the renewal of the city.

5.5.1 Botanical Resources

Botanical resources in the Merrimack River corridor vary between urban areas and non-urban areas. The vicinity of the Lowell Project are dominated by hemlock-hardwood-pine, Appalachian oak-pine, and grasslands (NHDFG 2015). These habitat types are discussed below in further detail.

5.5.1.1 Hemlock-Hardwood-Pine Forest

Hemlock-hardwood-pine forest is a wide-spread habitat in the lower Merrimack River corridor. It is a transitional forest between Appalachian oak-pine and northern hardwood found at elevations less than 400 feet and greater than 1,500 feet, respectively. White pine, *Pinus strobus*, and eastern hemlock, *Tsuga canadensis*, are the dominant trees, but American beech, *Fogus grandifolia*, and patches of sugar maple, *Acer saccharum*, white ash, *Fraxinus americana*, and red oak, *Quercus rubra*, contribute to a variable species mix of this forest type. The understory contains small trees and shrubs such as witch hazel, *Hamamelis virginiana*, maple-leaved viburnum, *Viburnum acerifolium*, black birch, *Betula nigra*, black cherry, *Prunus serotina* and ironwood, *Ostrya virginiana*. The forest floor contains starflower, *Trientalis borealis*, and Canada mayflower, *Maianthemum canadensis*.

Most white pine stands that have grown up from abandoned pastures are examples of this type of hemlock-hardwood pine forest habitat. On fertile soils, white pine is replaced by hemlock or hardwoods over time. Older forests that have succeeded to later stages contain patches of larger diameter trees (>18 inches) hemlock or beech in the canopy, layers of young trees and shrubs in the understory, many standing dead trees, and abundant decaying wood on the forest floor. Large-sized cavity trees, pockets of wetlands, patches of acorn-rich oaks, seeps, and tall pine trees make some patches of this forest type especially rich for wildlife (NHDFG 2015).

5.5.1.2 Appalachian Oak-Pine Forest

Appalachian oak-pine forests, with their abundance of nut-bearing oaks such as red oak, white oak, *Quercus alba*, and black oak, *Quercus velutina*, and hickories such as shagbark, *Carya ovata*, pignut, *Carya glabra*, and sweet pignut, *Carya ovalis*, provide a rich food source for wildlife such as ruffed grouse, turkey, black bear, squirrels, mice and chipmunks. Common understory shrubs and smaller trees of this forest are black birch, aspen, *Populus grandidentata*, sassafras, *Sassafras albidum*, and yellow birch, *Betula alleghaniensis*. Blueberries, *Vaccinium angustifolium and V. pallidum,* black huckleberry, *Gaylussacia baccata*, sheep laurel, *Kalmia angustifolia*, and Pennsylvania sedge, *Carex pennsylvanica,* are typical understory plants. Raptors such as northern goshawk feed on small mammals and find nesting and perching sites in white pines in the tree canopy. White pines adjacent to the Merrimack River provide key nest and perch sites for bald eagles, great blue herons, and osprey (NHDFG 2015).

Many stands of Appalachian oak-pine forest are of the same age, approximately 80-100 years. They grew after farms were abandoned throughout the last century. Many wildlife species found in this forest type are attracted to patches of old or young trees within the larger forested landscape. Historically, the dry soils and warm temperatures in this region allowed occasional low-intensity fires to burn in these forests. Without fire, these forests have a higher proportion of white pine, hemlock, sugar maple and birch, *Betula* spp., than nut-bearing trees. Mature Appalachian oak-pine forests may also be denser due to a lack of low ground fires to maintain an open understory (NHDFG 2015).

5.5.1.3 Grasslands

The most common grassland habitat in the lower Merrimack River corridor are agricultural fields such as hayfields, pastures, and fallow fields. Grassland vegetation is a mixture of grass species, or a combination of grasses, sedges, and wildflowers. Most plants found in grasslands are non-native grasses, introduced for agricultural use. These include timothy, *Phleum pretense*, Kentucky bluegrass, *Poa pratensis*, orchard grass, *Dactylis glomerata*, and perennial ryegrass, *Lolium perenne*. Common native plants include big bluestem, *Andropogon gerardi*, and little bluestem, *Schizachyrium scoparium*, and a variety of species of the wildflower genera *Solidago* (goldenrod) and *Aster*. Vegetation growing in grassland habitat ranges from less than 6 inches to over four feet in height. Vegetation height plays an important role in determining which wildlife species will use it. Few, if any, trees or shrubs are found in grasslands. Unless maintained, most grasslands will return to forest habitat (NHDFG 2015).

5.5.2 Wildlife Resources

The Merrimack River corridor provides habitat for a diversity of wildlife species. Diverse habitat such as wetlands, forests, fields, and the river and associated tributaries support a variety of species. The quality and types of habitat that the Merrimack River corridor provides is what dictates which wildlife species occupy and use it. Merrimack River mainstem is categorized as a large/great river habitat (Olivero and Anderson 2008). Large river habitats such as the Merrimack River support a diverse wildlife community which includes many of the mammalian, reptilian, and amphibian species found in northeastern North America. The Project area is dominated by three main habitat types: hemlock-hardwood-pine, Appalachian oak-pine, and grasslands.

Appalachian oak-pine forests are found at elevations below 900 feet in southern New Hampshire. The nutrient-poor, dry, sandy soils and warm, dry climate influences the typical vegetation including oak, hickory, mountain laurel, and sugar maple. Many wildlife species use these forests for part or all of their life cycle including whip-poor-wills, black bears, brown bats, and eastern hognose snakes (NHDFG 2015).

Hemlock-hardwood-pine forests are comprised of mostly hemlock, white pine, beech, and oak trees. It is a transitional forest that can occur at different elevations and over different types of soil and topography. The composition of the vegetation can be variable. This forest type provides habitat for numerous wildlife species such as the chestnut-sided warbler, tricolored bat, and bobcat (NHDFG 2015).

Grasslands are comprised of grasses, sedges, and wildflowers with little to no shrubs or trees. The most common grassland habitats are found in airports, capped landfills, wet meadows, and agricultural fields such as hayfields, pastures, and fallow fields. Grasslands provide habitat for wildlife species such as bobolink, wood turtles, and numerous snakes (NHDFG 2015).

Comprehensive lists of the mammalian, avian, amphibian, and reptilian species that use the habitat complex of woodland/grassland shoreline along this large river ecosystem follow in Sections 5.5.2.1-5.5.2.3.

5.5.2.1 Mammals

Mammals present in the vicinity of the Lowell Project are those commonly found throughout the region that are adapted to living near humans and urban areas. Raccoon, skunk, muskrat, porcupines, white-tailed deer, woodchucks, squirrels, mice, bats, and rabbits are common mammals of the Lowell Project and the lower Merrimack River corridor. Larger mammals that require extensive habitat areas, or species that require solitude, such as moose and black bear, prefer less developed environments that are scarce in the lower Merrimack River corridor and the Lowell Project. Table 5.5-1 lists the mammalian species potentially occurring in the vicinity of the Lowell Project.

Table 5.5-1. Mammalian Species Potentially Occurring in the Vicinity of the Lowell Project.

Common Name	Scientific Name
Beaver	*Castor canadensis*
Big brown bat	*Eptesicus fuscus*
Black bear	*Ursus americanus*
Black rat	*Rattus rattus*
Bobcat	*Lynx rufus*
Coyote	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Eastern chipmunk	*Tamias striatus*
Eastern red bat	*Lasiurus borealis*
Ermine	*Mustela ermina*
Fisher	*Pekania pennanti*
Gray fox	*Urcyon cinereoargenteus*
Gray squirrel	*Sciurus carolinensis*
Hairy-tailed mole	*Parascalops breweri*
Hoary bat	*Lasiurus cinereus*
House mouse	*Mus musculus*
Little brown bat	*Myotis lucifugus*
Long-tail weasel	*Mustela frenata*
Long-tailed shrew	*Sorex dispar*

Common Name	Scientific Name
Masked shrew	*Sorex cinereus*
Meadow jumping mouse	*Zapus hudsonicus*
Meadow vole	*Microtus pennsylvanicus*
Mink	*Mustela vison*
Moose	*Alces alces*
Muskrat	*Ondatra zibethicus*
Northern flying squirrel	*Glaucomys sabrinus*
Northern short-tailed shrew	*Blarina brevicauda*
Norway rat	*Rattus norvegicus*
Porcupine	*Erethizon dorsatum*
Pygmy shrew	*Sorex hoyi*
Raccoon	*Procyon lotor*
Red fox	*Vulpes vulpes*
Red squirrel	*Tamiasciurus hudsonicus*
River otter	*Lontra canadensis*
Silver-haired bat	*Lasionycteris noctivagans*
Small-footed bat	*Myotis leibii*
Smoky shrew	*Sorex fumeus*
Snowshoe hare	*Lepus americanus*
Southern bog lemming	*Synaptomys cooperi*
Southern flying squirrel	*Glaucamys volans*
Southern red-backed vole	*Clethrionomys gapperi*
Star-nosed mole	*Condylura cristata*
Striped skunk	*Mephitis mephitis*
Tricolored bat	*Perimyotis subflavus*
Virginia opossum	*Didelphis virginiana*
Water Shrew	*Sorex palustris*

Common Name	Scientific Name
White-footed mouse	*Peronyscus leucopus*
White-tailed deer	*Odocoileus virginianus*
Woodchuck	*Marmota monax*
Woodland jumping mouse	*Napaeozapus insignis*
Woodland vole	*Microtus pinetorum*

Source: NHDFG 2015.

5.5.2.2 Avifauna

The diversity of habitats in the Lowell Project and lower Merrimack River corridor provide breeding, migratory stopover, and wintering habitat for a high diversity of avifauna including neotropical songbirds, resident species, waterbirds, and waterfowl. Table 5.5-2 lists bird species potentially occurring in the vicinity of the Lowell Project.

Table 5.5-2. Avian Species Potentially Occurring in the Vicinity of the Lowell Project.

Common Name	Scientific Name
Alder flycatcher	*Empidonax alnorum*
American bittern	*Botaurus lentiginosus*
American black duck	*Anas rubripes*
American coot	*Fulica americana*
American crow	*Corvus brachyrhynchos*
American goldfinch	*Carduelis tristis*
American kestrel	*Falco sparverius*
American redstart	*Setophaga ruticilla*
American robin	*Turdus migratorius*
American woodcock	*Scolopax minor*
Bald eagle	*Haliaeetus leucocephalus*
Baltimore oriole	*Icterus galbula*
Barn swallow	*Hirundo rustica*
Belted kingfisher	*Megaceryle alcyon*
Black-billed cuckoo	*Coccyzus erythropthalmus*
Blackburnian Warbler	*Dendroica fusca*

Common Name	Scientific Name
Black-capped chickadee	*Poecile atricapillus*
Black-throated Blue Warbler	*Dendroica caerulescens*
Black-crowned night heron	*Nycticorax nycticorax*
Black-throated Green Warbler	*Dendroica virens*
Blue jay	*Cyanocitta cristata*
Blue-gray gnatcatcher	*Polioptila caerulea*
Blue-headed Vireo	*Vireo solitarius*
Bobolink	*Dolichonyx oryzivorus*
Broad-winged hawk	*Buteo platypterus*
Brown creeper	*Certhia americana*
Brown-headed cowbird	*Molothrus ater*
Brown thrasher	*Toxostoma rufum*
Bufflehead	*Bucephala albeola*
Canada goose	*Branta canadensis*
Canvasback	*Aythya valisineria*
Carolina Wren	*Thryothorus ludovicianus*
Cedar waxwing	*Bombycilla cedrorum*
Chestnut-sided Warbler	*Dendroica pensylvanica*
Chimney Swift	*Chaetura pelagica*
Chipping Sparrow	*Spizella passerina*
Common goldeneye	*Bucephala clangula*
Common grackle	*Quiscalus quiscula*
Common Merganser	*Mergus merganser*
Common nighthawk	*Chordeiles minor*
Common raven	*Corvus corax*
Common redpoll	*Acanthis flammea*
Common Yellowthroat	*Geothlypis trichas*
Cooper’s hawk	*Accipiter cooperii*

Common Name	Scientific Name
Dark-eyed junco	*Junco hyemalis*
Double-crested cormorant	*Phalacrocorax auritus*
Downy Woodpecker	*Picoides pubescens*
Eastern Bluebird	*Sialia sialis*
Eastern Kingbird	*Tyrannus tyrannus*
Eastern phoebe	*Sayornis phoebe*
Eastern screech owl	*Megascops asio*
Eastern Wood-Pewee	*Contopus virens*
European Starling	*Sturnus vulgaris*
Evening grosbeak	*Coccothraustes vespertinus*
Gadwall	*Mareca strepera*
Golden-crowned kinglet	*Regulus satrapa*
Golden eagle	*Aquila chrysaetos*
Gray catbird	*Dumetella carolinensis*
Great blue heron	*Ardea herodias*
Greater scaup	*Aythya marila*
Great crested flycatcher	*Myiarchus crinitus*
Great horned owl	*Bubo virginianus*
Great egret	*Ardea alba*
Green heron	*Butorides virescens*
Hairy Woodpecker	*Picoides villosus*
Hermit thrush	*Catharus guttatus*
Herring gull	*Larus argentatus*
Horned grebe	*Podiceps auritus*
House finch	*Carpodacus mexicanus*
House sparrow	*Passer domesticus*
House Wren	*Troglodytes aedon*
Indigo Bunting	*Passerina cyanea*

Common Name	Scientific Name
Killdeer	*Charadrius vociferus*
Least bittern	*Ixobrychus exilis*
Least flycatcher	*Empidonax minimus*
Long-eared owl	*Asio otus*
Louisiana Waterthrush	*Seiurus motacilla*
Magnolia Warbler	*Dendroica magnolia*
Mallard	*Anas platyrhynchos*
Mourning dove	*Zenaida macroura*
Mourning warbler	*Oporornis philadelphia*
Northern cardinal	*Cardinalis cardinalis*
Northern flicker	*Colaptes auratus*
Northern goshawk	*Accipiter gentilis*
Northern parula	*Setophaga americana*
Northern saw-whet owl	*Aegolius acadicus*
Northern shrike	*Lanius borealis*
Northern shoveler	*Spatula clypeata*
Northern waterthrush	*Seiurus noveboracensis*
Olive-sided flycatcher	*Contopus cooperi*
Orchard oriole	*Icterus spurius*
Osprey	*Pandion haliaetus*
Ovenbird	*Seiurus aurocapilla*
Pied-billed grebe	*Pied-billed grebe*
Pileated woodpecker	*Dryocopus pileatus*
Pine siskin	*Spinus pinus*
Purple finch	*Carpodacus purpureus*
Red-bellied woodpecker	*Melanerpes carolinus*
Red-breasted nuthatch	*Sitta canadensis*
Red crossbill	*Loxia curvirostra*

Common Name	Scientific Name
Red-eyed vireo	*Vireo olivaceus*
Redhead	*Aythya americana*
Red-shouldered hawk	*Buteo lineatus*
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-billed gull	*Larus delawarensis*
Ring-necked duck	*Aythya collaris*
Rock pigeon	*Columba livia*
Rose-breasted grosbeak	*Pheucticus ludovicianus*
Ruby-crowned kinglet	*Regulus calendula*
Ruby-throated hummingbird	*Archilochus colubris*
Ruddy duck	*Oxyura jamaicensis*
Ruffed grouse	*Bonasa umbellus*
Sandhill crane	*Antigone canadensis*
Savannah sparrow	*Passerculus sandwichensis*
Scarlet tanager	*Piranga olivacea*
Sharp-shinned hawk	*Accipiter striatus*
Short-eared owl	*Asio flammeus*
Snow bunting	*Plectrophenax nivalis*
Snow goose	*Anser caerulescens*
Snowy owl	*Bubo scandiacus*
Song sparrow	*Melospiza melodia*
Sora	*Porzana carolina*
Spotted sandpiper	*Actitis macularius*
Swainson’s thrush	*Catharus ustulatus*
Swamp sparrow	*Melospiza georgiana*
Tree swallow	*Tachycineta bicolor*
Tufted titmouse	*Baeolophus bicolor*

Common Name	Scientific Name
Turkey vulture	*Cathartes aura*
Veery	*Catharus fuscescens*
Virginia rail	*Rallus limicola*
Warbling vireo	*Vireo gilvus*
White-breasted nuthatch	*Sitta carolinensis*
White-winged crossbill	*Loxia leucoptera*
Wild turkey	*Meleagris gallopavo*
Wilson's warbler	*Cardellina pusilla*
Willow flycatcher	*Empidonax traillii*
Wood duck	*Aix sponsa*
Wood thrush	*Hylocichla mustelina*
Yellow warbler	*Dendroica petechia*
Yellow-bellied flycatcher	*Empidonaz flaviventris*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Yellow-billed cuckoo	*Coccyzus americanus*
Yellow-rumped warbler	*Dendroica coronata*
Yellow-throated vireo	*Vireo flavifrons*

Source: NHDFG 2015.

5.5.2.3 Reptiles and Amphibians

Reptiles and amphibians also use the diverse habitats associated with the lower Merrimack River corridor. Wetlands are important breeding habitats for amphibians. Upland woodland habitats are also important for terrestrial reptiles and amphibians during the non-breeding periods of their life cycle. Table 5.5-3 lists the species of amphibians potentially occurring in the vicinity of the Lowell Project during breeding or their entire life cycle. Table 5.5-4 lists the species of reptiles potentially occurring in the vicinity of the Lowell Project.

Table 5.5-3. Amphibian Species Potentially Occurring in the Vicinity of the Lowell Project.

Common Name	Scientific Name
American toad	*Anaxyrus americana*
Blue-spotted salamander	*Ambystoma laterale*
Bullfrog	*Lithobates catesbeiana*
Dusky salamander	*Desmognathus fuscus*
Four-toed salamander	*Hemidactylium scutatum*
Fowler's toad	*Anaxyrus fowleri*
Gray treefrog	*Hyla versicolor*
Green frog	*Lithobates clamitans melanota*
Marbled salamander	*Ambystoma opacum*
Northern leopard frog	*Lithobates pipiens*
Pickerel frog	*Lithobates palustris*
Redback salamander	*Plethodon cinereus*
Red-spotted newt	*Notophthalmus viridescens*
Spotted salamander	*Ambystoma maculatum*
Spring peeper	*Pseudacris crucifer*
Two-lined salamander	*Eurycea bislineata*
Wood frog	*Lithobates sylvatica*

Source: NHDFG 2015.

Table 5.5-4. Reptilian Species Potentially Occurring in the Vicinity of the Lowell Project.

Common Name	Scientific Name
Black racer	*Coluber constrictor*
Blanding's turtle	*Emydoidea blandingii*
Brown snake	*Storeria dekayi*
Common garter snake	*Thamnophis sirtalis*
Common musk turtle	*Sternotherus odoratus*

Common Name	Scientific Name
Eastern box turtle	*Terrapene carolina*
Eastern hognose snake	*Heterodon platirhinos*
Milk snake	*Lampropeltis triangulum*
Northern water snake	*Nerodia sipedon*
Painted turtle	*Chrysemys picta*
Red-bellied snake	*Storeria occipitomaculata*
Ribbon snake	*Thamnophis sauritus*
Ringneck snake	*Diadophis punctatus*
Smooth green snake	*Liochlorophis vernalis*
Snapping turtle	*Chelydra serpentina*
Spotted turtle	*Clemmys guttata*
Wood turtle	*Glyptemys insculpta*

Source: NHDFG 2015.

5.5.2.4 Invasive Terrestrial Species

The house mouse, *Mus musculus*, and the Norway rat, *Rattus norvegicus*, are prolific breeders able to increase their population rapidly. Most habitat types found in the vicinity of the Lowell Project are suitable for these rodents as they are found both in urban and rural areas. Their population sizes can increase quickly during optimal conditions. These rodents become a nuisance and often pose a risk of spreading disease when they infest places where they may encounter humans (NHDFG 2015).

5.6 Wetlands, Riparian, and Littoral Habitat (18 CFR § 5.6(d)(3)(vi))

Wetlands are generally defined as those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support vegetation typically adapted for life in saturated soil conditions. Most formal wetland definitions emphasize three primary components that define wetlands: the presence of water, unique soils, and hydrophytic vegetation. The USFWS (Cowardin et al. 1979) defines wetlands as:

> …lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have been one or more of the following three attributes: (1) at least periodically, the land supports predominately hydrophytes; (2) the

substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some point during the growing season of the year.

The USFWS, MADEP, and the NHDES have jurisdiction over wetlands within the Project area. The MADEP's and NHDES's wetland definition is consistent with the USFWS'.

Terrestrial habitat conditions in the Project area and upstream along the Merrimack River are largely a result of land use, especially of urban and suburban development (Boott Mills 1980). Wetlands along the Merrimack River primarily consist of low-lying areas near and adjacent to the river, with other isolated wetlands farther away from the river proper. The USEPA has designated the Merrimack River from Franklin, New Hampshire, to Lowell, Massachusetts, as a Priority Waterbody/Wetland due to its importance to waterfowl and fish populations (Carley 2001 as cited in USACE 2002).

The wetlands directly surrounding the Lowell Project are largely considered riverine wetlands with an unconsolidated bottom (Figure 5.6-1). Riverine wetlands include all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 parts per thousand (or greater (Cowardin et al. 1979).

The majority of the wetlands near or adjacent to the Project area are palustrine wetlands. Palustrine wetlands, often called fens, swamps, marshes, or bogs, are nontidal wetlands. These wetlands are dominated by trees, shrubs, and/or persistent plants/mosses. These wetlands may also be composed of shallow, open-water ponds (Cowardin et al. 1979).

According to a review of Geographic Information System (GIS) data (Massachusetts Bureau of Geographic Information [MassGIS]), there are no Massachusetts Natural Heritage and Endangered Species Program)-certified vernal pools within the Project boundary. Potential vernal pools were also identified using GIS data. According to MassGIS (2018*b*), two potential vernal pools are located within 100 feet of the Project boundary, but not within the Project boundary.

5.6.1 Wetland and Riparian Vegetation

No formal survey data on wetlands at or near the Project is available. However, riparian vegetation within the Project area appears to be consistent with these areas of New Hampshire and Massachusetts. Where steep banks present themselves, the riparian corridor is narrow with wetland vegetation only occurring immediately adjacent to the river/land interface. Where the shoreline is more gradual and the Merrimack River floodplain extends away from the current river course, palustrine wetlands cover areas of former oxbows, floodplain, and low-lying areas. According to the USACE (2002), freshwater wetland habitats play an integral role in the ecology of the Merrimack River corridor. The combination of high nutrient levels and primary productivity found in these habitats is ideal for the development of organisms that form the base of the food web.

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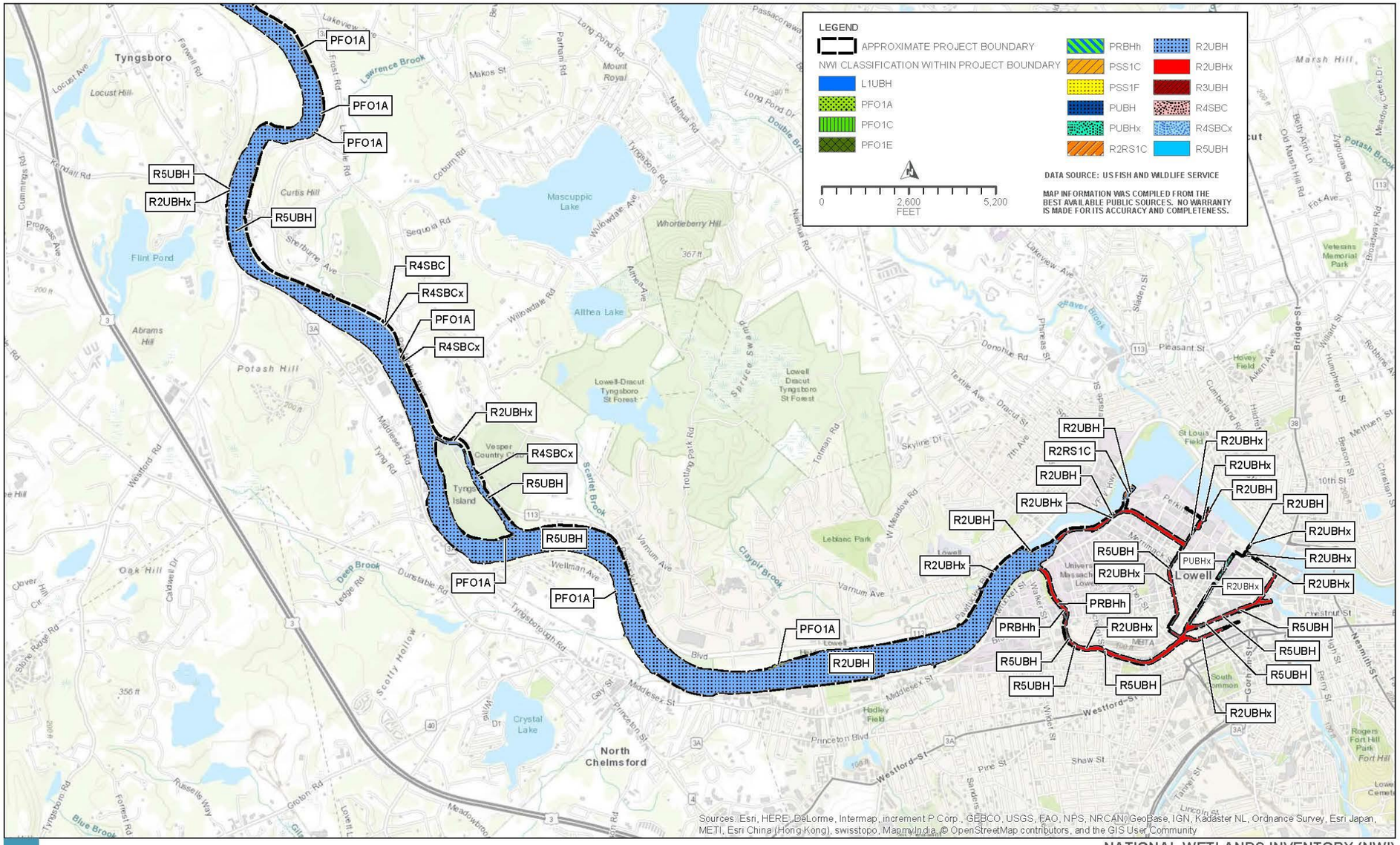
Figure 5.6-1. Wetlands in the Vicinity of the Lowell Hydroelectric Project.



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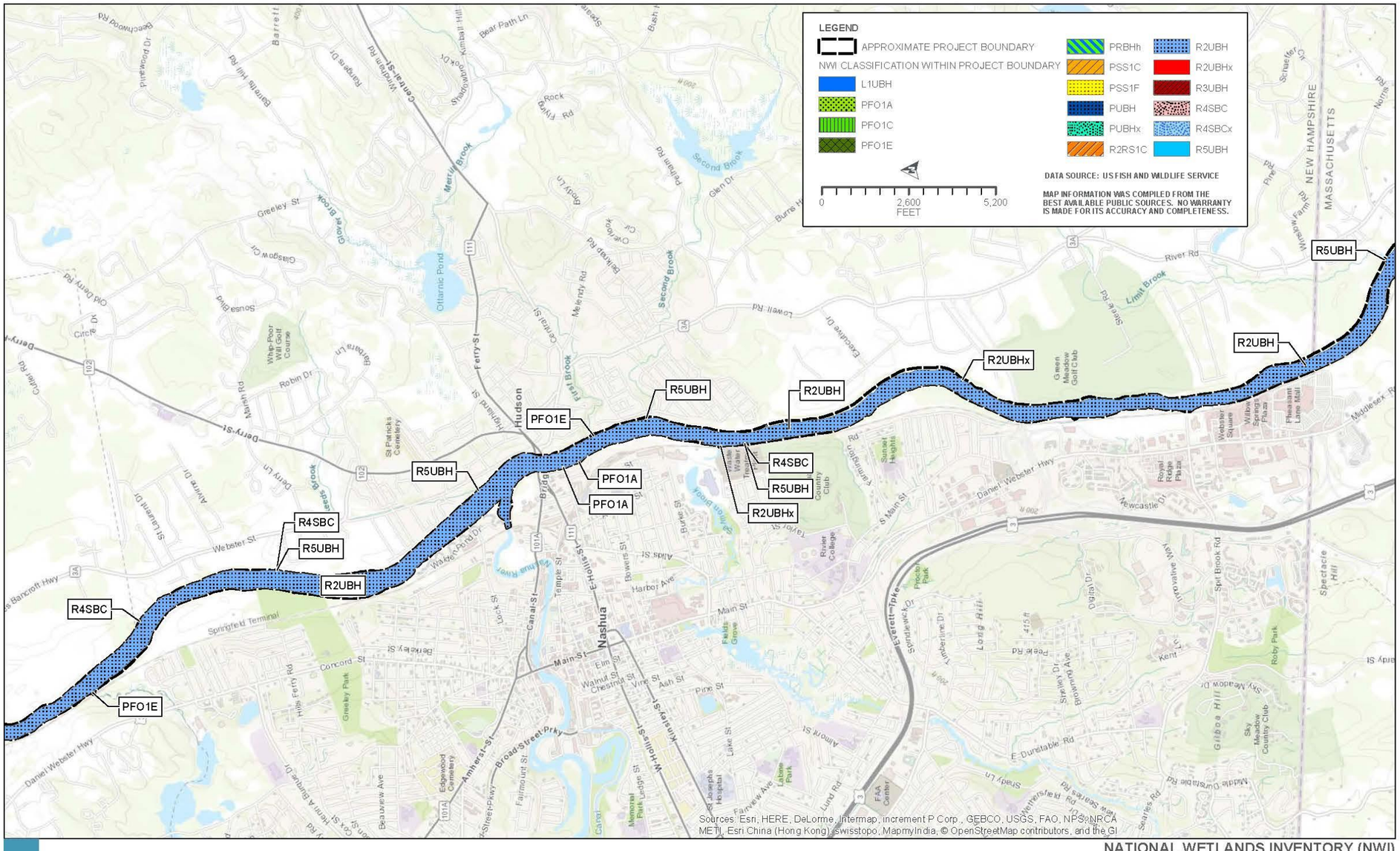
SHEET 1 OF 3

NATIONAL WETLANDS INVENTORY (NWI)
LOWELL HYDROELECTRIC PROJECT
FERC NO. 2790
MARCH 2018



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SHEET 2 OF 3

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LOWELL HYDROELECTRIC PROJECT
FERC NO. 2790
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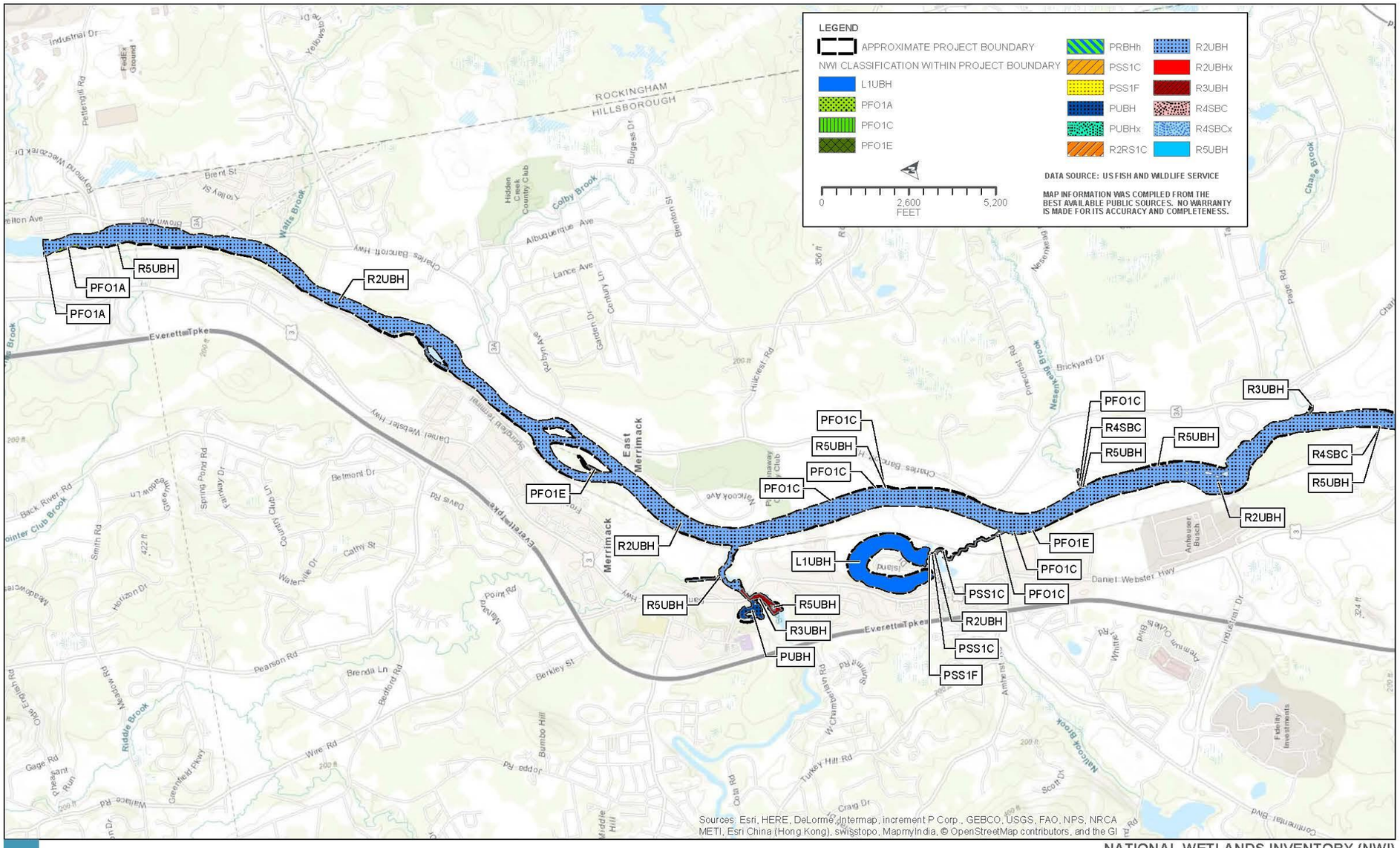

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SHEET 3 OF 3

NATIONAL WETLANDS INVENTORY (NWI)
LOWELL HYDROELECTRIC PROJECT
FERC NO. 2790

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Massachusetts floodplain communities are typically dominated by river birch (*Betula nigra*) associations (USACE 2002). Development activity is contributing to the decline of these riparian communities in Massachusetts (Carley 2001 as cited in USACE 2002). The palustrine forested wetland habitats located within and adjacent to the Project boundary are primarily dominated by broad-leaved deciduous subclasses located along forested floodplains. These areas are characterized by their flood regime; lower areas are annually flooded in spring, whereas higher areas are flooded irregularly. Common trees include silver maple (*Acer saccharinum*), cottonwood (*Populus deltoides*), and American elm (*Ulmus americana*). The shrub layer may include silky dogwood (*Swida amomum*) and buttonbush (*Cephalanthus occidentalis*). Common herbaceous species may include sensitive fern (*Onoclea sensibilis*), false nettle (*Boehmeria cylindrica*), water hemlock (*Cicuta maculata*), swamp candles (*Lysimachia terrestris*), and water parsnip (*Sium suave*) (Swain and Kearsley 2001; Sperduto and Nichols 2011).

5.6.2 Wetland and Riparian Wildlife

The Merrimack River provides habitat for a variety of large and small mammals. For example, the Merrimack River corridor serves as an important habitat for several water-dependent furbearers, including beaver (*Castor canadensis*), muskrat (*Ondatra zibethica*), and mink (*Mustela vision*). Larger mammals, such as the white-tailed deer (*Odocoileus virginianus*), and the eastern coyote (*Canis latrans*) also use the river corridor both as home range habitat and as a travel corridor to pass between other preferred habitats (USACE 2002). Wildlife species typically found in wetland and aquatic habitats include, the snapping turtle (*Chelydra serpentina*), northern water snake (*Nerodia sipedon*), bullfrog (*Lithobates catesbeianus*), northern leopard frog (*L. pipiens*), and green frog (*L. clamitans*). These species use aquatic habitats for foraging, loafing (i.e., resting), protection, reproduction, and hibernation (DeGraaf and Rudis 1983; Tyning 1990; DeGraaf and Yamasaki 2001).

Species typically found in riparian habitats include raccoon (*Procyon lotor*), deer, common garter snake (*Thamnophis sirtalis*), eastern ribbon snake (*Thamnophis sauritus*), spotted salamander *(Ambystoma maculatum*), gray tree frog (*Hyla versicolor*), striped skunk (*Mephitis mephitis*), coyote, muskrat, and Virginia opossum (*Didelphis virginiana*). Many species utilize riparian zones for shelter, venturing into more aquatic and/or terrestrial habitats to forage and reproduce (DeGraaf and Rudis 1983; Tyning 1990; DeGraaf and Yamasaki 2001).

The Merrimack River and associated water resources and bottomland areas in the Project's vicinity are used by migratory waterfowl and neotropical passerines. Avian species typically found in wetland habitats and along the shorelines of the Merrimack River include the great blue heron (*Ardea herodias*), red-winged blackbird (*Agelaius phoeniceus*), swamp sparrow (*Melospiza georgiana*), song sparrow (*M. melodia*), and mallard (*Anas platyrhynchos*) (DeGraaf and Yamasaki 2001). Species of ducks may nest within vegetated shallows and bottomlands and forage in open water (DeGraaf and Yamasaki 2001).

5.6.3 Wetland, Riparian Zone, and Littoral Maps

Maps of wetland habitats existing at the Project are presented in Figure 5.6-1 above. Table 5.6-1 defines the National Wetland Inventory's (NWI) classification system used on

the wetlands maps (USFWS 2018). Currently, data for littoral and riparian zone habitat cannot be found for the areas surrounding the Project. The MADEP and NHDES refer individuals to the MassGIS and NH GRANIT, New Hampshire's statewide geographic information system clearinghouse, respectively, that only contain information regarding wetland habitats for the Project location.

Table 5.6-1. National Wetlands Inventory Classification System.

Wetlands Code	System	Subsystem	Class	Subclass	Water Regime	Qualifier
R2UBH	Riverine	Lower Perennial	Unconsolidated Bottom	--	Permanently Flooded	
R2UBHx	Riverine	Lower Perennial	Unconsolidated Bottom	--	Permanently Flooded	Excavated
R3UBH	Riverine	Upper Perennial	Unconsolidated Bottom	--	Permanently Flooded	--
R2RS1C	Riverine	Lower Perennial	Rocky Shore	Bedrock	Seasonally Flooded	--
R4SBC	Riverine	Intermittent	Streambed	--	Seasonally Flooded	--
R4SBCx	Riverine	Intermittent	Streambed	--	Seasonally Flooded	Excavated
R5UBH	Riverine	Unknown Perennial	Unconsolidated Bottom	--	Permanently Flooded	--
PUBH	Palustrine	--	Unconsolidated Bottom	--	Permanently Flooded	--
PUBHx	Palustrine	--	Unconsolidated Bottom	--	Permanently Flooded	Excavated
L1UBH	Lacustrine	Limnetic	Unconsolidated Bottom	--	Permanently Flooded	--
PFO1A	Palustrine	--	Forested	Broad-leaved Deciduous	Temporarily Flooded	--
PFO1C	Palustrine	--	Forested	Broad-leaved Deciduous	Seasonally Flooded	--
PFO1E	Palustrine	--	Forested	Broad-leaved Deciduous	Seasonally Flooded/Saturated	--
PSS1F	Palustrine	--	Scrub-Shrub	Broad-leaved Deciduous	Semipermanently Flooded	--
PSS1C	Palustrine	--	Scrub-Shrub	Broad-leaved Deciduous	Seasonally Flooded	
PRBHh	Palustrine	--	Rock Bottom	--	Permanently Flooded	Diked/ Impounded

Source: USFWS 2018.

5.6.4 Estimates of Wetland, Riparian Zone, and Littoral Acreage

5.6.4.1 Wetland Acreage

There are MADEP and NHDES wetlands and NWI wetlands encompassed within, adjacent to, or in the close proximity to Project boundary. Most of the MADEP, NHDES, and NWI mapped wetland boundaries overlay each other[6]. There are approximately 739.2 acres of MADEP wetland, approximately 6.4 acres of NHDES wetland, and approximately 1,659 acres of NWI wetlands. The 745.6 acres of MADEP and NHDES wetlands are mostly encompassed within the 1,659 acres of NWI wetlands (MassGIS 2018*b*; NH GRANIT undated).

5.6.4.2 Littoral and Riparian Zone Acreage

Currently, no information on littoral and riparian zone acreage is available. The MADEP and NHDES refer individuals to MassGIS and NH GRANIT, which do not contain information regarding littoral and riparian zone acreage for the Project location.

5.7 Rare, Threatened, and Endangered Species (18 CFR § 5.6(d)(3)(vii))

As part of the information gathering process conducted to support the development of this PAD, Boott conducted an informal USFWS Information for Planning and Consultation (IPaC) search on February 28, 2018. The IPaC search generates a report listing species and other resources such as critical habitat under the USFWS' jurisdiction that are known or expected to be on or near the Project area. Boott will conduct formal RTE consultation with USFWS during the licensing process.

5.7.1 Federally Listed Threatened, Endangered, and Candidate Species

Based on an informal IPaC search conducted on February 28, 2018, the federally listed threatened Northern Long-eared bat, *Myotis septentrionalis*, was listed as potentially affected by activities in the Project area. No other federally listed species or critical habitats were listed in the informal IPaC search.

5.7.1.1 Northern Long-eared Bat

The Northern Long-eared bat is found across much of eastern and north-central United States and all Canadian provinces from the Atlantic Ocean west to the southern Yukon Territory and British Columbia (USFWS 2013). It is a medium-sized bat, measuring 3 – 3.7 inches, with a wingspan of 9 or 10 inches. Its fur color can be medium to dark brown on the back and tawny to pale-brown on the underside (USFWS 2013). The bat is distinguished by its long ears relative to other bats in the genus Myotis (USFWS 2013).

The Northern Long-eared bat spends winters hibernating in caves and mines, preferring hibernacula with very high humidity. During the summer months, the Northern Long-eared bat prefers to roost singly or in colonies underneath bark, in cavities, or in the

[6] The NHDES wetland data GIS layer only included data for the Palustrine System within the Project boundary.

crevices of live or dead trees (USFWS 2013). Breeding begins in late summer or early fall when males swarm near hibernacula. After a delayed fertilization, pregnant females migrate to summer colonies where they roost and give birth to a single pup. Young bats start flying 18 – 21 days after birth, and adult Northern Long-eared bats can live up to 19 years (USFWS 2013).

Northern Long-eared bats emerge at dusk and fly through the understory of forested hillsides feeding on moths, flies, leafhoppers, caddisflies, and beetles. They also feed by gleaning motionless insects from vegetation and water (USFWS 2013).

The most severe and immediate threat to the Northern Long-eared bat is white-nose syndrome. As a result of this disease, numbers have declined by 99 percent in the northeast. Other significant sources of mortality include impacts to hibernacula from human disturbance. Loss or degradation of summer habitat as a result of highway or commercial development, timber management, surface mining, and wind facility construction and operation also contribute to mortality (USFWS 2013).

5.7.2 State-listed Threatened, Endangered, and Candidate Species

Listings of the applicable state-listed threatened, endangered, and candidate species, as well as species of special concern, candidate species, and communities (RTE species) were obtained by request from map and database information provided by the Massachusetts Natural Heritage and Endangered Species Program (Massachusetts NHESP) and the New Hampshire Natural Heritage Bureau (New Hampshire NHB). In addition, habitat information was provided by the New Hampshire NHB, Massachusetts NHESP, as derived from the New Hampshire NHB's and Massachusetts NHESP's fact sheets, and flora manuals (e.g., Magee and Ahles 1999). Specific to the Project area, the potential presence of RTE species was determined by consulting with the Massachusetts NHESP and the New Hampshire NHB (see Appendix C). Table 5.7-1 lists the state-listed species and communities that the Commonwealth of Massachusetts and the State of New Hampshire list as potentially occurring within the Project area.

Table 5.7-1 State-listed threatened, endangered, species of special concern, candidate species, and communities potentially occurring within the Project vicinity.

Scientific Name	Common Name	Status[a, b]	Habitat/Notes
Massachusetts			
Haliaeetus leucocephalus	Bald Eagle	T	Large lakes, rivers; large riparian trees for nesting, roosting (DeGraaf and Yamasaki 2001).
Stylurus amnicola	Riverine Clubtail	E	Riverine clubtails inhabit primarily medium to large rivers. Although most species of Stylurus fly late in the season, riverine clubtails are on the wing from late June through mid-August (Massachusetts NHESP 2015).

Scientific Name	Common Name	Status[a, b]	Habitat/Notes
New Hampshire			
Alasmidonta varicosa	Brook Floater	E	Sections of stream with low to moderate flow and stable substrates (Nedeau et al. 2000).
Anguilla rostrata	American Eel	SC	American eels are opportunistic carnivores, selecting a range of prey items from small aquatic insects and crustaceans to larger macroinvertebrates and fish (Ross et al. 2001). Yellow eels associate with pools or backwater habitats and often have relatively small home ranges (Gunning and Shoop 1962).
Haliaeetus leucocephalus	Bald Eagle	SC	Large lakes, rivers; large riparian trees for nesting, roosting (DeGraaf and Yamasaki 2001).
Emydoidea blandingii	Blanding's Turtle	E	Permanent, shallow, dark waters with abundant vegetation; marshes, bogs, ditches, ponds, swamps, also in slow moving rivers and protected coves (DeGraaf and Yamasaki 2001).
Heterodon platirhinos	Eastern Hognose Snake	E	Where sandy soils predominate, such as beaches, open fields, dry, open pine or deciduous woods (DeGraaf and Yamasaki 2001).
Sturnella magna	Eastern Meadowlark	T	Large grassy fields of intermediate height and density but also uses grassy meadows, hay fields, tall-grass prairies, agricultural fields and open weedy orchards (DeGraaf and Yamasaki 2001).
Ammodramus savannarum	Grasshopper Sparrow	T	Generally prefers moderately open grasslands with patchy bare ground: dry hayfields, especially those with alfalfa and red clover, weedy fallow fields, prairies, and coastal dunes in Massachusetts (DeGraaf and Yamasaki 2001).
Sylvilagus transitionalis	New England Cottontail	E	Brushy areas, open woodlands, swamps, mountains, beaches, and open lands (DeGraaf and Yamasaki 2001).
Lithobates pipiens	Northern Leopard Frog	SC	Wet open meadows and fields and wet woods during summer months, including river floodplains (DeGraaf and Yamasaki 2001).

Scientific Name	Common Name	Status[a, b]	Habitat/Notes
Petromyzon marinus	Sea Lamprey	SC	In fresh water, sea lampreys use river reaches with gravel substrate for spawning. Spawning habitat is similar to that used by salmon, occurring at the upstream end of riffles and the tail end of pools (NHDFG undated*b*).
Porzana carolina	Sora	SC	Prefers freshwater marshes with shallow to intermediate water depths and dominated by emergent vegetation (DeGraaf and Yamasaki 2001).
Pooecetes gramineus	Vesper Sparrow	SC	Sparsley vegetated dry uplands such as short-grass meadows, grazed pastures, hayfields, grain fields, dry open uplands, and burned and cutover areas (DeGraaf and Yamasaki 2001).
Viola pedata var. pedata	Bird-foot Violet	T	This species occurs in sandplains, disturbed openings, dry forests, and thin woods. Threats would include direct destruction of the plants or major alterations in their habitat (Magee and Ahles 1999; New Hampshire NHB 2018).
*Cenchrus longispinus**	Long-spined Sandbur	E	This species grows in dry, sandy soil of fields, roadsides, waste areas, beaches, river flats, sandplains, and disturbed openings, and is sensitive to disturbances that eliminate its habitat (Magee and Ahles 1999; New Hampshire NHB 2018).
Betula nigra	River Birch	T	This species grows along rivers and streambanks and the population could be deleteriously affected by any project activities that alter the hydrology of its habitat, by increased sedimentation, and by increased nutrients/pollutants in stormwater runoff (Magee and Ahles 1999; New Hampshire NHB 2018).
Lupinus perennis ssp. perennis	Wild Lupine	T	This wildflower grows in extremely dry, sandy openings. It is tolerant of surrounding disturbance and depends upon periodic mowing (or, historically, wildfire) to eliminate trees that would otherwise shade it out (New Hampshire NHB 2018).

Scientific Name	Common Name	Status[a, b]	Habitat/Notes
Eleocharis diandra	Wright's Spikesedge	E	Wright's spikesedge is found along gently sloping freshwater shorelines and marshes. It commonly occurs in disturbed, saturated soils of river edges, often in small depressions. It is typically found in the zone along the water's edge that undergoes spring flooding and is exposed in the summer. The species is primarily vulnerable to changes to the hydrology of its wetland habitat, especially alterations that change water levels. It may also be susceptible to increased pollutants and nutrients carried in stormwater runoff (Magee and Ahles 1999; New Hampshire NHB 2018; Massachusetts NHESP 2012).
N/A	Hemlock Forest*	--	Hemlock forests typically occur on rocky, coarse, and/or thin soils poor in nutrients, including ravines, gorges, river and kame terraces, and other microsites below 2000 feet in elevation. Soils typically have well-developed E horizons (classic Spodosols), are very acidic, high in exchangeable aluminum, and low in available nitrogen and other nutrients. Threats include logging, introduction of invasive species, and direct destruction due to development (Sperduto and Nichols 2004; New Hampshire NHB 2018).
N/A	High-gradient Rocky Riverbank System	--	Threats are primarily changes to the hydrology of the river, land conversion and fragmentation, introduction of invasive species, and increased input of nutrients and pollutants (New Hampshire NHB 2018).

Sources: New Hampshire NHB 2018; Massachusetts NHESP 2018; Massachusetts Executive Office of Energy and Environmental Affairs (MEOEEA) 2018.
[a] "E" = Endangered, "T" = Threatened, "SC" = Special Concern, "--" = an exemplary natural community, or a rare species tracked by New Hampshire NHB that has not yet been added to the official state list. An asterisk (*) indicates that the most recent report for that occurrence was more than 20 years ago.
[b] The request to New Hampshire NHB included lands within the FERC Project boundary but did not specify a maximum linear distance from the Project boundary in which potential RTE species would be identified. Therefore, for the purposes of this PAD, the RTE project area in New Hampshire has been defined as all lands within the FERC Project boundary and lands within approximately 500 feet of the Project boundary.

5.7.2.1 Massachusetts NHESP Priority and Estimated Habitats

The Massachusetts NHESP identifies Priority Habitat based on the known geographical extent of habitat for all state-listed rare species, both plants and animals, and is codified under the Massachusetts Endangered Species Act (MESA). Habitat alteration within

Priority Habitat may result in a take of a state-listed species and is subject to regulatory review by the Massachusetts NHESP. Currently, a portion of the Project boundary, and adjacent terrestrial habitats outside the Project boundary, are listed as Massachusetts NHESP Priority Habitat (Priority Habitat 1987). This area extends from approximately 1.03 miles south of the New Hampshire border on the northern end to just south of the Greater Lowell Technical High School on the southern end along the Merrimack River (HDR 2018).

The Massachusetts NHESP also identifies Estimated Habitats, which are a sub-set of the Priority Habitats, and are based on the geographical extent of habitat of state-listed rare wetlands wildlife and is codified under the Wetlands Protection Act (WPA), which does not protect plants. State-listed wetland wildlife species are protected under the MESA as well as the WPA. Currently, a portion of the Project boundary, and adjacent terrestrial habitats outside the Project boundary, are listed as Massachusetts NHESP Estimated Habitat (Estimated Habitat 1320). This area extends from approximately 1.03 miles south of the New Hampshire border on the northern end to just south of the Greater Lowell Technical High School on the southern end along the Merrimack River (HDR 2018).

5.7.3 Biological Opinions, Status Reports, and Recovery Plans (18 CFR § 5.6(d)(3)(vii)(C))

Multiple biological opinions have been developed for the Northern Long-eared bat, but none are specific to the Lowell Project (USFWS 2017*a*).

5.7.4 Critical Habitat (18 CFR § 5.6(d)(3)(vii)(D))

Based on an informal IPaC search, the USFWS has not designated critical habitat in the vicinity of the Lowell Project.

5.8 Recreation and Land Use (18 CFR § 5.6(d)(3)(viii)

5.8.1 Existing Recreation Facilities and Opportunities

The Merrimack River provides extensive recreational opportunities. Activities such as boating, canoeing, kayaking, rowing, fishing, and swimming take place immediately on the river. The surrounding vicinity is used for hiking, cross country skiing, picnicking, bird watching, nature study, and overall enjoyment of scenic views (Nashua Regional Planning Commission [NRPC] 2008). Recreational opportunities differ closer to the larger, more populated cities along the river. Figure 5.8-1 depicts the wide range of recreational opportunities in the vicinity of the Project.

5.8.1.1 Recreational Opportunities in the Vicinity of the Project

Recreational fishing is popular in the Merrimack River by way of boat or shoreline. Game species sought by anglers on the Lower Merrimack River include small and large mouth bass as well as rainbow and brook trout, which are stocked by NHDFG (NHDES 2016*a*). For shoreline fishing, the canal walkways offer a pier-fishing experience for common warm water fishes (Orvis 2018).

Boating in the Project vicinity includes canoeing, kayaking, rowing, and motorboating. The river provides quickwater and flatwater experiences for canoeists and kayakers and is one of the largest surface water bodies in the region for motor boating. Local watershed organizations sponsor a variety of paddling trips on the Merrimack River and its tributaries throughout the spring, summer, and fall for beginner and intermediate paddlers (NHDES 2017*b*). Whitewater boating is less popular in the area; however, American Whitewater reports a 1.25-mile run on the Concord River through downtown Lowell with a difficulty of class III and class IV rapids under normal flows. The whitewater section has four named rapids, but has numerous surfing and play spots (American Whitewater 2018). Upstream of the northern extent of the Project impoundment is a whitewater kayak course located in Manchester, New Hampshire. There are also class I-II+ rapids located between Amoskeag Falls to Goffs Falls (City of Manchester 2018).

Additional recreational activities such as hiking, walking, and swimming are available in the Project vicinity at a number of parks and conservation areas. These facilities are discussed below.

Lowell National Historical Park

The Lowell National Historic Park was established in 1978 and is operated by the NPS. This National Historic Park is made up of a group of different sites in and around the city of Lowell, Massachusetts, related to the era of textile manufacturing that relied on hydroelectric power to operate during the Industrial Revolution of the early 1800s. It is a primary recreation attraction for the city of Lowell and the Lowell Project. Lowell National Historical Park amenities are discussed further in Section 5.8.1.2. Portions of the Lowell National Historic Park are within the Project boundary.

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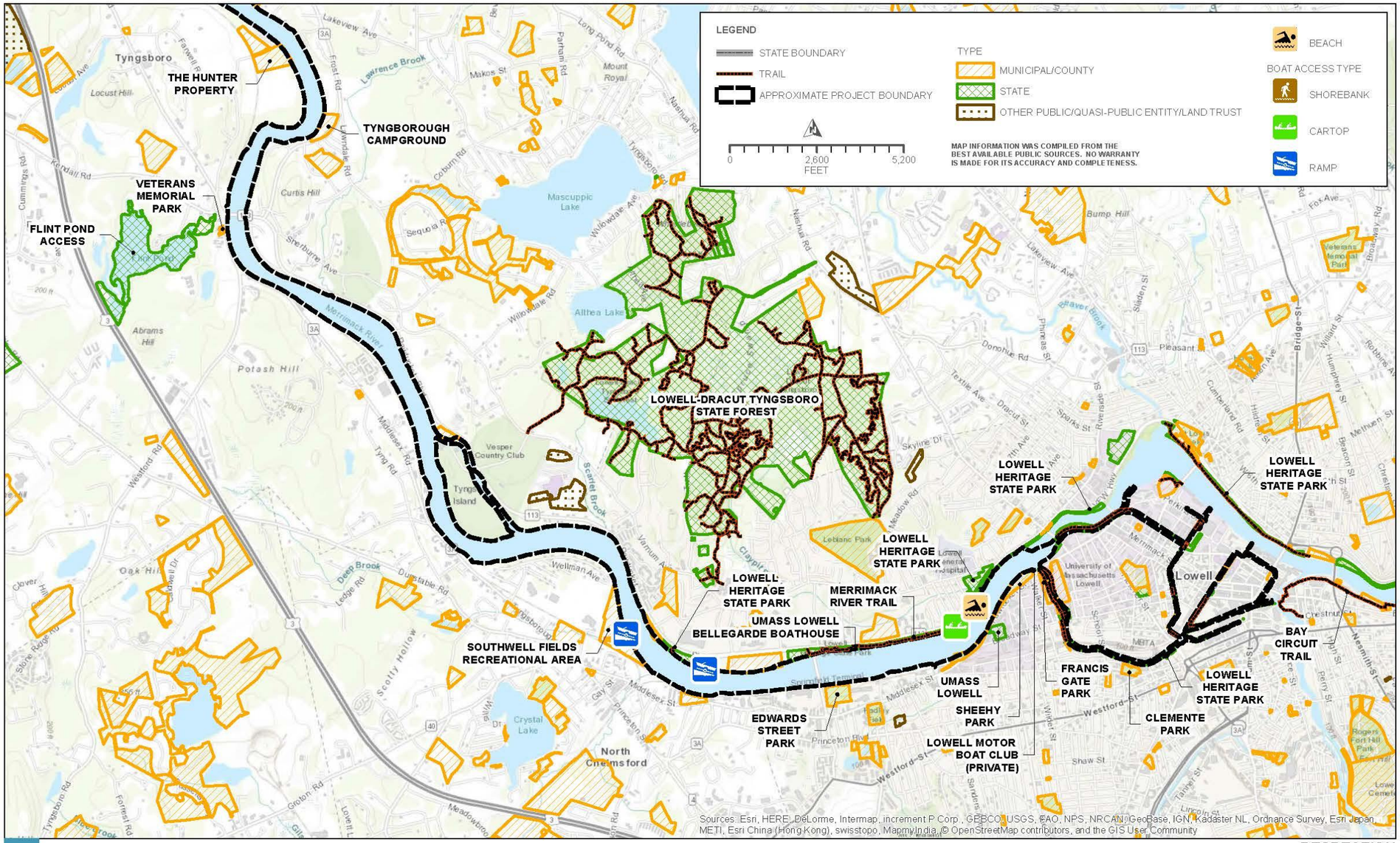
Figure 5.8-1. Recreation Opportunities in the Vicinity of the Lowell Hydroelectric Project.



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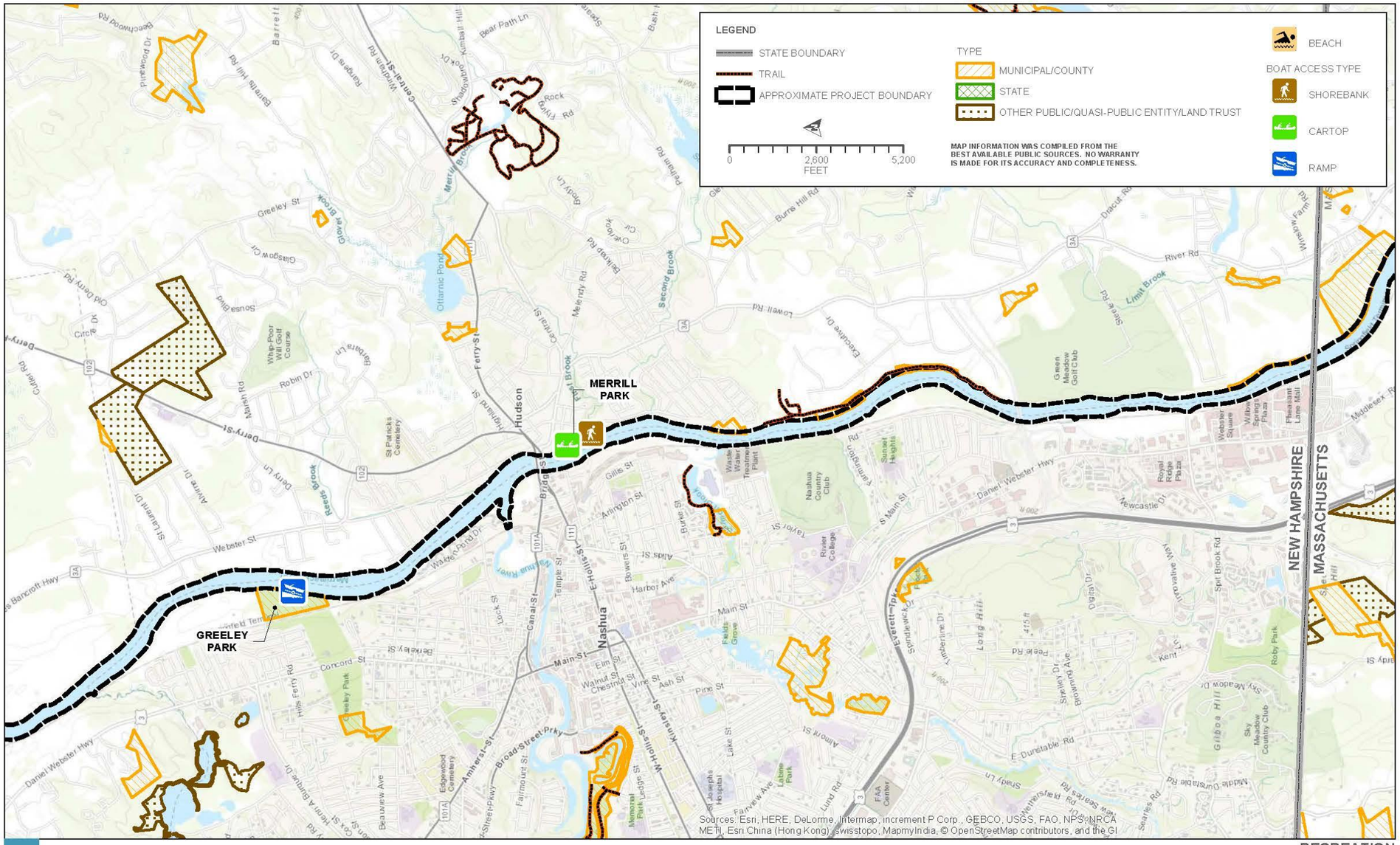

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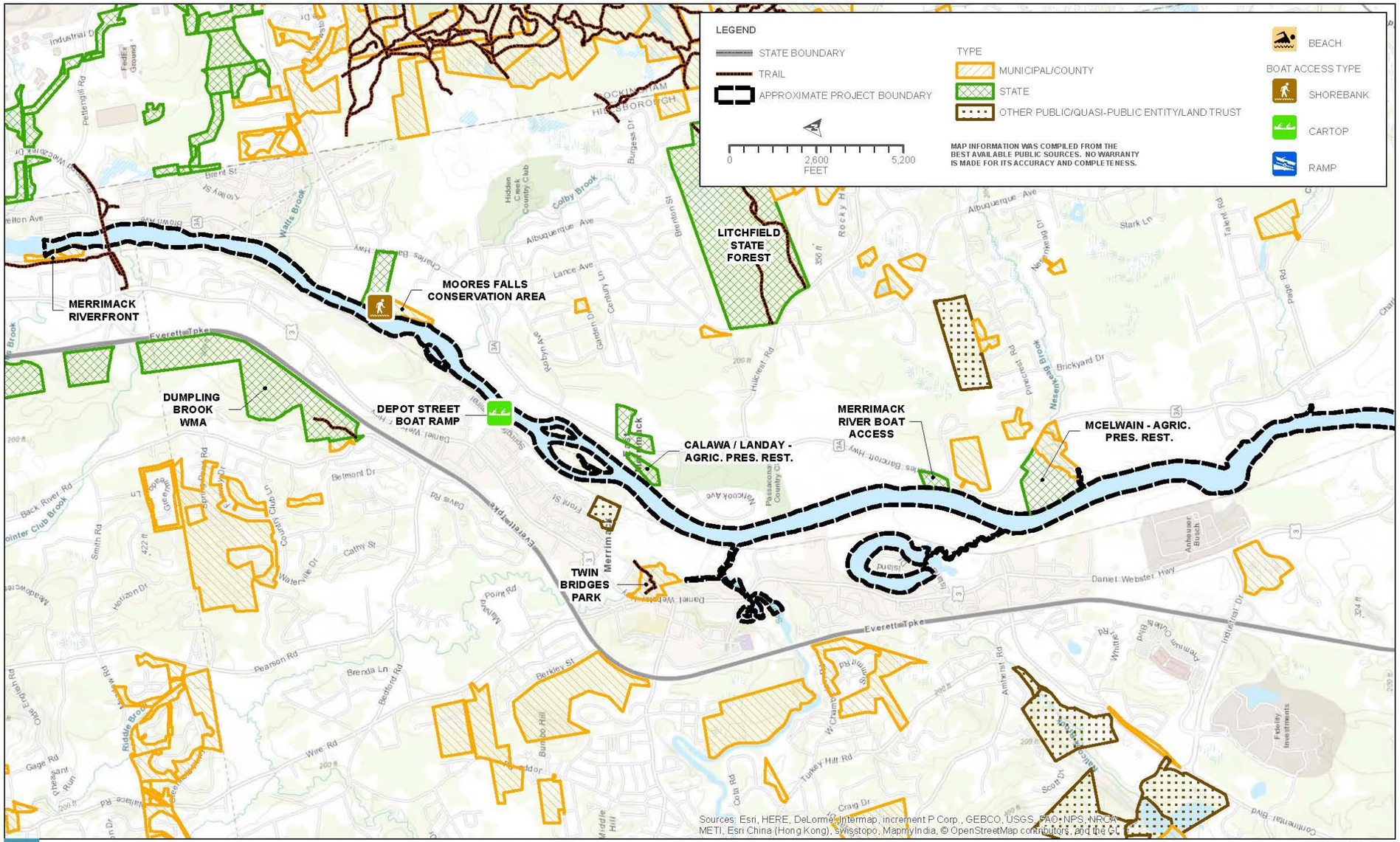

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Lowell Heritage State Park

The Lowell Heritage State Park occupies a 2-mile long stretch along the north bank of the project impoundment, upstream of the Pawtucket Dam. The park features historical exhibits that were created in partnership with the NPS to educate the public regarding the network of canals and mills constructed in the 19th century to power Lowell's then-bustling textile industry. Activities available include biking, boating (non-motorized and motorized), canoeing and kayaking, swimming, fishing, hiking, and educational programs. Facilities include a boat ramp, paved bike path and walking esplanade, picnic area, a beach, restrooms, scenic viewing area, an outdoor concert stage, and visitors center (Commonwealth of Massachusetts 2018*d*). Also located within the park boundary is the University of Massachusetts Lowell Bellegarde Boathouse, which also houses the Merrimack River Rowing Association, a non-profit rowing club. A trailered boat launch is provided at the Rourke Brothers Boat Ramp located on the north bank of the impoundment about 2 miles upstream of the dam.

Lowell-Dracut Tyngsborough State Forest

The Lowell-Dracut Tyngsborough State Forest spreads across three towns and features over 1,000 acres to explore. Popular activities include hiking, fishing, hunting, biking, horseback riding, snowmobiling, and cross-country skiing (Commonwealth of Massachusetts 2018*e*). The Lowell-Dracut Tyngsborough State Forest is approximately one mile north of the Project boundary.

Flints Pond Access

Flints pond is a 50-acre, warm water pond located in the town of Hollis in southern New Hampshire. The pond is open to the public for fishing, kayaking, and canoeing in the summer. In the winter ice fishing, snowshoeing, and snowmobiling are also popular. A boat ramp is available at the north end of the pond (Flint Pond Improvement Association 2015). Flints Pond Access is approximately ¼ mile west of the Project boundary.

Merrill Park

Merrill Park is located in Hudson, New Hampshire, and is a 9.3-acre park adjacent to the east river bank and project boundary. The park has picnic benches and includes a path which leads down to the Merrimack River allowing hand-carry access for canoes or kayaks (Town of Hudson undated).

Twin Bridge Park

Twin Bridge Park is located in Merrimack, New Hampshire, and features a baseball field, playground, picnic area, and extensive hiking trails through 27 acres of woods along Baboosic Brook (Town of Merrimack undated). Twin Bridge Park is approximately ¼ mile west of the Project boundary.

Moore's Falls Conservation Area

Moore's Falls Conservation Area offers shoreline fishing and car-top boating access to the project impoundment. There are also trails accessing the Merrimack River. Moore's Falls is adjacent to the Project boundary.

Merrimack River Boat Access

There are six boat access facilities with access to the Project impoundment. These facilities range in design from concrete ramps to shoreline access and are described below in Table 5.8-1. These access facilities are also depicted in Figure 5.8-1.

Table 5.8-1. Boat Access Facilities to the Lowell Project Impoundment.

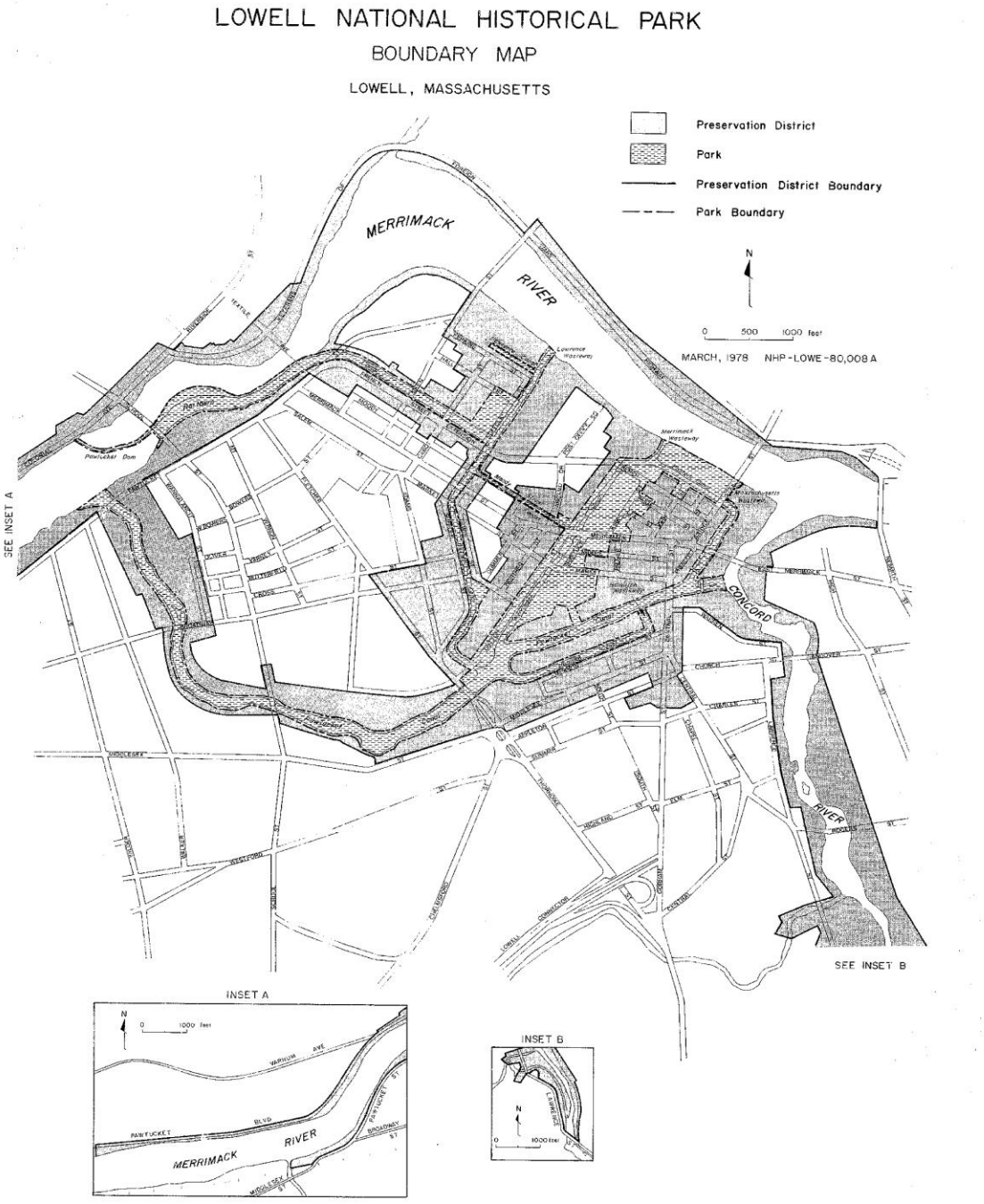
Name	Management	Location	Access Description
Lowell Heritage State Park – Rourke Brothers Boat Ramp	Massachusetts Department of Conservation Resources	Lowell, MA	Concrete ramp access with 44 trailer spots and 20 car spots.
Chelmsford Boat Access	Town of Chelmsford	Chelmsford, MA	Concrete pad access with 30 trailer spots.
Merrill Park	Town of Hudson	Hudson, NH	Walk-in access and unimproved parking.
Greeley Boat Ramp	City of Nashua	Nashua, NH	Concrete and gravel ramp access and gravel parking.
Depot St. Boat Ramp	Unknown	Merrimack, NH	Walk-in/car-top access with parking for eight vehicles.
Moore's Falls Conservation Area	Town of Litchfield	Litchfield, NH	Walk-in access with gravel parking.

Source: NHDFG 2018, MassGIS, 2018*a*.

5.8.1.2 Recreational Opportunities at the Project

As noted in Section 5.8.1.1, the Lowell National Historic Park was established in 1978 and is operated by the NPS. This National Historic Park is made up of a group of different sites in and around the city of Lowell, Massachusetts, (Figure 5.8-2) related to the era of textile manufacturing that relied on hydropower to operate during the Industrial Revolution of the early 1800s. Given its unique setting as the origin of the American Industrial Revolution, the historic value of the lower Merrimack River valley, the city of Lowell, and the Lowell Project is recognized as the Lowell National Historic Park. While the majority of the Project facilities, canals, gatehouses, dams, locks, and powerhouses, are necessary components of its operations, they serve a dual purpose as a NPS attraction for which it is maintained and preserved as a historic property (NPS undated*a)*. Although portions of the Lowell National Historic Park are within the Project boundary, it is not a FERC-approved recreation facility.

Figure 5.8-2 Lowell National Historic Park Boundary.



The attractions of the Lowell Project that are open to the public as part of the Lowell National Historic Park are managed by NPS. Opportunities available include walking tours of the waterways, guided tours, music concerts, boat rides, and museum exhibits. The walking tours, self- or professionally-guided, follow the network of canals originating at the Pawtucket Dam and ending at the confluence of the Concord and Merrimack Rivers (Figure 5.8-3) (NPS undated*b*).

Most of the walkways that follow the canals are integrated into the common thoroughfares of the city of Lowell. The Northern Canal Walkway is unique in that it contains a pedestrian bridge upstream of the E.L. Field Powerhouse that crosses the Northern Canal and turns upstream to follow the “Great River Wall,” the 36-foot-high granite wall that forms the canal. The Northern Canal Walkway provides interactive recreation with the historic structures of the Lowell Project, as well as a greenway along a scenic reach of the Merrimack River (Figure 5.8-4) (NPS undated*b*).

Boat tours led by NPS guides also provide access to the Project impoundment, Northern Canal, and other waterways of the Lowell historic district. The canal boat tours highlight some of the Lowell Project facilities by travelling through the historic navigation locks (NPS undated*b*).

Additional recreational opportunities provided by NPS at the Lowell National Historic Park include renovated historic textile mills that are open to visitors and trolley rides available for touring the city.

Figure 5.8-3. Walkway Tours in Lowell Historic National Park.

Source: NPS undated*b*.

Figure 5.8-4. View looking upstream along the Northern Canal Walkway.

5.8.1.3 FERC-Approved Recreation Facilities

Article 38 of the license required Boott to file a recreation plan that incorporated construction of a visitor center at the E.L. Field Powerhouse. The visitor center at the E.L. Field Powerhouse is the Project's only FERC-approved recreation facility. The visitor center offers a secured view of the interior of the turbine gallery and an interpretive display which provides information regarding the development history and operation of the Project, nearby historic, natural, cultural, recreational resources, and other items of interest (Figure 5.8-5).

Figure 5.8-5. Interpretive display at the E.L. Field Powerhouse Visitor Center.

5.8.2 Current Project Recreation Use Levels

The FERC Form 80 process documents recreation use levels at the Project. The most recent FERC Form 80 was submitted on May 29, 2015, and documented use levels for the Lowell Power Station in 2014. According to the Form 80, the interpretive display at the E.L. Field Powerhouse Visitor Center had a capacity utilization of 5 percent. On April 15, 2016, FERC waived filing of the FERC Form 80 for the Assets Power Station, Bridge Street Power Station, John Street Power Station, and Hamilton Power Station developments at the Lowell Project (FERC 2015*b*).

Although not FERC-approved recreation facilities, the FERC Form 80 also documented recreation use at recreation amenities adjacent to the Project including the facilities provided at the Lowell Heritage State Park. All of these areas were documented as a 40 percent capacity utilization or below (FERC 2015*b*).

5.8.3 Existing Shoreline Buffer Zones

At normal pool elevation of 92.2 feet NGVD, there are 36 shoreline miles bordering the impoundment impounded by the Pawtucket Dam.

In Massachusetts, the Wetlands Protection Act (Massachusetts General Laws Chapter 131, Section 40) protects important water-related lands such as wetlands (“swamps”), floodplains, riverfront areas, and other areas from destruction or alteration. The Act is implemented through 310 CMR 10.00 issued by the MADEP. In most cases, the regulations are implemented by the local Conservation Commission in each municipality.

Some municipalities may have zoning regulations which are more restrictive than the state regulation. The Act establishes a 100-foot buffer zone around all coastal banks, inland banks, freshwater wetlands, coastal wetlands, tidal flats, beaches, dunes, marshes, and swamps, and a riverfront area within 200 feet of rivers and streams (or 25 feet of some urban rivers) that flow year round. The canals in Lowell are specifically defined as not having a riverfront area [310 CMR 10.58 (2)1.g. Human-made canals (e.g., the Cape Cod Canal and canals diverted from rivers in Lowell and Holyoke) and mosquito ditches associated with coastal rivers do not have riverfront areas] (MACC undated).

Under the Act no one may “remove, fill, dredge, or alter” any wetland, floodplain, bank, land under a water body, land within 100 feet of a wetland, or land within 200 feet of a perennial stream or river (25 feet of a few urban rivers), without a permit (known as an Order of Conditions) from the local conservation commission that protects the wetland “interests” identified in the Act. The “interests” or values protected by the Act are: flood control; prevention of storm damage; prevention of pollution; and protection of fisheries, shellfish, groundwater, public or private water supply, and wildlife habitat (MACC undated).

A large amount of the Project impoundment is in New Hampshire. New Hampshire’s Comprehensive Shoreland Protection Act (CSPA) requires any disturbance activity greater than 50,000 feet^2 occurring within 250 feet of the Merrimack River to obtain an Alteration-of-Terrain permit (LMRLAC 2008). While the CSPA contains minimum standards to protect public surface waters and their immediate environs, the LMRLAC issued a 2008 Lower Merrimack River Corridor Management Plan which provides goals and objectives “to promote the conservation, protection, and sound management of the Lower Merrimack River corridor.”

5.8.4 Recreation Needs Identified in Management Plans

The most recent Massachusetts Statewide Comprehensive Outdoor Recreation Plan (SCORP) was published in 2012. The SCORP is a planning document that discusses the available recreational resources in a state, as well as its needs, and identifies the gaps between the two. In drafting of the SCORP, the Massachusetts Executive Office of Energy and Environmental Affairs (MEOEEA) hosted a series of public meetings across the state in the fall of 2011. Six meetings were held in each geographic region of the state and were advertised through press releases, signage, and email distribution lists. A web-based survey was also utilized to gather input from both residents and recreation providers. Over 3,000 citizens responded to the survey as well as 83 municipalities and 38 land trusts. A phone survey was also conducted (MEOEEA 2012).

The outreach conducted in support of the SCORP found that most respondents felt there was a need for additional trails and water-based recreation. Respondents requested more town or city-wide trail systems, loop trails within long distance trail networks that can be completed in a shorter amount of time, and urban trails that connect to water bodies. As for water-based recreation, respondents cited a need for more water access, whether for swimming or boating as well as the development of more boat ramps (MEOEEA 2012).

MEOEEA developed four goals through review of the outreach. These goals are as follows:

1. Increase the availability of all types of trails for recreation;
2. Increase the availability of water-based recreation;
3. Invest in recreation and conservation areas that are close to home for short visits; and
4. Invest in racially, economically, and age diverse neighborhoods given their projected increase in participation in outdoor recreation.

These goals are expected to help the Commonwealth of Massachusetts target their resources to facilities that meet the above demand and overcome barriers to recreation (MEOEEA 2012).

The most recent New Hampshire SCORP was developed in 2013. The primary goal of the New Hampshire SCORP is to identify outdoor recreation trends, needs, and issues for New Hampshire, as well as to provide a strategic plan to help address the concerns and expectations. In addition, the SCORP evaluates the demand and supply of outdoor recreation resources and facilities statewide. In development of the New Hampshire SCORP, the New Hampshire Department of Resources and Economic Development (NHDRED) and the New Hampshire Office of Energy and Planning (NHOEP) conducted outreach sessions around the state of New Hampshire and analyzed relevant national, regional, and state plans (New Hampshire Department of Natural and Cultural Resources [NHDNC] 2013).

The outreach conducted in support of the New Hampshire SCORP found that respondents were heavily involved in running, jogging, and trail running. Fishing was second in popularity followed by biking, camping, and hiking (NHDNC 2013). The public engagement process for the development of the SCORP yielded the following findings:

- Health and Quality of Life

  There is a growing appreciation for the benefits of outdoor recreation, including reduced health care and transportation costs. Access for all children, senior citizens, and people with disabilities is important.

- Economic Development and Funding

  Recreational opportunities contribute to economic vitality and attract business. Retailers should be enlisted to support the State’s outdoor recreation initiatives.

- Community Recreation, Children, and Youth

  Opportunities for the underserved (including urban populations and immigrants) are important, as well as leadership opportunities for young people, and education on how and where to recreate close to home.

- Connectivity - Places and People

  There is a high value placed on increasing connectivity among recreational sites and trails while addressing the environmental impact and safety concerns that come with multiple users.

- Communications and Outreach

  Cultivating volunteerism and developing partnerships to combine resources and a centralized source of importance were important. Addressing the risk aversion of parents letting children play outdoors, also identified as a “culture of fear,” was a priority.

- Stewardship

  It is important to implement sustainability practices in stewardship plans, including adequate funding and overall financial support for lands, facilities, and programs.

With the findings, NHDRED and NHOEP set the following four priorities for the State of New Hampshire:

1. Connect people to the outdoors;
2. Consistent stewardship and conservation;
3. Economic vitality; and
4. Education ethics and benefits.

These priorities are intended to provide guidance for a collective path to help move New Hampshire towards a variety of active outdoor recreational opportunities and enjoyment (NHDNC 2013).

The 2008 Lower Merrimack River Corridor Management Plan also includes recreation-related goals. The purpose of the plan is to provide guidance to the communities adjacent to the Lower Merrimack River as they make decisions having the potential to affect the Lower Merrimack River watershed, its river corridor, and the Lower Merrimack itself. One of the goals of the plan is to increase public access and use of the Lower Merrimack River. The plan includes two objectives to meet this goal:

- Objective 5.1 - Increase the recreational use of the Merrimack River corridor by at least 20 percent as measured in numbers and types of recreational users over the next 10 years by increasing the *quality* of recreational resource.
- Objective 5.2 - Increase the recreational use of the Merrimack River corridor by at least 20 percent as measured in numbers and types of recreational users over the next 10 years by increasing the *quantity* of the recreational resource.

Many of the recommendations to meet the objectives identified in the plan included developing additional parking areas or shared parking programs, improving signage at existing areas and providing signs for future public access areas, and facilitating improvements to the Greeley Boat Ramp (LMRLAC 2008).

5.8.5 Licensee’s Shoreline Permitting Policies

Boott does not have a shoreline management plan or permitting policy for the shoreline of the Lowell Project. For shoreline development actions within the Lowell Historic National Park, Boott coordinates with the NPS.

5.8.6 Specially Designated Recreation Areas

5.8.6.1 Wild and Scenic River System

The Merrimack River is not designated as part of the National Wild and Scenic River System.

5.8.6.2 Nationwide Rivers Inventory

The upper portion of the impoundment was listed under the National Rivers Inventory in 1995. The full classified reach is 16 miles long from Amoskeag Dam in Manchester to the confluence with Pennichuck Brook in Merrimack. The reach is considered notable due to fish, historic, recreational, and wildlife values (NPS undated*c).*

5.8.6.3 National Trails System and Wilderness Areas

The Lowell Project is not located within or adjacent to lands included in, or under study for inclusion in, the National Trails System or designated as, or under study for inclusion as, a Wilderness Area.

5.8.6.4 State-Protected River Segments

The lower reach of the Merrimack River, which includes the upstream impoundment of the Project in New Hampshire, is designated as a “Community River” under the New Hampshire Rivers Management and Protection Program (NHDES 2017*a*). Community rivers are defined as "those rivers or river segments which flow through populated areas of the state and which possess actual or potential resource values. Such rivers have some residential or other building development near their shorelines, are readily accessible by road or railroad, and may include some impoundments or diversion.” (NHDES 1990). The Lower Merrimack River Local Advisory Committee (LMRLAC) provides an advisory role on matters pertaining to the management of the river, and comments on development plans which might affect the river’s resource values. The LMRLAC also maintains a river corridor management plan pursuant to NH RSA 483:10 (NHDES 2008.

5.8.7 Regionally or Nationally Significant Recreation Areas

The Lowell Project is located within the Lowell National Historic Park, a regionally and nationally significant recreation area. The Lowell National Historic Park was established in 1978 and is operated by the NPS. This national historic park is made up of a group of different sites in and around the city of Lowell, Massachusetts, related to the era of textile manufacturing that relied on hydroelectric power to operate during the Industrial Revolution of the early 1800s. It is a primary recreation attraction for the City of Lowell and the Lowell Project. The Lowell National Historic Park is discussed in detail above in Section 5.8.1.1.

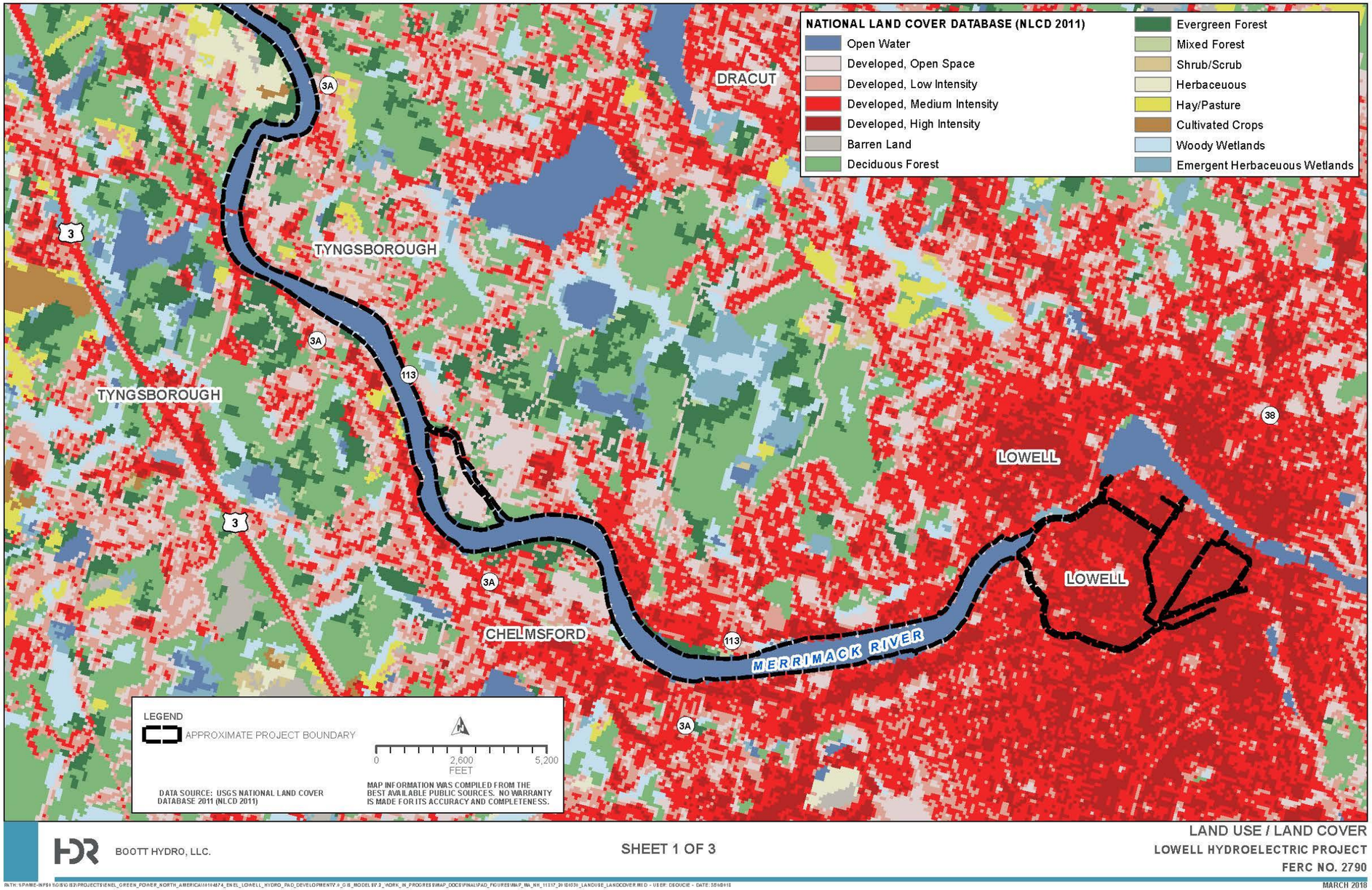
5.8.8 Land Use and Management

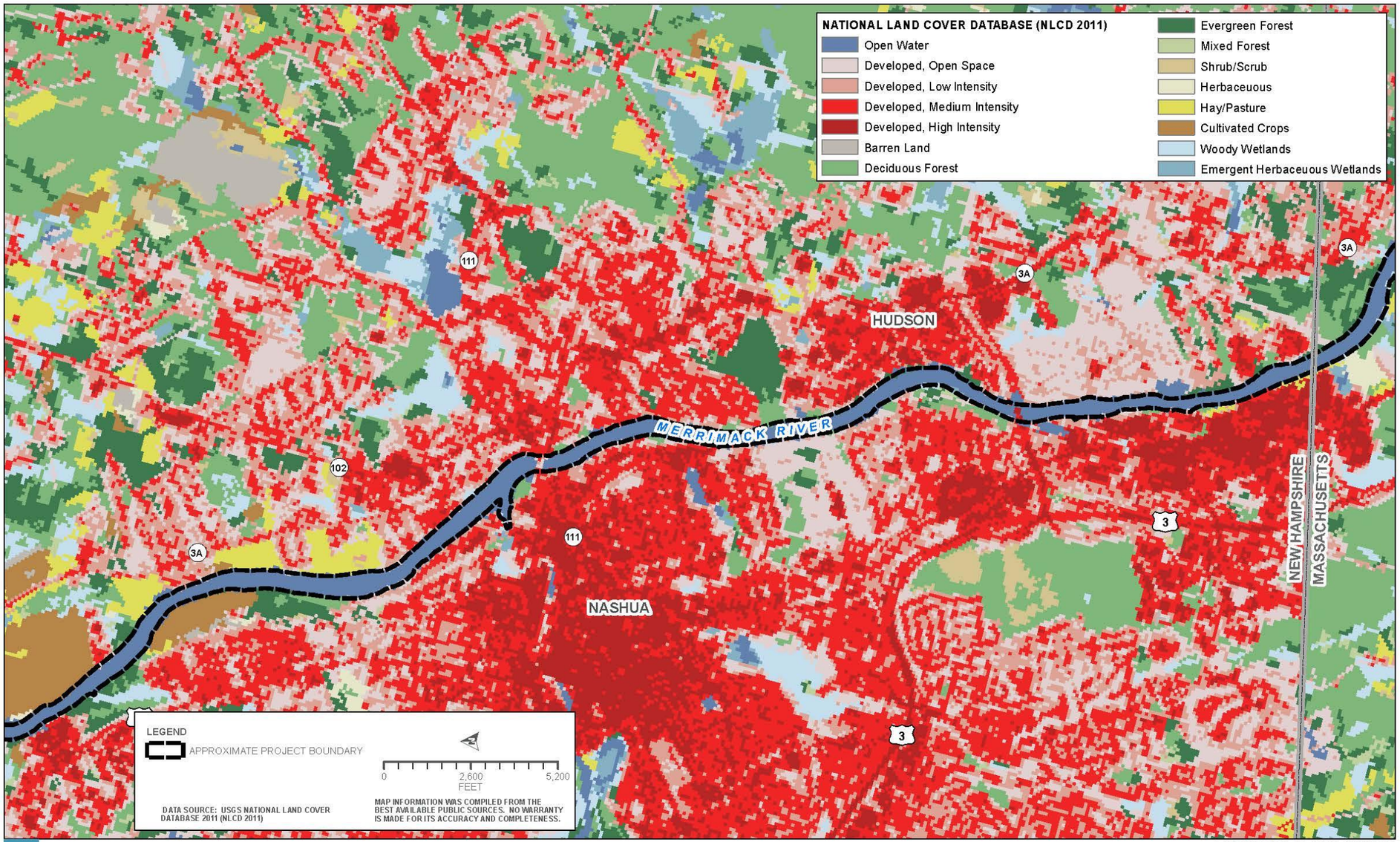
The facilities of the Lowell Project are situated in an intensely developed urban landscape. The historic use of the Merrimack River in the vicinity of the Lowell Project for navigation, transportation, and industrial applications remain as the primary feature

guiding its current use as a tourism attraction, municipal and industrial infrastructure element, and recreational asset. There are limited Project lands within the Project Boundary and only facilities needed for operation of the Project are included within the Project Boundary.

The impoundment of the Lowell Project varies more in land use. The impoundment is highly developed in the southern reach with more suburban and rural areas headed north to the Nashua area at which point the vicinity becomes medium to highly developed again. North of Nashua the area is more suburban, rural, and crops until the northern extent of the impoundment near Manchester at which point the area becomes developed again. Land use in the immediate vicinity of the Project is depicted in Figure 5.8-6.

Figure 5.8-6. Land Use in the Vicinity of the Lowell Project.





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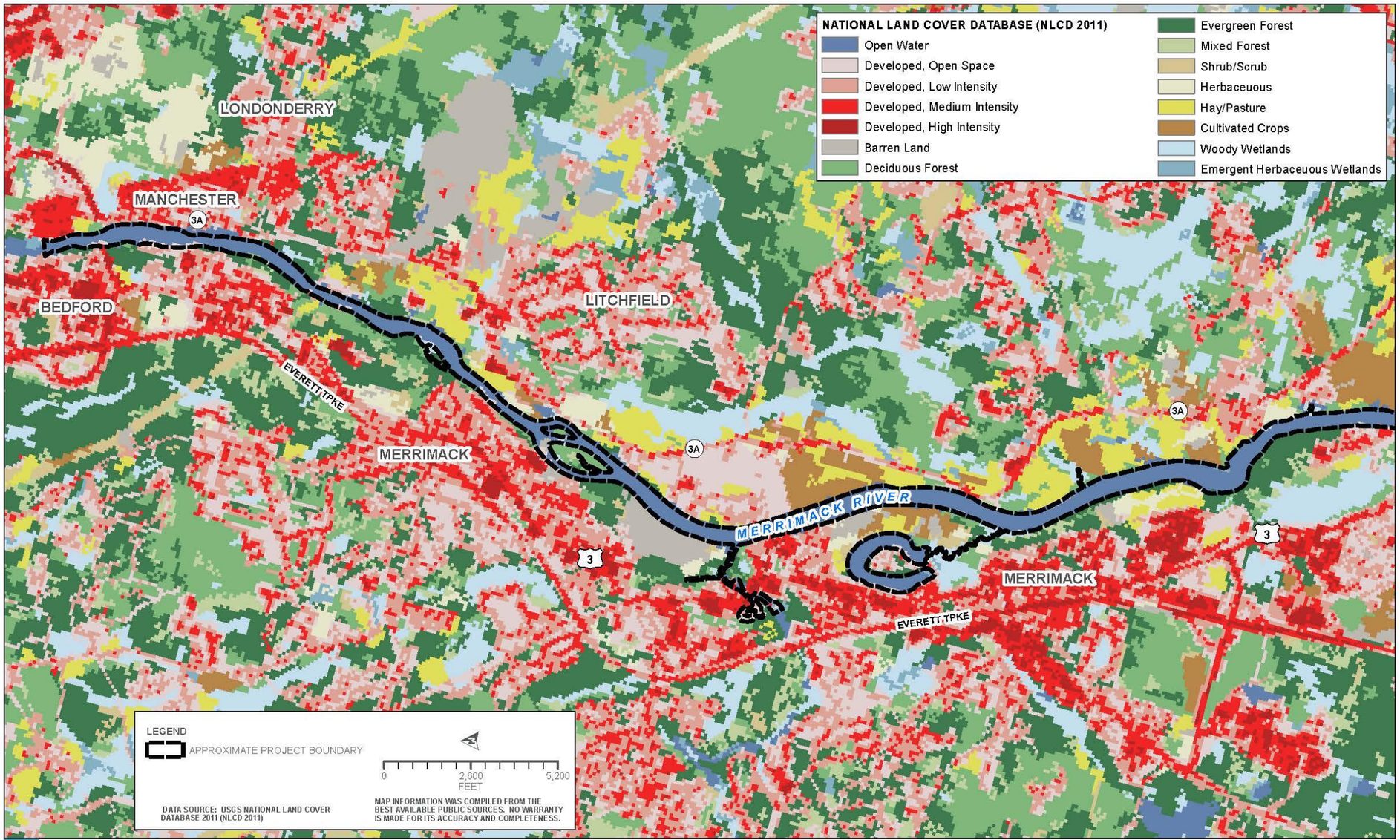

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5.9 Aesthetic Resources (18 CFR § 5.6(d)(3)(ix))

The aesthetic resources of the Lowell Project reside in the historic infrastructure that the Project is a part of. The multiple historic textile mills, gatehouses, locks, canals, and walkways that are part of the Lowell National Historic Park are the primary aesthetic attraction of the Lowell Project (Figures 5.9-1 through 5.9-3). Tourists are drawn to the city of Lowell to witness the historic site of the Industrial Revolution of the United States. In addition, the Project's immediate shoreline and river corridor offer a scenic backdrop in an intensely urbanized setting.

Figure 5.9-1. Pedestrian Walk with View of the Northern Canal (left) and Bypass Reach (right).

Figure 5.9-2. Guard Lock and Gates Facility.

Figure 5.9-3. Swamp Locks and Dam.

During the prior licensing, a number of officials stated that the powerhouse architecture should not mimic the nineteenth-century structures nearby. It was stated by officials that the modern nature of the new facility would be apparent and that it would harmonize well with the Northern Canal, the local neighborhood, and the river. The Licensee agreed to coordinate final exterior building design with the NPS and other interested agencies to help achieve this aim. Landscaping of the powerhouse area was also discussed in the prior application and the following proposals were made (Boott Mills 1980):

- Riverbank vegetation near the site to be protected the extent feasible;
- steep, riverside areas disturbed during construction are to be planted with native plant material;
- Street-level areas to compliment state and federal park design; and
- Transmission lines from station to adjacent highway bridge to be inconspicuous.

Photos 5.9-4 and 5.9-5 depict the Pawtucket Dam and E.L. Field Powerhouse, respectively. The E.L. Field Powerhouse is located in the vicinity of more modern architecture such as the University of Massachusetts Lowell dormitories.

Figure 5.9-4. Pawtucket Dam from Pawtucket Gatehouse (pneumatic crest gate system currently being installed).

Figure 5.9-5. E.L. Field Powerhouse with University of Massachusetts Lowell in the Background.

5.10 Cultural Resources (18 CFR § 5.6(d)(3)(x)

The Project is located within the Downtown Lowell Local Historic District as well as the Locks and Canals Historic District and the Lowell National Historical Park and Preservation District. The Downtown Lowell Heritage State Park was initially established in 1983 and later expanded in 1986 and 2004 with a mission which "…seeks to ensure that development activities within the district are consistent with the preservation of its 19th century setting."

Given its location within the historic district, Boott consults with various federal, state, and local historical-related stakeholders regarding Project operations and Project structures located within the districts. For example, Article 33 requires Boott, prior to the commencement of any construction activities, to cooperate with the Massachusetts State

Historic Preservation Officer and the NPS to carry out a mitigation program for avoiding or minimizing adverse effects on the Locks and Canals Historic District and the Lowell National Historic Park. In addition, any activities within the Downtown Lowell Historic District and ten additional neighborhood districts must be reviewed and approved by the Lowell Historic Board (City of Lowell undated*b*).

5.10.1 Historical Context

The text below provides a historical context of the Project area from Native American activity through the industrial revolution age.

Native American Activity at the Falls

For several thousand years, the Pawtucket Falls was a thriving center of Native American economic and cultural activity. The annual run of anadromous fish drew Pennacook Native Americans from a wide area of northern New England, and two subtribes, the Pawtuckets and Wamesits, established villages on the flats near the bend of the Merrimack below the falls. Salmon, sturgeon, shad, and alewives were harvested with nets, spears, and barbed arrows. The fish provided not only a large portion of the Native Americans' yearly protein intake, but also serves as fertilizer for the nearby agricultural fields. The site retains its Native American name today, for "Pawtucket" means rapids or falls in the Algonquin dialect of its early settlers (Boott Mills 1980).

Anglo-European settlers gradually acquired these Native American homelands, and private ownership divided the once common land into scattered farms. Proprietors of riverbank properties even acquired legal title to the fishing rights on sections of the rapids. Although remnants of former Native American bands made annual trips to fish at the Pawtucket Falls as late as the 1840s, they were considered a quaint curiosity in the growing industrial community (Boott Mills 1980).

Background of Industrial Lowell

A number of circumstances are responsible for Lowell becoming America's first industrial city, particularly, the existence of the great water power at the Pawtucket Falls. Although a transportation canal around the rapids at Lowell was completed in 1796, the manufacturing potential of the site was not fully appreciated until 1821. The Boston Associates chose the site of the Pawtucket Falls for their new textile manufacturing community (Boott Mills 1980).

The Boston investors acquired control of Proprietors of the Locks and Canals on Merrimack River, the company that had built the Pawtucket navigation canal and that, due to the success of the competing Middlesex Canal (direct route to Boston), was not doing well financially. The Boston investors and other industrialists formed a series of textile corporations in Lowell. The old canal company was set up to build canals, sell mill sites, manufacture machinery, and lease water power to the textile manufacturers (Boott Mills 1980).

The Pawtucket Canal became the feeder for a complex system of power canals beginning in 1822. By 1826, two canals branched from the Pawtucket and four additional canals were already envisioned. Ten years later, the expanded system was complete. Water drove the machinery of mills located on two distinct levels, with the tailraces of mills on the upper level emptying into canals leading to lower level mills. By 1846, when

a second major expansion of the canal system began, ten textile mill complexes and a machine shop received their power from Proprietors of the Locks and Canals on Merrimack River (Boott Mills 1980).

General History of the Northern Canal Area

Since 1826, engineers had been able to increase the flow into the Lowell Canal system by constructing dams at Pawtucket Falls. The first was a crude wooden structure; but by 1830, a masonry dam seated on heavy wooden cribbing was helping to maintain a "pond" behind the falls. Three years later, workmen added two more courses of granite headers and raised wooden flashboards. This raised the level of the upper river and diminished its current for over 18 miles upstream. However, the dam did not meet the water needs of the growing industrial city for long as the demand for water power continued to increase yearly as the textile corporations expanded their manufacturing operations. Power was continually scarce in the dry summer months; and by the 1840s, shortages were common throughout the year. One problem was the severe friction losses in the canals created by greater flow rates. When mills needed more water, the current had to increase to supply this demand. Increased current produced friction, which actually dropped the level of water in the canals and reduced the head, or potential to generate power. Thus, the mills could only get a greater flow of water by giving up some of the head that they also needed. In times of freshets, river water entering the tailraces of mills impeded their wheels. Such backwater conditions placed excessive demands on the canal system (Boott Mills 1980).

James B. Francis, the British-born chief engineer of Proprietors of the Locks and Canals of the Merrimack River, proposed the construction of a second feeder canal. This huge waterway would bring additional water into the system and allow a reduction of current in most of the canals. To make such a plan effective, however, two conditions had to be met. First, Locks and Canals would have to prohibit the use of water for manufacturing at night, so that the river's flow could be ponded until the morning. Second, the power company would have to control the outlets of the major lakes that fed the Merrimack River. Using the lakes as reservoirs, Lowell would then have a source of extra water in dry seasons (Boott Mills 1980).

With booming economic conditions in American textile manufacturing in the 1840s, the Essex Company of Lawrence and the Locks and Canals acquired control of over 100 square miles of lake surface in New Hampshire. James. B. Francis selected a new route for a second feeder canal. The route ran parallel to the river for over 2,000 feet, then turned inland to join the Western Canal. The route required Francis to build a "Great River Wall" to hold his canal above the Merrimack rapids and also required him to (1) rebuild a large part of the Pawtucket Dam, (2) construct sophisticated gate controls, and (3) modify the existing canal system to integrate it with the new canal (Boott Mills 1980).

The construction of the Northern Canal, under the supervision of James B. Francis in 1846-1847, was one of the most impressive achievements in the history of American engineering. The vast undertaking was the culmination of efforts to harness the flow of the Merrimack River at Pawtucket Falls to drive the textile machinery of the Boston investors. When completed, the project set new standards in civil and hydraulic engineering and introduced the famous "Francis" turbine to the world (Boott Mills 1980).

The Northern Canal brought water into the system with a higher head than had been previously possible, and it reversed the current in the Western Canal from the junction to the Swamp Locks Basin. Water from the Northern Canal supplied the demands of the Tremont, Suffolk, and Lawrence Mills. Once Francis had completed the Moody Street Feeder in 1848, the Northern Canal also fed the Merrimack Canal through three brick-vaulted tunnels. A smaller underground passage, known as the Boott Penstock, transferred some of this flow from the Merrimack Canal to the end of the Eastern Canal, where an adequate water level had always been hard to maintain (Boott Mills 1980).

After testing the results of his physical improvements to the system, Francis arranged for redistribution of power and an increase in the number of “mill powers” leased to each company. Because of the limitations of the old Pawtucket Canal as the sole feeder, only 91 mill powers had been leased up to that time. The Northern Canal enabled the chief engineer to lease 139 mill powers, a gain of more than 50 percent. These were "permanent mill powers” to be supplied in all seasons; for most of the year, the corporations could also purchase “surplus" mill powers at an inexpensive rate. The mill complexes were assured of almost 12,000 gross horsepower, even in summer (Boott Mills 1980).

Francis, acting as "The Chief of Police of Water,” tried to prevent waste in the system and developed techniques to monitor the water use by individual corporations. When the flow in the river was low, he even closed the gates of the Northern Canal during the noon break. His 1846 tests of Uriah Boyden's outward-flow turbines in the Appleton Mills convinced him that the corporations should switch from breastwheels to more efficient hydraulic turbines. In this way, they could produce more net horsepower from each “mill power" delivered to their sites. Also, turbines, which ran well underwater, could generate during the "backwater" conditions that ruined the efficiency of breastwheels. The widespread conversion to turbines in Lowell took place during and immediately following the construction of the Northern Canal. Francis' Northern Canal and its associated structures remain one of the most important historic engineering resources in the Northeast (Boott Mills 1980).

5.10.2 Archaeological and Historic Resources

5.10.2.1 Archaeological Resources

There are three pre-Contact archaeological sites recorded in the area of Lowell Park, however, many more exist along the Merrimack River both upstream and downstream of the Project. Many Archaic Period village sites, camp sites, and fishing grounds are document in the vicinity of the Project (Massachusetts Department of Conservation and Recreation [MADCR] 2014). Boott distributed PAD questionnaires to the Massachusetts Historical Commission (MHC) and the New Hampshire Division of Historical Resources (NHDHR); however, no responses were received. Boott will continue consultation with MHC and NHDHR over the course of the relicensing.

5.10.2.2 Historic Resources

In 1976 the Locks and Canals Historic District was listed on the National Register of Historic Places. The Locks and Canals Historic District includes the City of Lowell’s canal system, surviving millyards, and other industrial-related resources. In 1977, the Locks

and Canals Historic District was designated a National Historic Landmark, the nation's highest level of historic significance and recognition. In 1978, Congress passed the Lowell Act, which recognized the historical value of this industrial area and established the Lowell Park and Lowell Historic Preservation District, stating:

> *"…certain sites and structures in Lowell, Massachusetts, historically and culturally the most significant planned industrial city in the United States, symbolize in physical form the Industrial Revolution…"*

The Lowell Historic Preservation District surrounds Lowell Park as a buffer zone and enables federal assistance in the preservation and revitalization of the City of Lowell, while Lowell Park consists of the areas indeed for intensive visitor use in the interpretation of the City of Lowell and its canal system. The intention of the establishment of the Lowell Park and Lowell Historic Preservation District is to preserve and interpret the nationally significant historical and cultural sites, structures, and districts in Lowell, Massachusetts.

A Cultural Resources Inventory of the Lowell National Historical Park and Preservation District was prepared for the NPS in 1980 (included in Appendix I). This inventory was completed in response to the 1978 legislation establishing the Lowell National Historic Park and the Lowell Historic Preservation District. This legislation was two fold in that it created a park as well as a historic preservation district. The legislation outlined broad policies and goals of the federal commitment and required careful planning. To address this need for planning, the cultural resources inventory was conducted to assess the resources and aid in future planning.

The defining features of the Locks and Canals Historic District and Lowell National Historic District are discussed in further detail below.

Locks and Canals Historic District

The Locks and Canals Historic District was listed on the National Register in 1976 and became a National Historic Landmark in 1977. The Locks and Canals Historic District encompasses all of the canals in Lowell (built between 1793 and 1848), their associated locks, and the mills that were powered by the canals. This district contains features of the Lowell Project. There are approximately five miles of canals, and the associated mill yards increase the acreage of the district to approximately 100 acres. The canals are contiguous and meander throughout the city. The mill buildings and yards are all associated directly with a canal, and three boarding houses, not contiguous to the canals but built by mill owners for their workers, are also included in the district. The main components of the Locks and Canals Historic District are:

- Lock House
- Francis Gate and House
- Sluice Gate House
- Northern Canal Gatehouse
- Locks and Canals Blacksmith Shop
- Gate Keeper's Cottage
- Northern Canal
- Northern Canal Walk and Great River Wall
- Suffolk Millyard
- Tremont Gatehouse
- Tremont Yard

- Lawrence Yard
- Moody Street Feeder
- Moody Street Feeder Gatehouse
- Boott Mills
- Massachusetts Mills
- Boot Mills Boarding House
- Massachusetts Mills Boarding House
- Lower Locks, Pawtucket Canal
- Bigelow Yard
- Hamilton Yard
- Eastern canal
- Lower Pawtucket Canal
- Appleton Mills
- Hamilton Canal
- Swamp Locks
- Merrimack Canal
- Lowell Machine Shop
- Proprietors of Locks and Canals Yard
- Western Canal
- Upper Pawtucket Canal
- Pawtucket Dam
- Suffolk Manufacturing Company Boarding Houses

The Locks and Canals Historic District is significant for its contributions to the development of Lowell as the first great industrial city in the United States. A copy of the Locks and Canals Historic District National Register of Historic Places Inventory nomination form is included in Appendix I.

Lowell National Historic Park

The Lowell National Historic Park and Preservation District was listed on the National Register in 1978. The Lowell National Historic Park Preservation District includes within its boundaries an approximate 5-mile power canal system, a portion of the central business district, and three major mill complexes. The area within the park boundaries totals 134 acres, but with only NPS ownership of a handful of buildings with other property privately owned. The Lowell Historic Preservation District includes the mills or mill sites of most of the rest major textile corporations, the remainder of the historic central business district, and areas along the Concord River where smaller factories flourished outside the main waterpower system. There are 895 properties within Lowell Park and the Lowell Historic Preservation District and are classified as follows:

- 307 residential buildings
    - 147 single family
    - 62 duplexes
    - 99 multiple family
- 210 commercial buildings
- 130 buildings within textile mill complexes
- 27 other industrial structures
- 16 schools
- 9 churches

- 24 government buildings
- 92 vacant lots
- 33 components of the canal system
- 11 bridges
- 37 miscellaneous structures (theaters, parking garages, playgrounds, etc.)

In terms of the condition, the properties (excluding the canals) are classified according to 1979 data as follows: 56 in excellent condition, 412 in good condition, 244 need minor repair, 70 need major repair, and 8 are derelict. In terms of period, the structures range in period from pre-1820 to post-1950 with the greatest number of structures dated in the 1890s and from 1900-1925.

Lowell Park and the Lowell Historic Preservation District's most important historical resources are the canal system, the remaining major mill complexes, and the central business district's nineteenth century commercial buildings. The District also includes elements of other historic industrial enterprises, particularly along the Concord River. Residential properties within the District represent most of the range of styles, forms, and periods of Lowell's architectural history, but these houses generally fall short of Lowell's historic houses outside the Lowell Historic Preservation District's in quantity, quality, and concentration. A copy of the Lowell National Historic Park National Register of Historic Places Inventory nomination form is included in Appendix I.

Lowell Canal System

The Lowell Canal System has also been recognized for its significance within the field of engineering. The American Society of Civil Engineers designated the "Lowell Waterpower System" as a Historic Civil Engineering Landmark in 1984, and the American Society of Mechanical Engineers designated the "Lowell Power Canal System and Pawtucket Gatehouse" as a Historic Mechanical Engineering Landmark in 1985 (MADCR 2014).

5.11 Socioeconomic Resources (18 CFR § 5.6(d)(3)(xi)

The Lowell Project is located in Middlesex County, Massachusetts and Hillsborough County, New Hampshire. The population of Middlesex County, based on the 2010 census, was 1,503,085. The population estimate as of July 1, 2016, was 1,589,774 resulting in a 5.8 percent increase in population in Middlesex County (U.S. Census Bureau undated*a*). The population of Hillsborough County, based on the 2010 census, was 400,721. The population estimate as of July 1, 2016, was 407,761 resulting in a 1.8 percent increase in population in Hillsborough County (U.S. Census Bureau undated*b*).

According to the U.S. Census Bureau, the median household income in Middlesex County (in 2016 dollars) from 2012-2016 is estimated to be $89,019. There is an estimated 7.7 percent living below the poverty line in Middlesex County (U.S. Census Bureau undated*a*). The most common employment sectors for Middlesex County are healthcare and social assistance; professional, scientific, and tech services; and educational services (Data USA undated).

According to the U.S. Census Bureau, the median household income in Hillsborough County (in 2016 dollars) from 2012-2016 is estimated to be $73,189. There is an

estimated 8.0 percent living below the poverty line in Hillsborough County (US Census Bureau undated*b*). The most common employment sectors for Hillsborough County are healthcare and social assistance, manufacturing, and retail trade (Data USA undated).

The Lowell Project is located within the Greater Boston metropolitan area, which is primarily composed of urban and suburban towns and cities. The city of Lowell's estimated population in 2016 was 110,558 - making it the fourth largest city in Massachusetts. The population of Lowell grew an estimated 3.8 percent since the previous 2010 census. The median Middlesex County household annual income in 2010 was $77,377.00, while the Lowell household annual income was $51,714 in 2012. An estimated 15.2 percent of families were below the poverty line in 2012 (U.S. Census Bureau undated*a*).

The economy of Lowell employs approximately 50,000 people. Lowell's economy is specialized in manufacturing, administration, waste management services, and healthcare and social assistance. The largest industries in Lowell are healthcare, manufacturing, and retail trade. Educational, scientific, and technical services are also notable contributing industries to the Lowell economy (U.S. Census Bureau undated*a*).

The City of Lowell's Healthy and Sustainable Local Economy 2025 Master Plan targets multiple facets of the local economy and the well-being of its citizens. One facet is to continue to support the urban revitalization plan of the Hamilton Canal District which includes properties adjacent to Lowell Project facilities. A second facet of the City of Lowell's plan is to attract and maintain environmentally-sustainable businesses, institutions, and industry. Hydropower is a suitable industrial energy supplier that satisfies this local economic development goal (City of Lowell undated*a*).

5.12 Tribal Resources (18 CFR § 5.6(d)(3)(xii)

There are no Native American reservation lands within the Project boundary or immediate Project vicinity. The U.S. Bureau of Indian Affairs (BIA), via consultation, documented the following tribes as having historical interest in the Project area:

- Mashpee Wampanoag Tribe
- Wampanoag Tribe of Gay Head
- Penobscot Nation

Boott has distributed a PAD questionnaire to each of the above tribes, as well as to the Narragansett Indian Tribe and the Stockbridge Munsee Tribe, and requested a response regarding their level of interest in the Project area and information for this PAD.

6.0 Preliminary Issues, Project Effects, and Potential Studies List (18 CFR § 5.6 (d)(4))

6.1 Consultation to Date

To date, Boott has performed the following initial consultation activities:

- PAD questionnaires were distributed to 130 stakeholders.

- The Massachusetts Office of Coastal Zone Management was consulted regarding the location of the Project relative to the State's coastal zone.
- The NHDES' Coastal Program was consulted regarding the location of the Project relative to the State's coastal zone.
- The MADFW, NHDES, Massachusetts Division of Fisheries & Wildlife, and USFWS were contacted regarding federal or state-listed, threatened, or endangered species, critical habitat, sensitive natural communities, and species of special concern within the Project's vicinity.

6.2 Project Effects, Studies Needed, and Summary of Relevant Issues for the Lowell Project Relicensing

This section identifies preliminary issues pertaining to the continued operation of the Lowell Project based upon existing information summarized in Section 4 of this PAD and consultation with resource agencies and stakeholders. Boott received PAD responses from the following Project stakeholders:

- Town of Burlington, Massachusetts
- LMRLAC
- Town of Acton, Massachusetts
- Williamsburg 1 Condos in North Chelmsford, Massachusetts
- MADFW
- Town of Hudson, New Hampshire
- U.S. Bureau of Indian Affairs
- New Hampshire Natural Heritage Bureau
- Town of North Andover, Massachusetts
- Lowell Floodowner's Group
- NOAA
- NPS
- MADEP

Table 6.2-1 presents the preliminary issues identified by Project stakeholders through responses to the PAD questionnaire.

Table 6.2-1. Preliminary List of Resource Issues.

Resource Area	Issues pertaining to Specific Resource Areas
Flows	Bypass flow at the Project
Fisheries	Fish passage at the Project
Historical Resources	Maintaining historical resources at the Project
Recreation	Boating access in the impoundment
Inundation of Floodplains	Inundation within upstream floodplains

Boott notes that this list of resource issues is preliminary and Boott anticipates consulting with the resource agencies, stakeholders, and other interested parties regarding these resources areas as well as other potential resources areas of interest to the parties.

6.3 Potential Studies of Information Needs List

At this time, Boott is not proposing specific studies to analyze the preliminary resource issues identified in Section 6.2. Boott has had informal discussions with the members of the Technical Committee regarding fisheries studies anticipated to be conducted during the course of this relicensing effort. Boott will continue to consult with the appropriate resource agencies, Native American tribes, members of the public, and other stakeholders pursuant to the process defined in the ILP to determine which studies are necessary and applicable to collect information regarding the identified resource issues. As appropriate, such studies may include an evaluation of a minimum bypass flow, further evaluation of the Project's upstream and downstream fishways, and recreational use associated with the Project.

Within 60 days of the PAD/NOI notice and issuance of SD1, pursuant to 18 CFR § 5.9(a), each interested resource agency, Native American tribe, and stakeholder may provide study requests and written comments on the PAD and SD1. The Licensee respectfully requests that resource agencies and stakeholders utilize the ILP study request guidelines as set forth by the Commission at 18 CFR § 5.9(b) and outlined below. Addressing the criteria outlined below is required under the ILP and will better define the resource issues and provide for more effective studies that will better serve all parties throughout the relicensing process:

- Describe the goals and objectives of each study proposal and the information to be obtained;
- If applicable, explain the relevant resource management goals of the agencies or Native American tribes with jurisdiction over the resource to be studied;
- If the requester is not a resource agency, explain any relevant public interest considerations in regard to the proposed study;
- Describe existing information concerning the subject of the study proposal, and the need for additional information;

- Explain any nexus between Project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements;
- Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge; and
- Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

7.0 Comprehensive Plans (18 CFR § 5.6 (d)(4)

Boott has reviewed federal, Commonwealth of Massachusetts, and the State of New Hampshire comprehensive plans adopted by the FERC under section 10(a)(2)(A) of the Federal Power Act (FPA), 16 U.S.C. section 803(a)(2)(A). On April 27, 1988, the FERC issued Order No. 481-A, revising Order No. 481 issued on October 26, 1987, establishing that the Commission will accord FPA section 10(a)(2)(A) comprehensive plan status to any federal or state plan that:

1. Is a comprehensive study of one or more of the beneficial uses of a waterway or waterways;
2. Specifies the standards, data, and methodology used; and
3. Is filed with the Secretary of the Commission.

The Project is consistent with the goals outlined in these FERC-approved comprehensive plans.

7.1 Qualifying Comprehensive Plans Deemed Applicable

As of January 2018, FERC currently lists 65 comprehensive plans for the Commonwealth of Massachusetts and the State of New Hampshire. Of these, 29 are potentially relevant to the Project.

7.1.1 Federal Plans

Atlantic States Marine Fisheries Commission. 1995. Interstate fishery management plan for Atlantic striped bass. (Report No. 24). March 1995.

Atlantic States Marine Fisheries Commission. 1998. Amendment 1 to the Interstate Fishery Management Plan for Atlantic sturgeon (Acipenser oxyrhynchus oxyrhynchus). (Report No. 31). July 1998.

Atlantic States Marine Fisheries Commission. 1998. Interstate fishery management plan for Atlantic striped bass. (Report No. 34). January 1998.

Atlantic States Marine Fisheries Commission. 1999. Amendment 1 to the Interstate Fishery Management Plan for shad and river herring. (Report No. 35). April 1999.

Atlantic States Marine Fisheries Commission. 2000. Technical Addendum 1 to Amendment 1 of the Interstate Fishery Management Plan for shad and river herring. February 9, 2000.

Atlantic States Marine Fisheries Commission. 2000. Interstate Fishery Management Plan for American eel (Anguilla rostrata). (Report No. 36). April 2000.

Atlantic States Marine Fisheries Commission. 2008. Amendment 2 to the Interstate Fishery Management Plan for American eel. Arlington, Virginia. October 2008.

Atlantic States Marine Fisheries Commission. 2009. Amendment 2 to the Interstate Fishery Management Plan for shad and river herring, Arlington, Virginia. May 2009.

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Atlantic States Marine Fisheries Commission. 2013. Amendment 3 to the Interstate Fishery Management Plan for American eel. Arlington, Virginia. August 2013.

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National Park Service. The Nationwide Rivers Inventory. Department of the Interior, Washington, D.C. 1993.

U.S. Fish and Wildlife Service. 1989. Atlantic salmon restoration in New England: Final environmental impact statement 1989-2021. Department of the Interior, Newton Corner, Massachusetts. May 1989.

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U.S. Fish and Wildlife Service. Canadian Wildlife Service. 1986. North American waterfowl management plan. Department of the Interior. Environment Canada. May 1986.

U.S. Fish and Wildlife Service. n.d. Fisheries USA: the recreational fisheries policy of the U.S. Fish and Wildlife Service. Washington, D.C.

7.1.2 Massachusetts Plans

Massachusetts Department of Environmental Management. n.d. Commonwealth connections: A greenway vision for Massachusetts. Boston, Massachusetts.

Massachusetts Department of Fish and Game. 2006. Comprehensive wildlife conservation strategy. West Boylston, Massachusetts. September 2006.

Massachusetts Executive Office of Energy and Environmental Affairs. Statewide Comprehensive Outdoor Recreation Plan (SCORP): Massachusetts Outdoor 2006. Boston, Massachusetts.

7.1.3 New Hampshire Plans

Merrimack River Policy and Technical Committees. 1990. Strategic plan for the restoration of Atlantic salmon to the Merrimack River, 1990 through 2004. Concord, New Hampshire. April 1990.

New Hampshire Office of Energy and Planning. 2007. New Hampshire Statewide Comprehensive Outdoor Recreation Plan (SCORP): 2008-2013. Concord, New Hampshire. December 2007.

New Hampshire Office of State Planning. 1977. Wild, scenic, & recreational rivers for New Hampshire. Concord, New Hampshire. June 1977.

New Hampshire Office of State Planning. 1989. New Hampshire wetlands priority conservation plan. Concord, New Hampshire.

New Hampshire Office of State Planning. 1991. Upper Merrimack River corridor plan-volume 2: management plan. Concord, New Hampshire. March 1991.

New Hampshire Office of State Planning. 1991. Public access plan for New Hampshire's lakes, ponds, and rivers. Concord, New Hampshire. November 1991.

Policy Committee for Anadromous Fishery Management of the Merrimack River Basin. 1985. A strategic plan for the restoration of Atlantic salmon to the Merrimack River Basin, 1985 through 1999. Laconia, New Hampshire. May 1985.

State of New Hampshire. 1991. New Hampshire rivers management and protection program [as compiled from NH RSA Ch. 483, HB 1432-FN (1990) and HB 674-FN (1991)]. Concord, New Hampshire.

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Appendix A - PAD Questionnaire

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Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Boott Hydropower, LLC (Boott), a subsidiary of Enel Green Power North America, Inc. (Enel), is the Licensee and operator of the Lowell Hydroelectric Project (FERC No. 2790) (Project), with principal Project facilities located along the Merrimack River in Middlesex County, Massachusetts and a reservoir extending upstream to Hillsborough County, New Hampshire (see attached map). Boott, with assistance from HDR, Inc. (HDR), is beginning the Federal Energy Regulatory Commission (FERC) relicensing process for the existing Project. Accordingly, Boott is preparing a Pre-Application Document (PAD) that will provide FERC and other entities with existing, relevant, and reasonably available information pertaining to the Project that will be used to prepare documents related to analyzing the relicensing application to be prepared by Boott. To prepare the PAD, Boott will use information in its possession and information obtained from additional sources. This PAD Information Questionnaire will be used by Boott to help identify sources of existing, relevant, and reasonably available information that are not currently in Boott's possession.

1. Information about person completing the questionnaire:

Name & Title	
Organization	
Address	
Phone	
Email Address	

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

___ Yes (*If yes, please complete 2a through 2c)* __ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- ■ Geology and soils
- ■ Water resources
- ■ Fish and aquatic resources
- ■ Wildlife and botanical resources
- ■ Wetlands, riparian, and littoral habitat
- ■ Rare, threatened & endangered species
- ■ Recreation and land use
- ■ Aesthetic resources
- ■ Cultural resources
- ■ Socio-economic resources
- ■ Tribal resources
- ■ Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

___ Yes __ No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	
Address	
Phone	
Email Address	

Additional Representative Contact Information (Optional)

Name	
Address	
Phone	
Email Address	

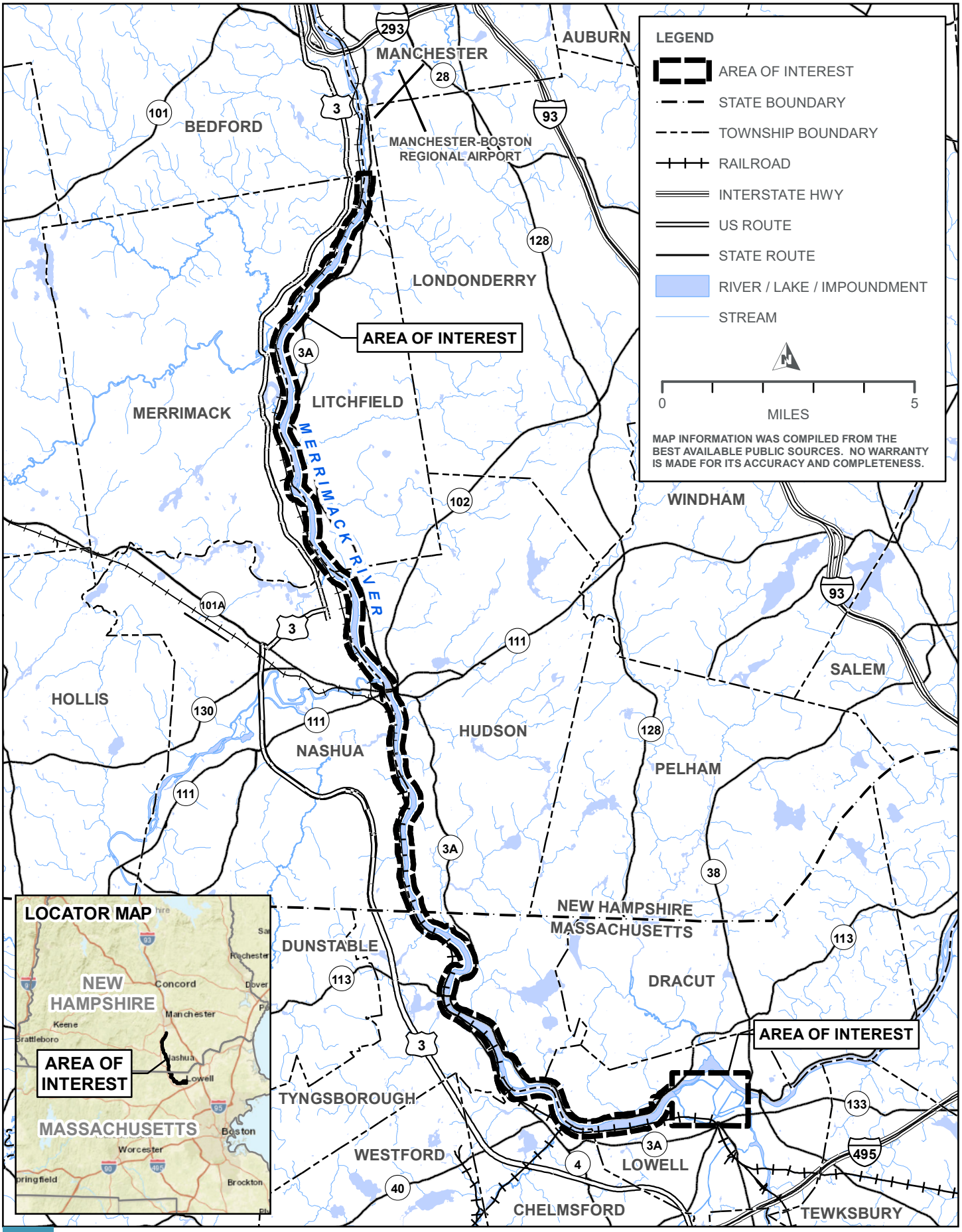
Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

If you have any questions about the Project, or the upcoming FERC licensing processes, please contact Mr. Kevin Webb, Enel Relicensing Manager for the Lowell Hydroelectric Project, at (978) 681-1900 ext. 809 or Kevin.Webb@enel.com; Jim Gibson at (315) 414-2202; or Rob Quiggle at (315) 414-2216.

Please return this questionnaire in the enclosed, self-addressed, stamped envelope within 21 days of receipt to allow for any follow-up contact that may be necessary by a representative from Boott or HDR. Not responding within 21 days indicates that you are not aware of any existing, relevant, and reasonably available information that describes the existing Project environment or known potential impacts of the Project.



LOWELL HYDROELECTRIC PROJECT
FERC NO. 2790
BOOTT HYDRO, LLC.

Lowell Hydroelectric Project (FERC No. 2790)
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Appendix B - Lowell Hydroelectric Project Distribution List

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Room 405
Boston, MA 02133

Kim Goddu
Merrimack River Watershed Council
60 Island Street
Suite 211-E
Lawrence, MA 01840

Rusty Russell
Executive Director
Merrimack River Watershed Council
60 Island Street
Suite 211-E
Lawrence, MA 01840

Fred Britton
Associate President
Thoreau's Landing Condominium Association
32 Walden Pond Drive
Nashua, NH 03064

Lowell Hydroelectric Project (FERC No. 2790)
Distribution List

Fred Jennings
President, Nor'East Chapter
Trout Unlimited
P.O. Box 946
Ipswich, MA 01938

Arthur Faneros
Universal Apartment Rental
114 University Avenue
Lowell, MA 01854

Michele Tremblay
Upper Merrimack River Local Advisory Committee
P.O. Box 3019
Penacook, NH 03303

Ann Kuster
US House of Representatives
137 Cannon House Office Building
2nd District
Washington, DC 20515

Seth Moulton
6th District
US House of Representatives
21 Front Street
Salem, MA 01970

Carol Shea-Porter
US House of Representatives
1530 Longworth House Office Building
1st District
Washington, DC 20515

Niki Tsongas
3rd District
US House of Representatives
126 John Street
Suite 12
Lowell, MA 01852

Margaret Hassan
US Senate
330 hart Senate Office Building
Washington, DC 20510

Edward Markey
US Senate
218 Russell Senate Office Building
Washington, DC 20510

Jeanne Shaheen
US Senate
506 Hart Senate Office Building
Washington, DC 20510

Elizabeth Warren
US Senate
317 Hart Senate Office Building
Washington, DC 20510

Dinell Clark
President
Williamsburg Condominium I
197 Wellman Avenue
North Chelmsford, MA 01863

Richard Howe
Register of Deeds - Middlesex County North
360 Gorham Street
Lowell, MA 01852

Appendix C - Consultation Correspondence

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From: Amy Warfield [mailto:awarfield@burlington.org]
Sent: Wednesday, March 14, 2018 10:25 AM
To: Gibson, Jim <Jim.Gibson@hdrinc.com>
Subject: Lowell Hydro Project (FERC Project No. 2790)

Dear Sir,

We have no information regarding this project.

Regards,

--
Amy E. Warfield , CMC, CMMC
Town Clerk, Burlington
Webmaster
Records Access Officer
29 Center St
Burlington, MA 01803
781-270-1660

Remember to be involved!!!
Town Election - April 7th - 8 AM to 8 PM, Burlington High School

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~~~~~~

From: gene porter [mailto:gporter77@gmail.com]
Sent: Thursday, March 15, 2018 12:40 PM
To: Gibson, Jim <Jim.Gibson@hdrinc.com>; Quiggle, Robert <Robert.Quiggle@hdrinc.com>
Cc: Madeline Mineau <mineaum@nashuanh.gov>
Subject: Relicensing FERC 2709

Greetings

Thanks for sending me the Information Questionnaire, which I have mailed back today.

You will note that I have identified the Nashua Waterways Manager, Dr Madeleine Mineau, as an important stakeholder that should be afforded an opportunity to comment on your preparations for this relicensing process. One obvious near term matter of joint interest is the interaction between your future management of headpond water levels and the City's contracting process for the design and construction of a new boat launch facility in Greeley Park.

I have copied her on this note

--
Best
Gene Porter
Chair, LMRLAC

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Boott Hydropower, LLC (Boott), a subsidiary of Enel Green Power North America, Inc. (Enel), is the Licensee and operator of the Lowell Hydroelectric Project (FERC No. 2790) (Project), with principal Project facilities located along the Merrimack River in Middlesex County, Massachusetts and a reservoir extending upstream to Hillsborough County, New Hampshire (see attached map). Boott, with assistance from HDR, Inc. (HDR), is beginning the Federal Energy Regulatory Commission (FERC) relicensing process for the existing Project. Accordingly, Boott is preparing a Pre-Application Document (PAD) that will provide FERC and other entities with existing, relevant, and reasonably available information pertaining to the Project that will be used to prepare documents related to analyzing the relicensing application to be prepared by Boott. To prepare the PAD, Boott will use information in its possession and information obtained from additional sources. This PAD Information Questionnaire will be used by Boott to help identify sources of existing, relevant, and reasonably available information that are not currently in Boott's possession.

1. Information about person completing the questionnaire:

Name & Title	Steven Ledoux, Town Manager
Organization	Town of Acton
Address	472 Main St
Phone	978-929-6611
Email Address	Manager@acton-ma.gov

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

___ Yes (*If yes, please complete 2a through 2c)* X No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- Geology and soils
- Water resources
- Fish and aquatic resources
- Wildlife and botanical resources
- Wetlands, riparian, and littoral habitat
- Rare, threatened & endangered species
- Recreation and land use
- Aesthetic resources
- Cultural resources
- Socio-economic resources
- Tribal resources
- Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

___ Yes ☒ No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	
Address	
Phone	
Email Address	

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Additional Representative Contact Information (Optional)

Name	
Address	
Phone	
Email Address	

Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

If you have any questions about the Project, or the upcoming FERC licensing processes, please contact Mr. Kevin Webb, Enel Relicensing Manager for the Lowell Hydroelectric Project, at (978) 681-1900 ext. 809 or Kevin.Webb@enel.com; Jim Gibson at (315) 414-2202; or Rob Quiggle at (315) 414-2216.

Please return this questionnaire in the enclosed, self-addressed, stamped envelope within 21 days of receipt to allow for any follow-up contact that may be necessary by a representative from Boott or HDR. Not responding within 21 days indicates that you are not aware of any existing, relevant, and reasonably available information that describes the existing Project environment or known potential impacts of the Project.

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

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1. Information about person completing the questionnaire:

Name & Title	Dinell Clark President
Organization	Williamsburg I Condos
Address	197 Wellman Ave No Chelmsford MA 01863
Phone	978-866-2580
Email Address	dinellclark@verizon.net

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

___ Yes (*If yes, please complete 2a through 2c)* ✓ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- ■ Geology and soils
- ■ Water resources
- ■ Fish and aquatic resources
- ■ Wildlife and botanical resources
- ■ Wetlands, riparian, and littoral habitat
- ■ Rare, threatened & endangered species
- ■ Recreation and land use
- ■ Aesthetic resources
- ■ Cultural resources
- ■ Socio-economic resources
- ■ Tribal resources
- ■ Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

X Yes __ No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	Dwell Clark
Address	197 Wellman Ave No Chelmsford MA 01863
Phone	978.866-2580
Email Address	dwellclark@verizon.net

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Additional Representative Contact Information (Optional)

Name	
Address	
Phone	
Email Address	

Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

If you have any questions about the Project, or the upcoming FERC licensing processes, please contact Mr. Kevin Webb, Enel Relicensing Manager for the Lowell Hydroelectric Project, at (978) 681-1900 ext. 809 or Kevin.Webb@enel.com; Jim Gibson at (315) 414-2202; or Rob Quiggle at (315) 414-2216.

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Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

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1. Information about person completing the questionnaire:

Name & Title	Gene Porter, Chairman
Organization	Lower Merrimack River Local Advisory Ctte (LMRLAC)
Address	77 Concord St Nashua, NH 03064
Phone	603 966 0015 (mob)
Email Address	gporter77@gmail.com

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

✓ Yes (*If yes, please complete 2a through 2c*) ___ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- Geology and soils
- Water resources
- Fish and aquatic resources
- Wildlife and botanical resources
- Wetlands, riparian, and littoral habitat
- Rare, threatened & endangered species
- Recreation and land use
- Aesthetic resources
- Cultural resources
- Socio-economic resources
- Tribal resources
- Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

The Project headpond in NH is a major recreational asset. The NH State SWAAB identified this water body as the highest priority for a new public access boat ramp, now being designed

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

See next page

Dr Mineau
Nashua Waterways Mgr

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

✓ Yes __ No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	Gene Porter
Address	77 Concord St Nashua, NH 03064
Phone	603 966-0015
Email Address	gporter77@gmail.com

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Additional Representative Contact Information (Optional)

Name	Dr. Madeleine Mineau
Address	Waterways Manager Nashua City Hall,
Phone	
Email Address	mineaum@nashuanh.gov

Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

If you have any questions about the Project, or the upcoming FERC licensing processes, please contact Mr. Kevin Webb, Enel Relicensing Manager for the Lowell Hydroelectric Project, at (978) 681-1900 ext. 809 or Kevin.Webb@enel.com; Jim Gibson at (315) 414-2202; or Rob Quiggle at (315) 414-2216.

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Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

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1. Information about person completing the questionnaire:

Name & Title	Caleb Slater PhD
Organization	Mass Wildlife
Address	1 Rabbit Hill Rd, Westborough MA 01581
Phone	508 389 6331
Email Address	Caleb.slater@state.ma.us

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

X Yes (*If yes, please complete 2a through 2c)* ___ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- ■ Geology and soils
- ■ Water resources
- ■ Fish and aquatic resources
- ■ Wildlife and botanical resources
- ■ Wetlands, riparian, and littoral habitat
- ■ Rare, threatened & endangered species
- ■ Recreation and land use
- ■ Aesthetic resources
- ■ Cultural resources
- ■ Socio-economic resources
- ■ Tribal resources
- ■ Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

- fish surveys
- T+E species maps
- fish lift counts

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

MA

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

(Yes) __No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	Caleb Slater, PhD
Address	1 Rabbit Hill Rd Westborough MA 01581
Phone	508 399 6331
Email Address	Caleb.slater@state.ma.us

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Additional Representative Contact Information (Optional)

Name	
Address	
Phone	
Email Address	

Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

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1. Information about person completing the questionnaire:

Name & Title	Stephen Malizia, Town Administrator
Organization	Town of Hudson, NH
Address	12 School Street Hudson, NH 03051
Phone	(603) 886-6024
Email Address	smalizia@hudsonnh.gov

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

___ Yes (*If yes, please complete 2a through 2c)* XX No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- Geology and soils
- Water resources
- Fish and aquatic resources
- Wildlife and botanical resources
- Wetlands, riparian, and littoral habitat
- Rare, threatened & endangered species
- Recreation and land use
- Aesthetic resources
- Cultural resources
- Socio-economic resources
- Tribal resources
- Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

___ Yes XX No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	Stephen Malizia
Address	12 School Street Hudson, NH 03051
Phone	(603) 886-6024
Email Address	smalizia@hudsonnh.gov

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Additional Representative Contact Information (Optional)

Name	Elvis Dhima, P.E. Town Engineer
Address	12 School Street Hudson, NH 03051
Phone	(603) 886-6008
Email Address	edhima@hudsonnh.gov

Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

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1. Information about person completing the questionnaire:

Name & Title	Harold Peterson, Natural Resources Officer
Organization	U.S. Bureau of Indian Affairs - Eastern Region
Address	545 Marriott Dr Ste 700 Nashville, TN 37214
Phone	615-564-6838
Email Address	harold.peterson@bia.gov

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

X Yes (*If yes, please complete 2a through 2c)* __ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- ■ Geology and soils
- ■ Water resources
- ■ Fish and aquatic resources
- ■ Wildlife and botanical resources
- ■ Wetlands, riparian, and littoral habitat
- ■ Rare, threatened & endangered species
- ■ Recreation and land use
- ■ Aesthetic resources
- ■ Cultural resources
- ■ Socio-economic resources
- (■) Tribal resources
- ■ Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

The following Tribes have historic interests in the area and should be consulted:
Mashpee Wampanoag Tribe
Wampanoag Tribe of Gay Head
Penobscot Nation

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

tribal leaders directory or www.big.gov

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

X Yes __ No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	Harold Peterson
Address	Same
Phone	
Email Address	

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Additional Representative Contact Information (Optional)

Name	
Address	
Phone	
Email Address	

Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

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HDR
1304 Buckley Rd Ste 202
Syracuse, NY 13212

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Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

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1. Information about person completing the questionnaire:

Name & Title	Amy Lamb, Ecological Information Specialist
Organization	NH Natural Heritage Bureau
Address	172 Pembroke Rd, Concord, NH 03301
Phone	603-271-2834
Email Address	amy.lamb@dncr.nh.gov

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

✓ Yes (*If yes, please complete 2a through 2c)* ___ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- ■ Geology and soils
- ■ Water resources
- ■ Fish and aquatic resources
- (■) Wildlife and botanical resources
- ■ Wetlands, riparian, and littoral habitat
- (■) Rare, threatened & endangered species
- ■ Recreation and land use
- ■ Aesthetic resources
- ■ Cultural resources
- ■ Socio-economic resources
- ■ Tribal resources
- ■ Other resource information

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire)*.

The NH Natural Heritage Bureau (NHB) maintains a database of known occurrences of Threatened, Endangered plant species, and exemplary natural communities. NHB routinely provides this information for various permitting processes, through an online tool called the "NHB Datacheck tool".

SEE PAGE 3

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire)*.

NHB Datacheck Tool: https://www2.des.state.nh.us/nhb_datacheck/

Contact: Amy Lamb (general/main contact)

Data Sharing Agreement contact: Sara Cairns, 603-271-2823 sara.cairns@dncr.nh.gov (if interested, see pg. 3)

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

✓ Yes ___ No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	Amy Lamb
Address	172 Pembroke Rd, Concord, NH 03301
Phone	603-271-2834
Email Address	amy.lamb@dncr.nh.gov

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Additional Representative Contact Information (Optional)

Name	Sara Cairns data manager	Sabrina Stanwood Bureau administrator
Address	172 Pembroke Rd Concord, NH 03301	(same)
Phone	603-271-2823	271-2861
Email Address	sara.cairns@dncr.nh.gov	sabrina.stanwood@dncr.nh.gov

Additional Information (additional space provided on the following page):

Note: NHB's database also contains data on occurrences of protected wildlife species (Threatened, Endangered, special concern, or otherwise rare/protected), which is maintained in conjunction with the NH Fish & Game Department. NHFG has jurisdiction over wildlife.

Data for both rare plants/exemplary natural communities AND NH Fish & Game rare species data is available through NHB. Preliminary data may be obtained through the NHB DataCheck Tool or via the enclosed hard copy form. However, for large projects we may also be able to share our digital data, if needed, through a Data Sharing Agreement.

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

If you have any questions about the Project, or the upcoming FERC licensing processes, please contact Mr. Kevin Webb, Enel Relicensing Manager for the Lowell Hydroelectric Project, at (978) 681-1900 ext. 809 or Kevin.Webb@enel.com; Jim Gibson at (315) 414-2202; or Rob Quiggle at (315) 414-2216.

Please return this questionnaire in the enclosed, self-addressed, stamped envelope within 21 days of receipt to allow for any follow-up contact that may be necessary by a representative from Boott or HDR. Not responding within 21 days indicates that you are not aware of any existing, relevant, and reasonably available information that describes the existing Project environment or known potential impacts of the Project.

RECEIVED MAR 22 2018

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Boott Hydropower, LLC (Boott), a subsidiary of Enel Green Power North America, Inc. (Enel), is the Licensee and operator of the Lowell Hydroelectric Project (FERC No. 2790) (Project), with principal Project facilities located along the Merrimack River in Middlesex County, Massachusetts and a reservoir extending upstream to Hillsborough County, New Hampshire (see attached map). Boott, with assistance from HDR, Inc. (HDR), is beginning the Federal Energy Regulatory Commission (FERC) relicensing process for the existing Project. Accordingly, Boott is preparing a Pre-Application Document (PAD) that will provide FERC and other entities with existing, relevant, and reasonably available information pertaining to the Project that will be used to prepare documents related to analyzing the relicensing application to be prepared by Boott. To prepare the PAD, Boott will use information in its possession and information obtained from additional sources. This PAD Information Questionnaire will be used by Boott to help identify sources of existing, relevant, and reasonably available information that are not currently in Boott's possession.

1. Information about person completing the questionnaire:

Name & Title	Andrew G Maylor, Town Manager
Organization	Town of North Andover
Address	120 Main St. North Andover, MA 01845
Phone	978-688-9510
Email Address	amaylor@northandoverma.gov

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

___ Yes (*If yes, please complete 2a through 2c)* ✓ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- ■ Geology and soils
- ■ Water resources
- ■ Fish and aquatic resources
- ■ Wildlife and botanical resources
- ■ Wetlands, riparian, and littoral habitat
- ■ Rare, threatened & endangered species
- ■ Recreation and land use
- ■ Aesthetic resources
- ■ Cultural resources
- ■ Socio-economic resources
- ■ Tribal resources
- ■ Other resource information

RECEIVED MAR 30 2018

Lowell Hydroelectric Project (FERC Project No. 2790)
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1. Information about person completing the questionnaire:

Name & Title	Stephen Masse
Organization	Lowell Flood Owners Group
Address	186 Humphrey St Lowell, MA 01850
Phone	978-397-4180
Email Address	SMasse64@yahoo.com

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

X Yes (*If yes, please complete 2a through 2c)* __ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- (■) Geology and soils
- (■) Water resources
- ■ Fish and aquatic resources
- ■ Wildlife and botanical resources
- ■ Wetlands, riparian, and littoral habitat
- ■ Rare, threatened & endangered species
- (■) Recreation and land use
- ■ Aesthetic resources
- ■ Cultural resources
- ■ Socio-economic resources
- ■ Tribal resources
- (■) Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

The Lowell Boott Hydro Project has increased the level of the Historic Granite Dam from its original 3 ft to its current height without payments for increased flood occurances in terms of costs to home owners for flood insurance, damages to private property and increased use of dewatering/ground water control in private residences, all uncompensated as the FERC has continually allowed Taller Granite Dams, Wooden Flashboards and now, Nigher Bladder Type Flashboard structures on said Granite Dam.

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

X Yes ___ No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	Stephen Moss, LFOG
Address	186 Humphrey St Lowell MA 01850
Phone	978 397-4180
Email Address	SMOSS64@yahoo.com

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Additional Representative Contact Information (Optional)

Name	
Address	
Phone	
Email Address	

Additional Information (additional space provided on the following page):

LFLOG will oppose Re-Licensing of this Project UNTIL Compensation is offered to all Land owners for the Taking of their Private Property (Flood Costs, Ground De-Watering Costs & Insurance costs) for a "Public" use by a "For Profit" Corporate interest.

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

If you have any questions about the Project, or the upcoming FERC licensing processes, please contact Mr. Kevin Webb, Enel Relicensing Manager for the Lowell Hydroelectric Project, at (978) 681-1900 ext. 809 or Kevin.Webb@enel.com; Jim Gibson at (315) 414-2202; or Rob Quiggle at (315) 414-2216.

Please return this questionnaire in the enclosed, self-addressed, stamped envelope within 21 days of receipt to allow for any follow-up contact that may be necessary by a representative from Boott or HDR. Not responding within 21 days indicates that you are not aware of any existing, relevant, and reasonably available information that describes the existing Project environment or known potential impacts of the Project.

Lowell Hydroelectric Project (FERC Project No. 2790)
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1. Information about person completing the questionnaire:

Name & Title	Sue Tuxbury Fishery Biologist
Organization	NOAA Fisheries
Address	55 Great Republic Dr. Gloucester, MA 01930
Phone	978-281-9176
Email Address	Susan.tuxbury@noaa.gov

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

X Yes (*If yes, please complete 2a through 2c)* __ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- ■ Geology and soils
- ■ Water resources
- ■ Fish and aquatic resources
- ■ Wildlife and botanical resources
- ■ Wetlands, riparian, and littoral habitat
- ■ Rare, threatened & endangered species
- ■ Recreation and land use
- ■ Aesthetic resources
- ■ Cultural resources
- ■ Socio-economic resources
- ■ Tribal resources
- ■ Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

Passage of Radio-tagged American Shad Through the Northern Canal Headgate Structure, Lowell Hydroelectric Project. Nov 1988
Prepared by RMC Environmental Services

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

We can provide a pdf upon request

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

X Yes __ No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	Sue Tuxbury
Address	55 Great Republic Dr. Gloucester, MA 01930
Phone	978-281-9176
Email Address	susan.tuxbury@noaa.gov

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Additional Representative Contact Information (Optional)

Name	Sean McDermott
Address	55 Great Republic Dr. Gloucester, MA 01930
Phone	978-281-9113
Email Address	sean.mcdermott@noaa.gov

Additional Information (additional space provided on the following page):

The PAD should discuss the gatehouse and operation/condition of the boat lock system adjacent to the gatehouse

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

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D 315.414.2202 M 315.415.2729
jim.gibson@hdrinc.com

hdrinc.com/follow-us

From: Aucella, Peter [mailto:peter_aucella@nps.gov]
Sent: Wednesday, April 4, 2018 5:08 PM
To: Kevin Webb <kevin.webb@enel.com>; Gibson, Jim <Jim.Gibson@hdrinc.com>; Quiggle, Robert <Robert.Quiggle@hdrinc.com>
Subject: Lowell Hydroelectric Project (FERC 2790) Relicensing Pre-Application Questionnaire - Lowell National Park Response

Hello:

On behalf of Lowell National Historical Park, this is to reply to your survey seeking document related to the Lowell Project relicensing.

I have attached the questionnaire responses plus the following documents:

1) Lowell National Historical Park Authorizing Legislation with reference to Lowell Canal System.
2) Lowell National Historical Park Boundary Map referenced in authorizing law.
3) National Register Nomination for the Locks & Canals Historic District (1976).
4) The Lowell Heritage State Park Resource Management Report referencing the Lowell Canal System.

Please let me know if you have any questions.

Thanks,

Peter Aucella
Assistant Superintendent
Lowell National Historical Park
67 Kirk Street
Lowell, MA 01852
978-275-1722

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

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1. Information about person completing the questionnaire:

Name & Title	PETER AUCELLA, ASSISTANT SUPERINTENDENT
Organization	LOWELL NATIONAL HISTORICAL PARK
Address	67 KIRK ST., LOWELL, MA. 01852
Phone	978-275-1722
Email Address	PETER_AUCELLA@NPS.GOV

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

✓ Yes (*If yes, please complete 2a through 2c)* __ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- ■ Geology and soils
- ■ Water resources
- ■ Fish and aquatic resources
- ■ Wildlife and botanical resources
- ■ Wetlands, riparian, and littoral habitat
- ■ Rare, threatened & endangered species
- ■ Recreation and land use
- ■ Aesthetic resources
- ■ Cultural resources
- ■ Socio-economic resources
- ■ Tribal resources
- ■ Other resource information

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Additional Representative Contact Information (Optional)

Name	CELESTE BERNARDO, SUPERINTENDENT
Address	LOWELL NHP, 67 KIRK ST, LOWELL, MA. 01852
Phone	978-275-1700
Email Address	CELESTE_BERNARDO@NPS.GOV

Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

If you have any questions about the Project, or the upcoming FERC licensing processes, please contact Mr. Kevin Webb, Enel Relicensing Manager for the Lowell Hydroelectric Project, at (978) 681-1900 ext. 809 or Kevin.Webb@enel.com; Jim Gibson at (315) 414-2202; or Rob Quiggle at (315) 414-2216.

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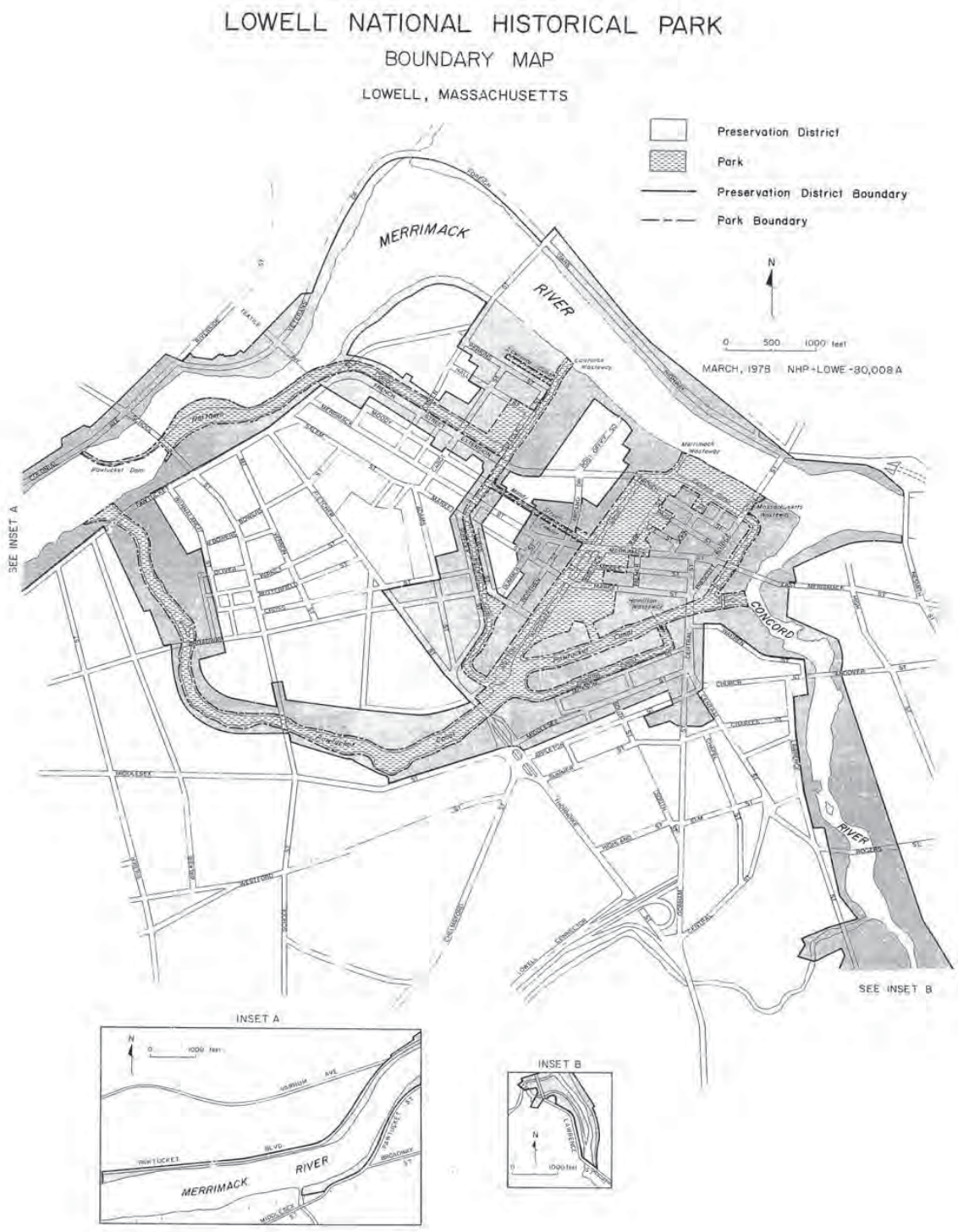

LOWELL NATIONAL HISTORICAL PARK
BOUNDARY MAP
LOWELL, MASSACHUSETTS
Preservation District
Park
Preservation District Boundary
Park Boundary
N
0 500 1000 feet
MARCH, 1978 NHP-LOWE-80,008A
MERRIMACK
RIVER
CONCORD
SEE INSET A
SEE INSET B
INSET A
INSET B

Appendix E

Legislation

16 USC 410cc.

LOWELL NATIONAL HISTORICAL PARK

PART A—ESTABLISHMENT OF PARK AND PRESERVATION DISTRICT

§ 410cc. Congressional statement of findings and purpose

(a) The Congress finds that—

(1) certain sites and structures in Lowell, Massachusetts, historically and culturally the most significant planned industrial city in the United States, symbolize in physical form the Industrial Revolution;

(2) the cultural heritage of many of the ethnic groups that immigrated to the United States during the late nineteenth and early twentieth centuries is still preserved in Lowell's neighborhoods;

(3) a very large proportion of the buildings, other structures, and districts in Lowell date to the period of the Industrial Revolution and are nationally significant historical resources, including the five-and-six-tenths-mile power canal system, seven original mill complexes, and significant examples of early

housing, commercial structures, transportation facilities, and buildings associated with labor and social institutions, and

(4) despite the expenditure of substantial amounts of money by the city of Lowell and the Commonwealth of Massachusetts for historical and cultural preservation and interpretation in Lowell, the early buildings and other structures in Lowell may be lost without the assistance of the Federal Government.

(b) It is the purpose of sections 410cc to 410cc-37 of this title to preserve and interpret the nationally significant historical and cultural sites, structures, and districts in Lowell, Massachusetts, for the benefit and inspiration of present and future generations by implementing to the extent practicable the recommendations in the report of the Lowell Historic Canal District Commission.

(Pub.L. 95-290, § 1, June 5, 1978, 92 Stat. 290.)

§ 410cc-1. Definitions

For purposes of sections 410cc to 410cc-37 of this title—

(1) the term "park" means the Lowell National Historical Park, established by section 410cc-11(a)(1) of this title;

(2) the term "preservation district" means the Lowell Historic Preservation District, established by section 410cc-11(a)(1) of this title;

(3) the term "Commission" means the Lowell Historic Preservation Commission established by section 410cc-31(a) of this title;

(4) the term "Secretary" means the Secretary of the Interior; and

(5) the term "report of the Lowell Historic Canal District Commission" means the report submitted to the Congress by the Lowell Historic Canal District Commission pursuant to an Act entitled "An Act to provide for a plan for the preservation, interpretation, development and use of the historic, cultural, and architectural resources of the Lowell Historic Canal District in Lowell, Massachusetts, and for other purposes", approved January 4, 1975 (88 Stat. 2330).

(Pub.L. 95-290, § 2, June 5, 1978, 92 Stat. 290.)

References in Text. An Act entitled "An Act to provide for a plan for the preservation, interpretation development and use of the historic, cultural, and architectural resources of the Lowell Historic Canal District in Lowell, Massachusetts, and for other purposes", approved January 4, 1975 (88 Stat. 2330), referred to in par. (5), is Pub.L. 93-645, Jan. 4, 1975, 88 Stat. 2330, and is set out as a note under section 461 of this title.

§ 410cc-11. Establishment of Lowell National Historical Park; establishment and administration of Lowell Historic Preservation District; establishment, publication, and revision of boundaries

(a)(1) To carry out the purpose of sections 410cc to 410cc-37 of this title, there is established as a unit of the National Park System in the city of Lowell, Massachusetts, the Lowell National Historical Park. There is further established in an area adjacent to the park the Lowell Historic Preservation District, which will be administered by the Secretary and by the Commission in accordance with sections 410cc to 410cc-37 of this title. The boundaries of the park and preservation district shall be the boundaries depicted on the map entitled "Lowell National Historical Park, Massachusetts", dated March 1978, and numbered "Lowe—80,008A". Such map shall be on file and available for inspection in the office of the National Park Service, Department of the Interior, and in the office of the city clerk, city of Lowell.

(2) The Secretary shall publish in the Federal Register, as soon as practicable after June 5, 1978, a detailed description and map of the boundaries established under paragraph (1) of this subsection.

(b) The Secretary may make minor revisions of the park and preservation district boundaries established under subsection (a)(1) of this section, after consulting with the Commission and the city manager of Lowell, by publication of a revised drawing or other boundary description in the Federal Register, but no waters, lands, or other property outside of the park or preservation district boundaries established under such subsection may be added to the park or preservation district without the consent of the city manager of Lowell and the city council of Lowell. A boundary revision made under this subsection shall be effective only after timely notice in writing is given to the Congress.

(Pub.L. 95-290, Title I, § 101, June 5, 1978, 92 Stat. 291.)

§ 410cc-12. Consultations, cooperation, and conduct of activities by Federal entities; issuance of licenses or permits by Federal entities

(a) Any Federal entity conducting or supporting activities directly affecting the park or preservation district shall—

(1) consult with, cooperate with, and to the maximum extent practicable, coordinate its activities with the Secretary and with the Commission; and

(2) conduct or support such activities in a manner which (A) to the maximum extent practicable is consistent with the standards and criteria established pursuant to section 410cc-32(e) of this title, and (B) will not have an adverse effect on the resources of the park or preservation district.

(b) No Federal entity may issue any license or permit to any person to conduct an activity within the park or preservation district unless such entity determines that the proposed activity will be conducted in a manner consistent with the standards and criteria established pursuant to section 410cc-32(e) of this title and will not have an adverse effect on the resources of the park or preservation district.

(Pub.L. 95-290, Title I, § 102, June 5, 1978, 92 Stat. 291.)

§ 410cc-13. Authorization of appropriations

(a) General authority; maximum amounts

There are authorized to be appropriated such sums as may be necessary to carry out sections 410cc to 410cc-37 of this title, except that—

(1) the total of the amounts authorized to be appropriated for the purpose of acquisition and development under the park management plan established pursuant to section 410cc-21(b) of this title and emergency assistance under section 410cc-25(a)(1) of this title shall not exceed $18,500,000; and

(2) the total of the amounts authorized to be appropriated for the purpose of carrying out section 410cc-32(b)(2) of this title, for the payment of grants and loans under section 410cc-33 of this title, for the acquisition of property under section 410cc-34 of this title, and for carrying out any transportation program and any educational and cultural program described in section 410cc-32(c) of this title shall not exceed $21,500,000.

(b) Commencement date

No funds shall be authorized pursuant to this section prior to October 1, 1978.

(c) Availability of appropriations

Funds appropriated under subsection (a) of this section shall remain available until expended.

(d) Aggregate amount of money expended; certifying statement to Congress as limiting availability of appropriated amounts

(1) Within 60 days after June 5, 1978, and on each subsequent October 1 and March 1, the Secretary shall submit to the Congress a statement certifying the aggregate amount of money expended by the Commonwealth of Massachusetts, the city of Lowell, and by any nonprofit entity for activities in the city of Lowell consistent with the purpose of sections 410cc to 410cc-37 of this title during the period beginning on January 1, 1974, and ending on the date such statement is submitted.

(2) The aggregate amount of funds made available by the Secretary to the Commission from funds appropriated under subsection (a)(2) of this section may not exceed the amount certified by the Secretary in the most recent statement submitted to the Congress under paragraph (1) of this subsection.

(Pub.L. 95-290, Title I, § 103, June 5, 1978, 92 Stat. 292.)

§ 410cc–14. Funding limitations

Notwithstanding any other provision of sections 410cc to 410cc–36 of this title, no authority to enter into agreements or to make payments under sections 410cc to 410cc–37 of this title shall be effective except to the extent, or in such amounts, as may be provided in advance in appropriation Acts.

(Pub.L. 95–290, Title I, § 104, June 5, 1978, 92 Stat. 292.)

PART B—POWERS AND DUTIES OF SECRETARY

§ 410cc–21. Park management plan; submission date and contents of preparatory statement to Congress; establishment, submission date, contents, etc., of plan

(a) The Secretary shall submit a statement to the Congress, within two years after the date on which funds are made available to carry out sections 410cc to 410cc–37 of this title, which—

(1) reports on the progress that the Secretary has made in acquiring the properties identified under section 410cc–22 of this title, and describes the way the Secretary intends to use these properties;

(2) identifies the properties within the park and preservation district respecting which the Secretary has entered into or intends to enter into agreements relating to interpretive exhibits or programs under section 410cc–23(a) of this title;

(3)(A) reports on the progress of the Secretary in leasing a portion of the Lowell Manufacturing Company, located on Market Street, for the purpose of establishing a visitors' center in close proximity to parking and other transportation facilities, and (B) identifies any other property within the park which the Secretary has leased or intends to lease for purposes of the park;

(4) reports any other activities which the Secretary has taken or intends to take to carry out the purpose of sections 410cc to 410cc–37 of this title; and

(5) contains a tentative budget for the park and preservation district for the subsequent five fiscal years.

(b)(1) Not later than three years after the date on which funds are made available to carry out sections 410cc to 410cc–37 of this title, the Secretary shall establish and submit to the Congress a park management plan containing the information described in subsection (a) of this section. Such plan shall, upon request, be available to the public.

(2) After consulting with the Commission, the city manager of Lowell, and the Commonwealth of Massachusetts, the Secretary may make revisions in the park management plan established pursuant to paragraph (1) of this subsection by publication of such revisions in the Federal Register. A revision made under this paragraph shall be effective 90 days after written notice of the revision is submitted to the Congress.

(Pub.L. 95–290, Title II, § 201, June 5, 1978, 92 Stat. 292.)

§ 410cc–22. Acquisition of property

(a) Specified property; manner of acquisition

(The Secretary is authorized to acquire the properties designated in paragraph (2) of this subsection, or any interest therein, by donation, purchase with donated or appropriated funds, condemnation, or otherwise. Any property or interest therein owned by the Commonwealth of Massachusetts or any political subdivision thereof may be acquired only by donation. The Secretary may initiate condemnation proceedings under this paragraph only after making every reasonable effort to acquire property through negotiations and purchase, and consulting with the Commission (if established) and the city council of Lowell.

(2) The properties referred to in paragraph (1) of this subsection are the following:

(A) The Linus Childs House, 63 Kirk Street.

(B) The H and H Paper Company (commonly referred to as Boott Mill Boarding House), 42 French Street.

(C) Old City Hall, 226 Merrimack Street.

(d) Merrimack Gatehouse, 269 Merrimack Street.

(E) The Wannalancit Textile Company, 562 Suffolk Street.

(F) The structures containing the Jade Pagoda and Solomon's Yard Goods, 210 and 200 Merrimack Street.

(b) Other property within park or preservation district; criteria for acquisition; manner of acquisition

Until the date on which the Commission conducts its first meeting, the Secretary may acquire any property within the park or preservation district not designated in subsection (a)(2) of this section, or any interest therein, if such property—

(1) is identified in the report of the Lowell Historical Canal District Commission as a property which should be preserved, restored, managed, developed, or maintained in a manner consistent with the purpose of sections 410cc to 410cc–37 of this title;

(2) is listed in the National Register of Historic Places, as maintained by the Secretary pursuant to section 470a(a) of this title, and section 462(b) of this title; or

(3) is determined by the Secretary to be of national significance;

and would be subject to demolition or major alteration in a manner inconsistent with the purposes of sections 410cc to 410cc–37 of this title unless acquired by the Secretary. Such property may be acquired only as provided in subsection (a)(1) of this section.

(c) Easements; manner of acquisition

The Secretary may acquire easements within the park for the purpose of carrying out sections 410cc to 410cc–37 of this title. Such easements may be acquired only as provided in subsection (a)(1) of this section.

(Pub.L. 95–290, Title II, § 202, June 5, 1978, 92 Stat. 293.)

§ 410cc–23. Agreements and technical assistance

(a) The Secretary may enter into agreements with any owner of property with national historic or cultural significance within the park to provide for interpretive exhibits or programs. Such agreements shall provide, whenever appropriate, that—

(1) the public may have access to such property at specified, reasonable times for purposes of viewing such property or the exhibits or attending the programs established by the Secretary under this subsection; and

(2) the Secretary may make such minor improvements to such property as the Secretary deems necessary to enhance the public use and enjoyment of such property, exhibits, and programs.

(b)(1) The Secretary shall provide, upon request, technical assistance to—

(A) the city of Lowell to assist the city in establishing regulations or laws consistent with the standards and criteria established pursuant to section 410cc–32(e) of this title; and

(B) the Commission to assist the Commission in establishing the index and the standards and criteria required by section 410cc–32 of this title.

(2) The Secretary may provide to any owner of property within the park or preservation district, the Commission, the Commonwealth of Massachusetts, the city of Lowell, and any other Federal entity or any institution such technical assistance as the Secretary considers appropriate to carry out the purpose of sections 410cc to 410cc–37 of this title.

(Pub.L. 95–290, Title II, § 203, June 5, 1978, 92 Stat. 294.)

§ 410cc–24. Withholding of funds; criteria

The Secretary may refuse to obligate or expend any money appropriated for the purposes described in section 410cc–13(a)(1) or section 410cc–13(a)(2) of this title if the Secretary determines that—

(a) the city of Lowell has failed to establish regulations or laws consistent with the standards and criteria established pursuant to section 410cc–32(e) of this title within one year after the date such standards and criteria have been established, except that the Secretary may extend such one-year period for not

more than six months if the Secretary determines that the city has made a good faith effort to establish such regulations or laws;

(b) the city of Lowell has failed to notify the Commission of (1) applications for building permits or zoning variances respecting any property which is included in the index established pursuant to section 410cc-32(d) of this title, or (2) any proposals of the city of Lowell to change the regulations or laws described in paragraph (c)(1) of this subsection;

(c)(1) during the period before the city of Lowell has established regulations or laws consistent with the standards and criteria established pursuant to section 410cc-32(e) of this title, the city of Lowell has granted any building permit or zoning variance or has taken any other action respecting any property within the park or preservation district, which either the Secretary or the Commission consider to be inconsistent with such standards and criteria;

(2) after the city of Lowell has established the regulations or laws described in subparagraph (1) of this paragraph, the city of Lowell has granted any building permit or zoning variance or has taken any other action respecting any property within the park or preservation district, which either the Secretary or the Commission consider to be inconsistent with such regulations or laws; or

(d) the Commission has not made good faith efforts to (1) provide for the preservation, restoration, management, development, or maintenance of property within the park and preservation district or (2) carry out the park preservation plan approved under section 410cc-32 of this title.

(Pub.L. 95-290, Title II, § 204, June 5, 1978, 92 Stat. 294.)

§ 410cc-25. Administrative functions

(a) Implementation of park management plan; emergency assistance for protection of property owners; availability of funds for Commission

(1) The Secretary, acting through the National Park Service, shall take appropriate actions to implement to the extent practicable the park management plan established pursuant to section 410cc-21(b) of this title. In carrying out such plan, the Secretary shall administer the park in accordance with laws, rules, and regulations applicable to the national park system. Before the date on which the Commission conducts its first meeting, the Secretary may take any other action the Secretary deems necessary to provide owners of property with national historic or cultural significance within the park or preservation district with emergency assistance for the purpose of preserving and protecting their property in a manner consistent with the purpose of sections 410cc to 410cc-37 of this title.

(2) Subject to sections 410cc-24 and 410cc-32(b) of this title, the Secretary shall make available to the Commission any funds appropriated under section 410cc-13(a)(2) of this title for the purpose of carrying out sections 410cc-31 to 410cc-36 of this title.

(b) Acceptance of donations of funds, property, or services for implementation of park management plan

Notwithstanding any other provisions of law, the Secretary may accept donations of funds, property, or services from individuals, foundations, corporations, and other private entities, and from public entities, for the purpose of implementing the park management plan.

(c) Sponsorship or coordination of educational or cultural programs

The Secretary may sponsor or coordinate within the park and preservation district such educational or cultural programs as the Secretary considers appropriate to encourage appreciation of the resources of the park and preservation district.

(d) Acquisition of leases respecting property within park

The Secretary may acquire such leases respecting property within the park as may be necessary to carry out the purpose of sections 410cc to 410cc-37 of this title.

(Pub.L. 95-290, Title II, § 205, June 5, 1978, 92 Stat. 295.)

Part C—Powers and Duties of Preservation Commission

§ 410cc-31. Lowell Historic Preservation Commission

(a) Establishment and administrative role; composition of membership

There is established within the Department of the Interior a commission to be known as the Lowell Historic Preservation Commission which shall administer the preservation district and provide certain services within the park in accordance with this part. The Commission shall consist of fifteen members appointed by the Secretary as follows:

(1) Three members who are members of the city council of Lowell, appointed from recommendations made by the mayor of Lowell.

(2) Three members appointed from recommendations made by the city manager of Lowell of persons who are representative of organized labor, the business community, local neighborhoods, and cultural institutions, and who are not elected officials.

(3) One member appointed from recommendations made by the president of the University of Lowell.

(4) Three members appointed from recommendations made by the Governor of the Commonwealth of Massachusetts.

(5) One member appointed from recommendations made by the Secretary of Commerce and who shall be an employee of the Department of Commerce.

(6) One member appointed from recommendations made by the Secretary of Transportation and who shall be an employee of the Department of Transportation.

(7) One member appointed from recommendations made by the Secretary of Housing and Urban Development and who shall be an employee of the Department of Housing and Urban Development.

(8) Two members who are qualified to serve on the Commission because of their familiarity with programs of the Department of the Interior involving national parks and historic preservation and who shall be an employee of the Department of the Interior.

(b) Continuation of status as appointed member for member leaving government office or becoming elected official of government; duration

If any member of the Commission who was appointed to the Commission under paragraph (1) or (4) of subsection (a) of this section as a member of the city council of Lowell or any other government leaves that office, or if any member of the Commission who was appointed from persons who are not elected officials of any government becomes an elected official of a government, such person may continue as a member of the Commission for not longer than the thirty-day period beginning on the date such person leaves that office or becomes such an elected official, as the case may be.

(c) Terms of office and reappointment of members

(1) Except as provided in paragraph (2) of this subsection, members shall be appointed for terms of two years. A member may be reappointed only three times unless such member was originally appointed to fill a vacancy pursuant to subsection (e)(1) of this section, in which case such member may be reappointed four times.

(2) Of the members first appointed pursuant to subsection (a) of this section, the following shall be appointed for terms of three years:

(A) The members appointed pursuant to paragraphs (2), (3), and (8) of such subsection.

(B) One of the members appointed pursuant to paragraph (4) of such subsection, as designated by the Secretary at the time of appointment upon recommendation of the Governor.

(d) Chairman; election by members; term of office

The chairman of the Commission shall be elected by the members of the Commission. The term of the chairman shall be two years.

(e) Vacancies; appointment and term of office; service by member after expiration of term

(1) Any vacancy in the Commission shall be filled in the same manner in which the original appointment was made.

(2) Any member appointed to fill a vacancy shall serve for the remainder of the term for which his predecessor was appointed. Any member may serve after the expiration of his term for a period not longer than thirty days.

(f) Quorum and holding of hearings

Eight members of the Commission shall constitute a quorum, but a lesser number may hold hearings.

(g) Meetings

The Commission shall meet at least once each month, at the call of the chairman or a majority of its members.

(h) Compensation; travel expenses and per diem

(1) Except as provided in paragraph (2) of this subsection, members of the Commission shall each be entitled to receive $100 for each day (including travel time) during which they are engaged in the performance of the duties of the Commission.

(2) Members of the Commission who are full-time officers or employees of the United States, the city of Lowell, or the Commonwealth of Massachusetts shall receive no additional pay on account of their service on the Commission.

(3) While away from their homes or regular places of business in the performance of services for the Commission, members of the Commission shall be allowed travel expenses, including per diem in lieu of subsistence, in the same manner as persons employed intermittently in the Government service are allowed expenses under section 5703 of Title 5.

(i) Termination

The Commission established pursuant to sections 410cc to 410cc–37 of this title, shall cease to exist ten years from June 5, 1978.

(Pub L. 95-290, Title III, § 301, June 5, 1978, 92 Stat. 295.)

§ 410cc–32. Park preservation plan and index

(a) Submission by Commission and approval or disapproval by Secretary of draft and final plans; procedures applicable; revisions in approved plan

(1) Within one year after the date on which the Commission conducts its first meeting, the Commission shall submit to the Secretary a draft park preservation plan meeting the requirements of subsection (c) of this section. The Secretary shall review the draft park preservation plan and, within ninety days after the date on which such plan is submitted to the Secretary, suggest appropriate changes in such plan to the Commission.

(2) Within eighteen months after the date on which the Commission conducts its first meeting, the Commission shall submit to the Secretary a park preservation plan which meets the requirements of subsection (c) of this section. The Secretary shall, within ninety days after the date on which such plan is submitted to the Secretary, approve or disapprove such plan. The Secretary may not approve such plan unless the Secretary determines that such plan would adequately carry out the purpose of sections 410cc to 410cc–37 of this title.

(3) If the Secretary disapproves a park preservation plan, the Secretary shall advise the Commission of the reasons for such disapproval together with the recommendations of the Secretary for revision of such plan. Within such period as the Secretary may designate, the Commission shall submit a revised park preservation plan to the Secretary. The Secretary shall approve or disapprove any revised park preservation plan in the same manner as required in paragraph (2) of this subsection for the approval or disapproval of the original park preservation plan.

(4) If the Secretary approves a park preservation plan, the Secretary shall publish notice of such approval in the Federal Register and shall forward copies of the approved plan to the Congress.

(5) Any park preservation plan or draft plan submitted to the Secretary under this subsection shall, upon request, be available to the public.

(6) No changes other than minor revisions may be made in the approved park preservation plan without the approval of the Secretary. The Secretary shall approve or disapprove any proposed change in the approved park preservation plan, except minor revisions in the same manner as required in paragraph (2) of this subsection for the approval or disapproval of the original park preservation plan.

(b) Funding availability and requirements for plan implementation, activities, etc.

(1) Except as provided in paragraph (2) of this subsection, the Secretary shall not make any funds available to the Commission to carry out section 410cc–33 or 410cc–34 of this title until a park preservation plan has been approved under subsection (a) of this section.

(2) Before a park preservation plan is approved under subsection (a) of this section, the Secretary may make available to the Commission such funds as the Commission may request to carry out any activity specified in paragraph (3) of this section. However, no funds shall be made available under this paragraph unless a proposal describing such activity is reviewed and approved by the Secretary.

(3) The Commission may request funds from the Secretary to—

(A) carry out activities to preserve, restore, manage, develop, or maintain any property identified in subsection (c) (1) of this section;

(B) take any action the Commission considers necessary to provide owners of property with national historical or cultural significance within the park or preservation district with emergency assistance for the purpose of preserving and protecting their property in a manner consistent with the purpose of sections 410cc to 410cc–37 of this title; or

(C) acquire in accordance with section 410cc–34 of this title, any property within the park which—

(i) is identified in the report of the Lowell Historic Canal District Commission as a property which should be preserved, restored, managed, developed, or maintained in a manner consistent with the purpose of sections 410cc to 410cc–37 of this title;

(ii) is listed in the National Register of Historic Places, as maintained by the Secretary pursuant to section 470a(a) of this title, and section 462(b) of this title; or

(iii) is determined by the Secretary to be of national significance;

and would be subject to demolition or major alteration in a manner inconsistent with the purpose of sections 410cc to 410cc–37 of this title unless acquired by the Commission.

(c) Requirements for plan

Any plan submitted to the Secretary under subsection (a) of this section shall—

(1) describe the manner in which the Commission, to the extent practicable in accordance with the recommendations in the report of the Lowell Historic Canal District Commission, proposes to provide for the preservation, restoration, management, development, or maintenance of—

(A) the Welles Block, 169 Merrimack Street;

(B) the Jordan Marsh Company Building, 153 Merrimack Street and 15 Kirk Street;

(C) the Yorick Club, 91 Dutton Street;

(D) the Lowell Gas Light Company, 22 Shattuck Street;

(E) St. Anne's Church and Rectory, 237 Merrimack Street;

(F) Lowell Institution for Savings, 18 Shattuck Street;

(G) the Ahepa Building, 31 Kirk Street;

(H) Boott Mill, Foot of John Street;

(I) Lowell Manufacturing Company on Market Street; and

(J) the structure commonly referred to as the Early Residence, 45, 47, and 49 Kirk Street;

(2) identify the properties included in the index established pursuant to subsection (d) of this section;

(3) identify the properties which the Commission intends to acquire under section 410cc-34 of this title and specify how such properties shall be used;

(4) include the standards and criteria established pursuant to subsection (e) of this section;

(5) provide a detailed description of the manner in which the Commission intends to implement the grant and loan programs under section 410cc-33 of this title, including information relating to the estimated amount of such grants and the manner in which such grants shall be awarded by the Commission;

(6) provide for a transportation program by which the Commission shall provide, directly or by agreement with any person or any public or private entity, transportation services and facilities for park and preservation district visitors, including barge equipment, docking facilities, and local rail facilities;

(7) provide for educational and cultural programs to encourage appreciation of the resources of the park and preservation district; and

(8) include a tentative budget for the subsequent five fiscal years.

(d) Establishment and contents of index; modification of index

The Commission shall establish, within one year after the date on which the Commission conducts its first meeting, an index which includes—

(1) any property in the park or preservation district (except for any property identified in section 410cc-21(a)(2) of this title) which should be preserved, restored, managed, developed, maintained, or acquired by the Commission because of its national historic or cultural significance; and

(2) any property which should be preserved, restored, managed, developed, or maintained in a manner compatible with the purpose of sections 410cc to 410cc-37 of this title because of its proximity to (A) any property referred to in paragraph (1) of this subsection, or (B) any property designated in section 410cc-21(a)(2) of this title.

The index may be modified only by a majority vote of the members of the Commission, taken when a quorum is present.

(e) Standards and criteria for construction, preservation, etc., of properties within preservation district and park; authorization; establishment; revisions; publication in Federal Register

(1) The Commission shall establish standards and criteria applicable to the construction, preservation, restoration, alteration, and use of all properties within the preservation district with the advice of the Commonwealth of Massachusetts and of the Secretary, and the consent of the city manager of Lowell.

(2) The Commission shall establish the standards and criteria described in paragraph (1) of this subsection for any property within the park with the advice of the Commonwealth of Massachusetts and the city manager of Lowell and subject to the review and approval of the Secretary.

(3) The Commission shall establish standards and criteria under paragraphs (1) and (2) of this subsection within one year after the date on which the Commission conducts its first meeting. Such standards and criteria may be revised in the same manner in which they were originally established.

(4) The Secretary shall publish the standards and criteria established under paragraphs (1) and (2) of this subsection, and any revisions thereof, in the Federal Register.

(Pub.L. 95-290, Title III, § 302, June 6, 1978, 92 Stat. 297.)

§ 410cc-33. Financial and technical assistance

(a) Loans to Lowell Development and Financial Corporation for loans for preservation, etc., of property; terms of loan agreement with corporation; determination of compliance by corporation with requirements for loans; repayment by corporation

The Commission may make loans to the Lowell Development and Financial Corporation (established under chapter 844 of the Massachusetts General Laws and hereinafter referred to as the "corporation") to enable the corporation to provide low interest loans for the preservation, restoration, or development of any property described in section 410cc-32(d)(1) of this title. The Commission may make any such loan to the corporation only after entering into a loan agreement with the corporation which includes the following terms:

(1) The loan to the corporation shall have a maturity of thirty-five years. At the end of such period, the corporation shall repay to the Secretary of the Treasury (in a lump sum) for deposit in the general fund of the Treasury the full amount of the loan and any additional amounts accruing to the corporation pursuant to this subsection excepting those amounts expended by the corporation for reasonable administrative expenses.

(2) The money received from the Commission, and any interest earned on such money, may be obligated by the corporation only for low interest loans made under paragraphs (6) and (7) of this subsection, except that the corporation may use such money to the extent the Commission considers reasonable to satisfy the costs of the corporation in administering the loan or procuring loan guarantees or insurance.

(3) Within five years after receiving the loan from the Commission, the corporation shall make loans under paragraphs (6) and (7) of this subsection which, in the aggregate, obligate the full amount of money received from the Commission (minus any amount required to satisfy the costs described in paragraph (2) of this subsection).

(4) As loans made under paragraphs (6) and (7) of this subsection are repaid, the corporation shall make additional loans under such paragraphs with the money made available for obligation by such repayments.

(5) The corporation shall make available to the Commission and to the Secretary, upon request, all accounts, financial records, and other information related to loans made under paragraphs (6) and (7) of this subsection.

(6) Before the corporation approves any application for a low interest loan for which money has been made available to the corporation by the Commission, the corporation shall require the prospective borrower to furnish the corporation with a statement from the Commission stating that the Commission has reviewed the application and has determined that any loan received by the prospective borrower will be spent in a manner consistent with—

(A) the standards and criteria established pursuant to section 410cc-32(e) of this title, and

(B) the goals of the park preservation plan approved under section 410cc-32(a) of this title.

(7) The corporation may approve any application for a low interest loan which meets the terms and conditions prescribed by the corporation with the approval of the Commission and for which money has been made available to the corporation by the Commission if—

(A) the prospective borrower furnishes the corporation with the statement described in paragraph (6) of this subsection;

(B) the corporation determines that such borrower has sufficient financial resources to repay the loan; and

(C) such borrower satisfies any other applicable credit criteria established by the corporation.

In order to determine whether the corporation has complied with this subsection, the Commission, or such other appropriate person or entity as the Commission may designate, shall conduct an audit at least once every two years of all accounts, financial records, and other information related to loans made under paragraphs (6) and (7) of this subsection. If the Commission determines, after conducting a hearing on the record, that the corporation has substantially failed to comply with this subsection, the outstanding balance of any loan made to the corporation under this subsection shall become payable in full upon the demand of the Commission.

(b) Grants to property owners for preservation, etc., of property; grants to persons or public or private entities for educational and cultural programs or for necessary services; terms of grant agreements; recovery of amounts for inconsistent uses

(1) The Commission may make grants to owners of property described in section 410cc-32(d)(1) of this title for the preservation, restoration, management, development, or maintenance of such property in a manner consistent with the standards and criteria established pursuant to section 410cc-32(e) of this title.

(2) The Commission, with the approval of the Secretary, may make grants to any person or any public or private entity to provide for (i) educational and cultural programs which encourage appreciation of the resources of the park and preservation district, or (ii) any planning, transportation, maintenance, or other services the Commission considers necessary to carry out the purposes of sections 410cc to 410cc-37 of this title.

(3) Grants under this subsection shall be made under agreements which specify the amount of the grant, the installments (if any) by which the grant shall be paid to the grant recipient, the purpose for which the grant may be used, and any other condition the Commission considers appropriate. The Commission shall be entitled, under the terms of any grant agreement, to recover from the recipient any funds used in a manner inconsistent with such grant agreement.

(c) Technical assistance to property owners, etc.

The Commission with the advice of the Secretary may provide technical assistance to—

(1) owners of property within the park or preservation district to assist such owners in (A) making repairs to or improvements in any property included in the index established pursuant to section 410cc-32(d) of this title, or (B) applying for loans under subsection (a) of this section; and

(2) any other person or public or private entity to assist such person or entity in taking actions consistent with the purpose of sections 410cc to 410cc-37 of this title.

(d) Availability to Secretary of all accounts, financial records, and other information relating to loans and grants

The Commission shall make available to the Secretary, upon request, all accounts, financial records, and other information of the Commission relating to grants and loans made under this section.

(e) Annual report to Congress; contents

The Secretary shall make an annual report to the Congress describing the loans, grants, and technical assistance provided under this section and under section 410cc-23 of this title. Such report shall specify the amount, recipient, and purpose of any loan, grant or technical assistance so provided and contain such additional information as the Secretary considers appropriate.

(Pub.L. 95-290, Title III, § 303, June 5, 1978, 92 Stat. 300.)

§ 410cc-34. Acquisition and disposition of property

(a) Acquisition of specified property; manner of acquisition

(1) The Commission may acquire any property designated in paragraph (3) of this subsection, any property described in section 410cc-32(d)(1) of this title, or any interest therein, by donation, by purchase with donated or appropriated funds, or by condemnation in accordance with paragraph (2) of this subsection.

(2) Only properties within the park or property designated in paragraph (3) of this subsection may be acquired by the Commission by condemnation. The Commission may initiate condemnation proceedings only after making every reasonable effort to acquire any such property through negotiations and purchase and consulting with the city council of Lowell. No lands or interests therein may be acquired by the Commission by condemnation without the approval of the Secretary.

(3) The Commission may acquire in accordance with paragraph (1) of this subsection the following properties, or any interest therein:

(A) World Furniture Building, 125 Central Street; and

(B) The Martin Building, 102-122 Central Street.

(b) Sale or lease of specified property; conditions

The Commission, with the approval of the Secretary, may sell or lease any property which it acquires under subsection (a) of this section subject to such deed restrictions or other conditions as the Commission deems appropriate to carry out the purpose of sections 410cc to 410cc-37 of this title.

(c) Agreement for disposal of specified property to Commonwealth of Massachusetts; purposes of transfers

Pursuant to a written agreement between the Commission and the Commonwealth of Massachusetts, the Commission, with the approval of the Secretary, may sell, donate, lease, or in any other manner the Commission and the Secretary deem appropriate make available to the Commonwealth any property which the Commission has acquired under subsection (a) of this section in order to provide for the administration or maintenance of such property by the Commonwealth in a manner consistent with the purpose of sections 410cc to 410cc-37 of this title.

(Pub.L. 95-290, Title III, § 304, June 5, 1978, 92 Stat. 302.)

§ 410cc-35. Powers of Commission

(a) Conduct of hearings, etc.

The Commission may for the purpose of carrying out sections 410cc to 410cc-37 of this title hold such hearings, sit and act at such times and places, take such testimony, and receive such evidence, as the Commission may deem advisable. The Commission may administer oaths or affirmations to witnesses appearing before it.

(b) Authorization of action by member or agent

When so authorized by the Commission, any member or agent of the Commission may take any action which the Commission is authorized to take by this section.

(c) Receipt of necessary information from other Federal departments or agencies; information furnished upon request by Chairman

Subject to section 552a of Title 5, the Commission may secure directly from any department or agency of the United States information necessary to enable it to carry out sections 410cc to 410cc-37 of this title. Upon request of the chairman of the Commission, the head of such department or agency shall furnish such information to the Commission.

(d) Authorization to seek and accept donations of funds, property, or services

Notwithstanding any other provision of law, the Commission may seek and accept donations of funds, property, or services from individuals, foundations, corporations, and other private entities, and from public entities, for the purpose of carrying out its duties.

(e) Use of funds for obtaining additional moneys

The Commission may use its funds to obtain money from any source under any program or law requiring the recipient of such money to make a contribution in order to receive such money.

(f) Use of mails

The Commission may use the United States mails in the same manner and upon the same conditions as other departments and agencies of the United States.

(g) Purchase, rental, donation, etc., of property, facilities, and services; manner of acquisition; transfers to Department of Interior upon termination of Commission

The Commission may obtain by purchase, rental, donation, or otherwise, such property, facilities, and services as may be needed to carry out its duties. Any acquisition of property by the Commission shall be in accordance with section 410cc-34 of this title: *Provided, however*, That the Commission may not acquire land or interests therein pursuant to this subsection by condemnation. Upon the termination of the Commission, all property, personal and real, and unexpended funds shall be transferred to the Department of the Interior.

(Pub.L. 95-290, Title III, § 305, June 5, 1978, 92 Stat. 302.)

§ 410cc-36. Staff of Commission

(a) Appointment and compensation of Director

The Commission shall have a Director who shall be appointed by the Commission and who shall be paid at a rate not to exceed the rate of pay payable for grade GS-15 of the General Schedule.

(b) Appointment and compensation of additional personnel

The Commission may appoint and fix the pay of such additional personnel as the Commission deems desirable.

(c) Applicability of civil service provisions to appointment and compensation of Director and staff

The Director and staff of the Commission may be appointed without regard to the provisions of Title 5 governing appointments in the competitive service, and may be paid without regard to the provisions of chapter 51, and subchapter III of chapter 53 of such title relating to classification and General Schedule pay rates, except that no individual so appointed may receive pay in excess of the annual rate of basic pay payable for grade GS-15 of the General Schedule.

(d) Temporary or intermittent services; procurement and compensation

Subject to such rules as may be adopted by the Commission, the Commission may procure temporary and intermittent services to the same extent as is authorized by section 3109(b) of Title 5, but at rates determined by the Commission to be reasonable.

(e) Detail of personnel from other Federal agencies represented by members on Commission; reimbursement by Commission; administrative support services by Administrator of General Services Administration; reimbursement by Commission

(1) Upon request of the Commission, the head of any Federal agency represented by members on the Commission may detail, on a reimbursable basis, any of the personnel of such agency to the Commission to assist it in carrying out its duties under sections 410cc to 410cc-37 of this title.

(2) The Administrator of the General Services Administration shall provide to the Commission on a reimbursable basis such administrative support services as the Commission may request.

(Pub.L. 95-290, Title III, § 306, June 5, 1978, 92 Stat. 303.)

§ 410cc-37. Use of funds; maintenance of financial records; audits

(a) Any revenues or other assets acquired by the Commission by donation, the lease or sale of property or fees for services shall be available to the Commission, without fiscal year limitation, to be used for any function of the Commission authorized under sections 410cc to 410cc-37 of this title. The Commission shall keep financial records fully disclosing the amount and source of revenues and other assets acquired by the Commission, and shall keep such other financial records as the Secretary may prescribe.

(b) The Secretary shall require audits of the financial records of the Commission to be conducted not less frequently than once each year in order to ensure that revenues and other assets of the Commission are being used in a manner authorized under sections 410cc to 410cc-37 of this title.

(Pub.L. 95-290, Title III, § 307, as added Pub.L. 96-344, § 10, Sept. 8, 1980, 94 Stat. 1136.)

An Act

Oct. 16, 1987
[H.R. 2035]

To amend the Act establishing Lowell National Historical Park, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. AMENDMENTS.

The Act entitled "An Act to provide for the establishment of the Lowell National Historical Park in the Commonwealth of Massachusetts, and for other purposes", approved June 5, 1978 (92 Stat. 290; 16 U.S.C. 410cc et seq.), is amended—

16 USC 410cc-13.

(1) in section 103(a)—

(A) by striking "$18,500,000" and inserting "$19,300,000" in paragraph (1); and

(B) by striking "$21,500,000" and inserting "$33,600,000" in paragraph (2);

16 USC 410cc-31.

(2) in section 301(e)(2) by striking "for a period not longer than thirty days" and inserting "until his successor is appointed"; and

(3) in section 301(i) by striking "ten" and inserting "seventeen".

16 USC 410cc-13 note.

SEC. 2. EFFECTIVE DATES.

(a) IN GENERAL.—Except as provided in subsection (b), the amendments made by section 1 shall take effect on the date of the enactment of this Act.

(b) EFFECTIVE DATE OF AUTHORIZATION OF APPROPRIATION.—The amendments made by section 1(1) shall take effect on October 1, 1987.

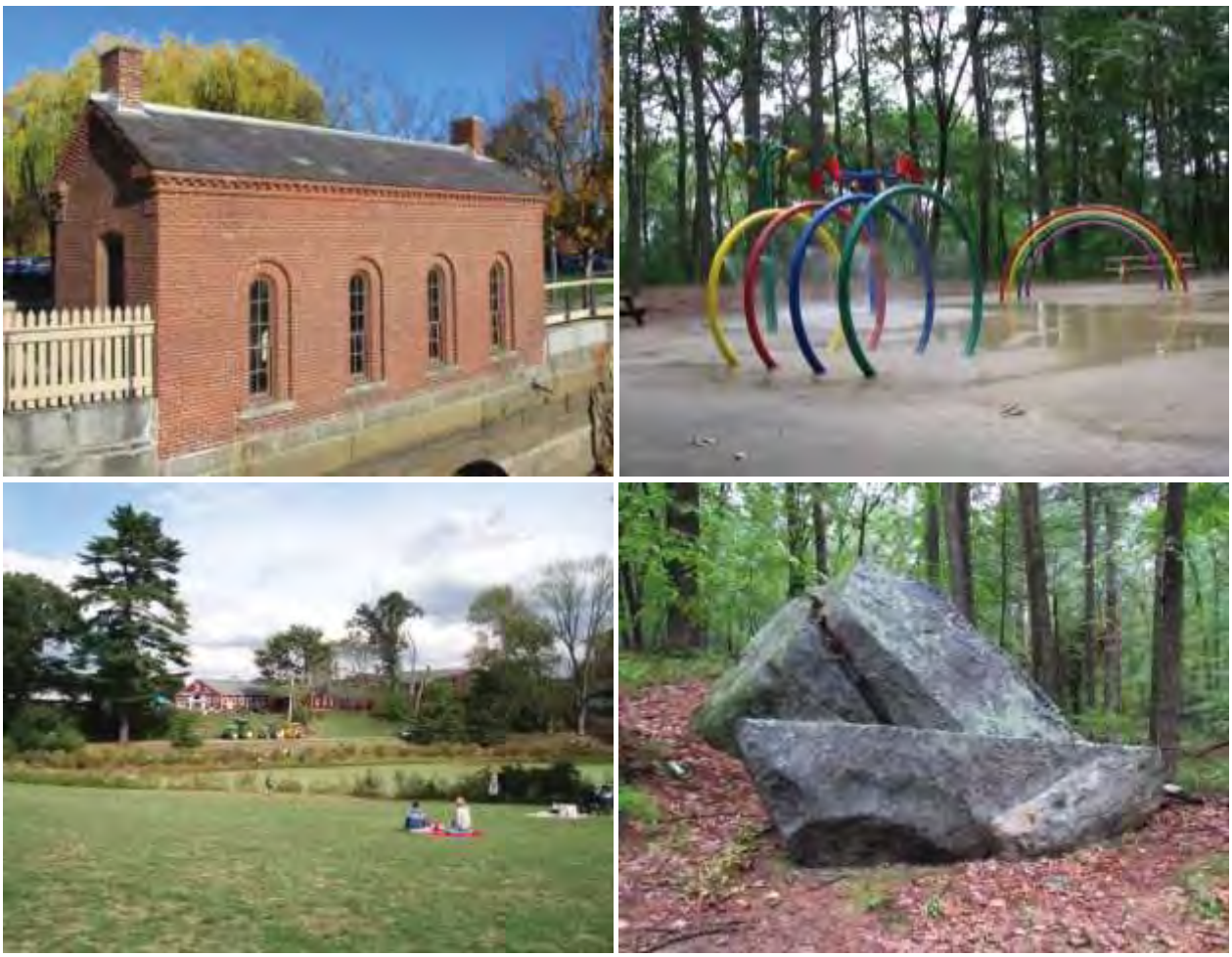
Approved October 16, 1987.

Massachusetts Department of Conservation and Recreation
Bureau of Planning and Resource Protection
Resource Management Planning Program

RESOURCE MANAGEMENT PLAN

Lowell/Great Brook Planning Unit

Including Lowell-Dracut-Tyngsborough State Forest, Lowell Heritage State Park, Great Brook Farm State Park, Carlisle State Forest, Warren H. Manning State Forest, Billerica State Forest, and Governor Thomas Dudley State Park



July 2014 – Public Review Draft

dcr
Massachusetts

Lowell/Great Brook Planning Unit

Including Lowell-Dracut-Tyngsborough State Forest, Lowell Heritage State Park, Great Brook Farm State Park, Carlisle State Forest, Warren H. Manning State Forest, Billerica State Forest, and Governor Thomas Dudley State Park

RESOURCE MANAGEMENT PLAN

2014

Deval L. Patrick, Governor
Maeve Vallely Bartlett, Secretary
John P. Murray, Commissioner
Kevin J. Whalen, Deputy Commissioner for Park Operations

Resource Management Plans provide guidance for managing properties under the stewardship of the Department of Conservation and Recreation (DCR). They are intended to be working documents for setting priorities, enabling the DCR to adapt to changing fiscal, social, and environmental conditions. The planning process provides a forum for communication and cooperation with park visitors and the surrounding communities to ensure transparency in the DCR's stewardship efforts.

The Lowell/Great Brook Planning Unit is as diverse as the DCR's park system as a whole. From the collection of highly significant cultural resources and urban green spaces that make up Lowell Heritage State Park, to the historic working agricultural landscape of Great Brook Farm State Park, to the roughly 1,500 acres that encompass five other heavily wooded properties in the planning unit, visitors can enjoy a range of urban, rural, and backwoods experiences all within a seven mile radius. It is really pretty remarkable.

There are also many educational and recreational opportunities available within the planning unit, from learning about the 19th century textile industry and the inner workings of a dairy farm, to hiking, biking, and cross-country skiing by moonlight, the properties provide a little bit of everything for everyone. In several cases, the DCR has partnered with private and public entities to further enhance these opportunities, and ensure that the planning unit is able to be enjoyed today, and for years to come.

This Resource Management Plan provides recommendations that protect the natural and cultural resources of each property, while providing for compatible recreation, so that they are available for future generations.

John P. Murray
Commissioner

The Massachusetts Department of Conservation and Recreation (DCR), an agency of the Executive Office of Energy and Environmental Affairs, oversees 450,000 acres of parks and forests, beaches, bike trails, watersheds, dams and parkways. Led by Commissioner John P. Murray, the agency's mission is to protect, promote and enhance our common wealth of natural, cultural and recreational resources. To learn more about the DCR, our facilities and our programs, please visit us at www.mass.gov/dcr. Contact us at mass.parks@state.ma.us.

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EXECUTIVE SUMMARY

INTRODUCTION

The Department of Conservation and Recreation is directed by a legislative mandate (M.G.L. Chapter 21, Section 2F) to prepare management plans for every reservation, park and forest, to provide guidelines for the management and stewardship of natural and cultural resources and ensure consistency between recreation, resource protection and sustainable forest management. The legislative mandate also requires the incorporation of public review and input into the development of management plans, and review and adoption by the DCR Stewardship Council.

Resource Management Plans (RMPs) consider the past, present and future of a reservation, park or forest. Through an assessment of resources and their existing conditions, clear management goals and objectives are developed, and short and long-term implementation action plans are identified for the management of properties under the stewardship of the DCR. RMPs are written to meet the information needs of a diverse audience: from the decision-makers directly involved in the operation and management of a property, to a variety of outside stakeholders. RMPs are intended to be working documents for setting priorities, budgeting and resource allocation, and establishing guidelines for balancing sustainable recreation with the stewardship of natural and cultural resources. Finally, RMPs are of value to users that are interested in learning more about specific properties, the challenges the DCR faces and how decisions affecting the properties are made.

This plan covers the Lowell/Great Brook Planning Unit in the municipalities of Lowell, Dracut, Tyngsborough, Carlisle, Chelmsford, and Billerica, Massachusetts.

THE LOWELL/GREAT BROOK PLANNING UNIT

The Lowell/Great Brook Planning Unit is very diverse and can be viewed as a microcosmic representation of the DCR state park system as a whole. From the collection of highly significant cultural resources and urban greenspaces that make up Lowell Heritage State Park, to the historic working agricultural landscape of Great Brook Farm State Park, to the roughly 1,500 acres encompassing the five other heavily wooded properties in this planning unit, and a range of recreational uses in between, there are few characteristics that can be applied to the planning unit as a whole. In addition, there are several complex partnerships and co-management relationships to balance at many of these facilities. The defining characteristics for the individual properties are as follows:

Lowell-Dracut-Tyngsborough State Forest

A large swath of protected open space that is predominantly wooded, with many low wet areas and little park infrastructure, Lowell-Dracut-Tyngsborough provides miles of trails and recreational access for the nearby urban population, along with habitat protection that is regionally important. There are also three Conservation Restrictions associated with the forest, totaling approximately 73 acres.

Lowell Heritage State Park

An urban park encompassing a variety of parcels within the City of Lowell and operated through multiple and complex shared management systems, this property was established to help showcase the history of the city. The DCR owns numerous historic and a few more recently constructed buildings, including four gatehouses that are a part of canal operations and the Mack building; greenspaces ranging from a small Victorian garden to the one-mile-long Vandenberg esplanade along the river; and some unusual resources, including air rights over many of the city's canals. Lowell Heritage State Park provides both interpretive opportunities and recreational access in a dense urban environment.

Great Brook Farm State Park

A working dairy farm connected to miles of trails that are used for a variety of recreational activities, Great Brook Farm includes historic buildings and resources alongside a new "smart" barn with a robotic milking system, interpretive programming and a cross-country ski concession.

Carlisle State Forest

A small wooded property protected from forestry activities at the turn of the 20th century to conserve an older stand of exceptionally large white pines. Undeveloped and used primarily by local residents, this small gem provides recreational access and habitat protection.

Warren H. Manning State Forest

A largely wooded property with a small recreation area, complete with a spray deck, picnic area and fitness trail. Named for the preeminent landscape architect that advocated (and donated land for) the establishment of a town forest, this property provides recreational opportunities and habitat protection in a suburban environment.

Billerica State Forest

An undeveloped and largely wooded property bordering Route 3, this property provides recreational access and habitat protection.

Governor Thomas Dudley State Park

The smallest facility within the planning unit, this 11-acre park is a small wooded parcel that provides access to the Concord River and links to other protected open space.

MANAGEMENT PRINCIPLE AND GOALS

Through the Resource Management Planning process, a principle for managing the Lowell/Great Brook Planning Unit was established and four associated goals developed.

Management Principle

Protect the natural and cultural resources of the planning unit and provide enhanced recreational and educational opportunities for visitors through the creative use of state resources and partnerships.

Management Goals

The following four management goals have been developed to achieve the management principle. These goals are of equal importance, and are not presented in order of priority.

Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.

Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.

Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.

Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.

PRIORITY RECOMMENDATIONS

Recommendations are characterized on the basis of priority (i.e., High, Medium, or Low) and resource availability. High priority recommendations are those that address regulatory compliance or public health and safety; prevent immediate damage to, or loss of, resources; or repair or replace damaged equipment or systems critical to park operations. They are typically time sensitive. Medium priority recommendations maintain existing resources and visitor experiences. Low priority recommendations enhance resources or visitor experiences; they are not time sensitive.

Resource availability considers both funding and labor. A resource availability of one indicates that funding and/or labor are available to implement the recommendation. A resource availability of two indicates that funding and/or labor are not currently available, but may become so in the near future (i.e., the next five years). A resource availability of three indicates that funding and/or labor are not anticipated in the next five years. Resources to implement these recommendations may, or may not, become available after five years.

This RMP identifies 150 management recommendations; 69 are classified as high priorities. Resources are currently available to implement 46 of these high priority recommendations. It is anticipated that resources will be available within the next five years to implement 19 additional high priority recommendations. These recommendations, and the lead DCR unit responsible for their implementation, are identified in the Action Plan that accompanies this Executive Summary.

Table ES.1. Summary of management recommendations.

	Resource Availability			
Priority	**1**	**2**	**3**	*Total*
High	41	24	4	*69*
Medium	14	30	7	*51*
Low	7	12	11	*30*
Total	*62*	*66*	*22*	

PUBLIC PARTICIPATION IN DEVELOPING THIS RMP

Notice of a public meeting and the DCR's intent to prepare a Resource Management Plan for the Lowell/Great Brook Planning Unit appeared in the July 11, 2012 issue of the Environmental Monitor. Additional announcements were posted on the DCR website and press releases were provided to the local media. Announcements were also distributed to individuals, statewide, regional and local stakeholder organizations and local officials. An initial public meeting occurred on July 23, 2012 in the Hart Barn at Great Brook Farm State Park in Carlisle. Approximately 20 people attended this initial meeting. Public input was received at the meeting and through e-mail received during a 30-day public comment period after the meeting.

A public meeting to present an overview of the draft RMP held on July 21, 2014 in Alumni Hall at the University of Massachusetts Lowell; it was attended by [#] people. Notice of the meeting was published in the July 9, 2014 issue of the Environmental Monitor and posted on the DCR website. Press releases were provided to local media and notices were sent directly to individuals, stakeholder organizations and local officials. The draft RMP was made available on the DCR website, at the Powell Memorial Library in Lowell, Gleason Public Library in Carlisle, Billerica Public Library, Parker Memorial Library in Dracut, and Tyngsborough Public Library, as well as at the Great Brook Farm State Park headquarters on [DATE].

The public comment period on the draft RMP ran from July 22, 2014 to August 29, 2014. [#] sets of comments were received and incorporated into the final RMP (see Appendix B). This Resource Management Plan was submitted to the DCR's Stewardship Council on [DATE] and was adopted by the Council on [DATE].

Action Plan 2014-2019

Priority Action	DCR Lead Unit(s)
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.	
Remove the debris at the former headquarters site that poses a threat to significant resources (i.e., the pump house cellar hole) and public safety (i.e., glass bottles). [LDT SF]	Mass Parks
Address the culverts within the forest that are blocked and/or collapsing. [LDT SF]	MassParks, Planning and Engineering
Remove the graffiti from Sheep Rock and work with the Environmental Police to curb the illegal activities that take place at the site. [LDT SF]	MassParks and Planning
Assess the condition of the interior and exterior of the Rynne bathhouse and make repairs, where necessary. [Lowell Heritage SP]	MassParks, Planning and Engineering
Meet with the National Park Service to develop and implement a preservation plan for the Hamilton Wasteway Gatehouse. [Lowell Heritage SP]	MassParks, Planning and Engineering
Revisit the draft Comprehensive Interpretive Plan; revise and update as necessary and finalize. [Great Brook Farm SP]	MassParks
Develop interpretive programs, opportunities, and products as identified in the Comprehensive Interpretive Plan, working to expand interpretive offerings beyond the smart barn tours. [Great Brook Farm SP]	MassParks
Clear the debris currently built up around the beaver deceivers to maintain water flow and keep them operational. [Great Brook Farm SP]	MassParks
Routinely monitor "The City," particularly the Garrison House site, for stability and potential disturbances. [Great Brook Farm SP]	MassParks and Planning
Remove the broken sign at the Garrison House site. [Great Brook Farm SP]	MassParks
North Schoolhouse: Carefully remove the English ivy from the walls, with guidance from DCR's Office of Cultural Resources. [Great Brook Farm SP]	MassParks and Planning
Main Farm House: Install an appropriate gutter, with guidance from DCR's Office of Cultural Resources. [Great Brook Farm SP]	Planning
Main Farm House: Complete minor repairs to the siding and the front door sill, with guidance from DCR's Office of Cultural Resources. [Great Brook Farm SP]	Planning
Tie Stall Barn: Assess the stability of the foundation in areas where it has visibly been compromised, and repair as necessary, with guidance from DCR's Office of Cultural Resources. [Great Brook Farm SP]	Planning and Engineering
Litchfield House: Complete repairs to the barn. [Great Brook Farm SP]	Planning
Update the inventory of the large eastern white pine trees, last done in 1980. [Carlisle SF]	Forestry
After completion of tree inventory update, revisit the Land Stewardship Zoning to determine if any changes are applicable. [Carlisle SF]	Planning and Forestry
Monitor for invasive pests, especially hemlock wooly adelgid. Propose biological or chemical controls if warranted on the specimen trees. [Carlisle SF]	Forestry
Clean up the dumping debris located off of Rangeway Road, and continue to monitor the area for illegal dumping. [Manning SF]	MassParks
Dismantle the fire ring located at the top of Gilson Hill, to discourage use. [Billerica SF]	MassParks
Clean up the dumping debris located adjacent to Winning Street, and continue to monitor the area for illegal dumping. [Billerica SF]	MassParks

Continued on next page.

Action Plan 2014-2019 (Continued)

Priority Action	DCR Lead Unit(s)
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.	
Review and update or create, where appropriate, a trail map for each of the properties in the planning unit, and make the maps available through multiple outlets. [Planning Unit]	MassParks and External Affairs
Work with the Environmental Police to curb the illegal recreation activities (e.g., off-highway vehicle use and paintball games) taking place at the forest. [LDT SF]	MassParks
Post signs that clearly indicate the boundary of the forest's "No Hunting Areas." [LDT SF]	MassParks and Forestry
Improve the trail signage within the forest, adding trail names and intersection numbers where appropriate. [LDT SF]	MassParks and Forestry
Post fish consumption advisory signs in multiple, locally spoken languages at popular fishing spots along the Merrimack River and Lowell Canal System. [Lowell Heritage SP]	MassParks and External Affairs
Ensure that all of the violations noted in the most recent inspection of the Lord pool are addressed in the upcoming modernization project. [Lowell Heritage SP]	Engineering
Develop a trails plan, assessing existing density and incorporating critical information developed through the hydrological study to better address areas that have trail washout problems. [Great Brook Farm SP]	Planning
Securely cover the open well located southeast of the Litchfield House. [Great Brook Farm SP]	MassParks
Reassess all boardwalk crossings to identify older ones in need of replacement, including those on the Acorn Trail. [Great Brook Farm SP]	MassParks
Establish designated handicapped accessible parking spaces in the parking lot, total number to be determined in consultation with DCR's Universal Access Program. [Manning SF]	Engineering
Goal 3. Address vacant infrastructure to improve visitor experiences and DCR operational responsibilities.	
Former Regional HQ site: remove former sign holder and pavement to let the site return to a natural state. [Great Brook Farm SP]	MassParks and Engineering
Tie Stall Barn: Address the outstanding permit issues for the event space and renew discussions about future use. [Great Brook Farm SP]	MassParks and Engineering
Farnham Smith's Cabin: Undertake a structural assessment and reuse feasibility study to determine if reuse is possible and develop some potential options. [Great Brook Farm SP]	Planning, MassParks and Engineering
Cabin Shed: Access and clean out the interior of the shed, so that it does not become a potential nuisance. [Great Brook Farm SP]	MassParks
Boat House: Complete and submit MHC Inventory form. [Great Brook Farm SP]	Planning
Boat House: Undertake demolition. [Great Brook Farm SP]	Engineering
South House/District 6 Fire Control: Assess for any reuse possibilities by the park and/or the region, such as accommodating the storage needs currently being met by the Hadley House and the Anderson Barn. [Great Brook Farm SP]	Planning, MassParks and Forestry
Hadley House: Investigate alternative uses of the property and possibly making it available to be moved. If not possible, identify a funding source for demolition before it becomes an attractive nuisance. [Great Brook Farm SP]	Planning, MassParks and Engineering
West Farm/Manseau House: Assess for inclusion in the Historic Curatorship Program. If not a good candidate, identify a funding source for demolition, before it becomes an attractive nuisance. [Great Brook Farm SP]	Planning, MassParks and Engineering
North Farm House and Barn: Make sure the buildings are secure, and routinely monitor to ensure they aren't damaged or broken into. [Great Brook Farm SP]	MassParks

Continued on next page.

Action Plan 2014-2019 (Continued)

Priority Action	DCR Lead Unit(s)
Goal 3. Address vacant infrastructure to improve visitor experiences and DCR operational responsibilities.	
North Farm House and Barn: Work with current long term leaseholders of other facilities within the park to identify any potential complementary reuses for this property, and explore putting out a Request for Proposals. [Great Brook Farm SP]	Planning, MassParks and External Affairs
Anderson Barn: Explore any potential interest in, and options for, permitting use of the barn by others, and relocate current storage closer to the Park HQ. [Great Brook Farm SP]	MassParks and Planning
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.	
Establish webpages on the DCR website for the properties in the planning unit that currently do not have a webpage. [Planning Unit]	MassParks and External Affairs
Renew the agreement with the Greater Lowell Indian Cultural Association (GLICA). [LDT SF]	MassParks and Legal
Arrange a meeting between the Dracut Water Supply District and appropriate DCR staff to discuss their need to replace the reservoir at the forest. [LDT SF]	MassParks and Legal
Work with the Merrimack Valley Chapter of the New England Mountain Bike Association to review and approve, where appropriate, the existing technical features in the forest. [LDT SF]	Planning, MassParks and Legal
Develop a formal agreement with the Merrimack Valley Chapter of the New England Mountain Bike Association regarding the review and approval of their trail maintenance, repair and construction projects within the forest. [LDT SF]	Planning, MassParks and Legal
Determine the owner of the Hadley House and establish an agreement that guides the management and use of the building. [Lowell Heritage SP]	Planning, MassParks and Legal
Install DCR signs at the parking areas along the Vandenberg esplanade, next to the Lord pool and on Broadway Street. [Lowell Heritage SP]	MassParks
Renew the agreements with the City of Lowell related to their management of the regatta field and Rynne beach, as well as their use of the Rynne bathhouse. [Lowell Heritage SP]	MassParks and Legal
Renew the agreement with the stakeholders in the Lowell Canal System. [Lowell Heritage SP]	MassParks and Legal
Renew the agreement with the New England Electric Railway Historical Society / Seashore Trolley Museum. [Lowell Heritage SP]	MassParks and Legal
Establish an agreement with the Boston & Maine Railroad Historical Society regarding their maintenance of the B&M 410. [Lowell Heritage SP]	MassParks and Legal
Finalize the transfer of the Bellegarde boathouse, obtaining a copy of the items listed in Section 4.4. and executing the care, custody, management and control agreement. [Lowell Heritage SP]	Legal
Conduct annual meetings with lease holders and annual property inspections of leased property as specified in lease agreements and permits. [Great Brook Farm SP]	MassParks and Legal
Woods House: Update and renew the expired lease agreement for the Woods House with the old North Bridge Hounds. [Great Brook Farm SP]	Legal
Clear the vegetation from around the former DEM sign stanchion, and hang a new DCR entrance sign from the existing sign stanchion. [Carlisle SF]	MassParks
Work with the Town of Billerica to get a Special Use Permit in place, to formalize their operation of the recreational area. [Manning SF]	MassParks and Legal
Hold bi-annual meetings with the Town of Billerica Recreation Department to discuss programs, events, and maintenance and operation of the recreational area. [Manning SF]	MassParks and External Affairs
Provide DCR information on the informational kiosk. [Manning SF]	External Affairs
Install a DCR entrance sign for the forest. [Billerica SF]	MassParks

Continued on next page.

Action Plan 2014-2019 (Continued)

Priority Action	DCR Lead Unit(s)
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.	
Hold an annual meeting with the MA Department of Fish & Game and the Town of Billerica Conservation Commission to discuss any issues, plans or projects. [Dudley SP]	MassParks
With the MA Department of Fish & Game and the Town of Billerica Conservation Commission, conduct the stipulated 5 year review of the Management Agreement. [Dudley SP]	MassParks and Legal
Working with the Town of Billerica and the MA Department of Fish & Game, identify an appropriate location for an entrance sign that recognizes the partners. [Dudley SP]	MassParks

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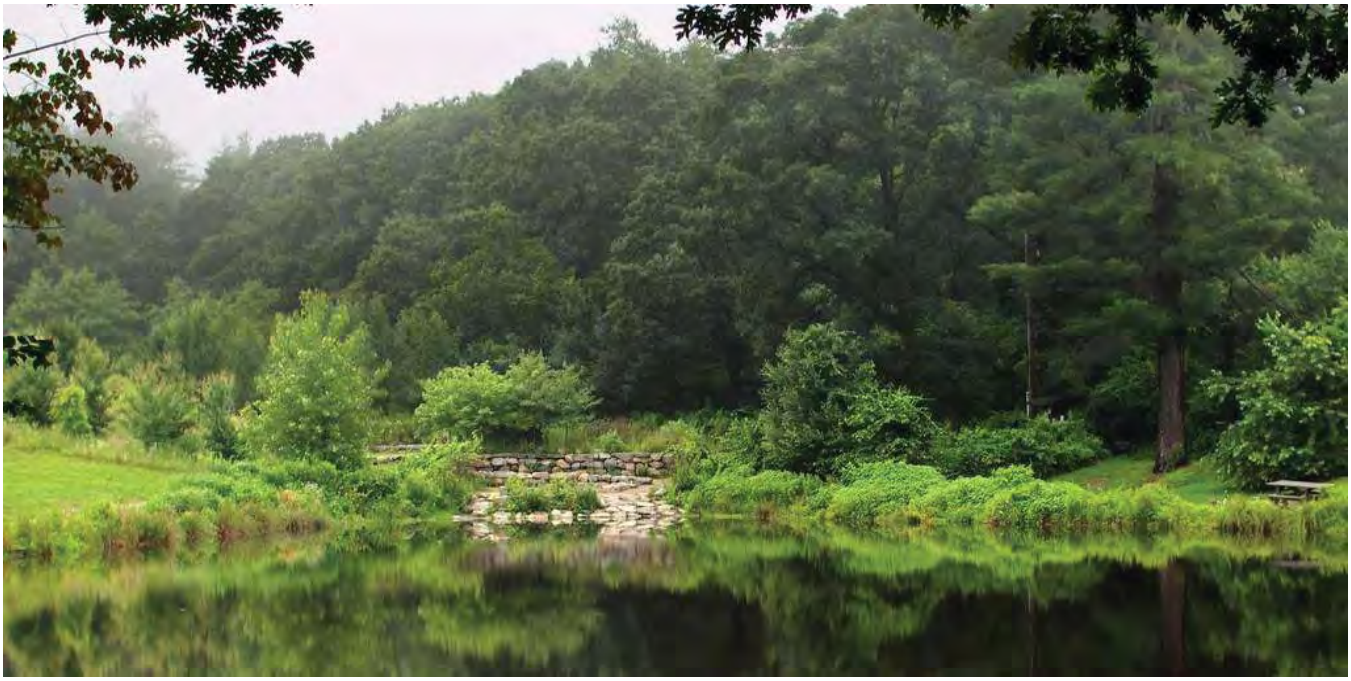

Great Brook Farm State Park (Peter E. Lee; CC BY-NC 2.0; cropped from original)

SECTION 1. INTRODUCTION

1.1. MISSION OF THE DEPARTMENT OF CONSERVATION AND RECREATION

The Department of Conservation and Recreation (DCR) is responsible for the stewardship of approximately 450,000 acres of Massachusetts' forests, parks, reservations, greenways, historic sites and landscapes, seashores, lakes, ponds, reservoirs and watersheds. The mission of the DCR is:

"To protect, promote and enhance our common wealth of natural, cultural and recreational resources for the well-being of all."

In meeting today's responsibilities and planning for tomorrow, the DCR's focus is on:

- Improving outdoor recreational opportunities and natural resource conservation;
- Restoring and improving our facilities;
- Expanding public involvement in carrying out our mission; and
- Establishing first-rate management systems and practices.

The DCR was created pursuant to state legislation that in 2003 merged the former Metropolitan District Commission and the former Department of Environmental Management. The DCR manages over 300,000 acres of the state's forests, parks, beaches, mountains, ponds, rivers and trails. The Department has broad management responsibilities for the preservation, maintenance and enhancement of the natural, scenic, historic and aesthetic qualities within these areas.

The health and happiness of people across Massachusetts depend on the accessibility and quality of our green spaces, natural and cultural resources, recreation facilities and great historic landscapes. The DCR continues to improve this vital connection between people and their environment.

1.2. INTRODUCTION TO RESOURCE MANAGEMENT PLANS

The Department of Conservation and Recreation is directed by a legislative mandate (M.G.L. Chapter 21, Section 2F) to prepare management plans for every reservation, park and forest, to provide guidelines for the management and stewardship of natural and cultural resources and ensure consistency between recreation, resource protection and sustainable forest management. The legislative

mandate also requires the incorporation of public review and input into the development of management plans, and review and adoption by the DCR Stewardship Council.

Resource Management Plans (RMPs) consider the past, present and future of a reservation, park or forest. Through an assessment of resources and their existing conditions, clear management goals and objectives are developed, and short and long-term implementation action plans are identified for the management of properties under the stewardship of the DCR. RMPs are written to meet the information needs of a diverse audience: from the decision-makers directly involved in the operation and management of a property, to a variety of outside stakeholders. RMPs are intended to be working documents for setting priorities, budgeting and resource allocation, and establishing guidelines for balancing sustainable recreation with the stewardship of natural and cultural resources. Finally, RMPs are of value to users that are interested in learning more about specific properties, the challenges the DCR faces and how decisions affecting the properties are made.

DCR staff undertook a statewide survey in 2008–2009 to assess the level of existing resource and planning data available, and correlate that with operations and management considerations. This assessment was used to identify groupings of properties that should be included together in a single RMP, i.e. planning units. The statewide survey was also used to develop a tiered sequence for preparing RMPs. The Lowell/Great Brook Planning Unit is ranked 6th out of the 80 planning units identified statewide.

1.3. The Planning Process

Resource Management Plans are developed by the DCR's Resource Management Planning Program through an iterative process of data gathering and analyses, public input, review and revision. Administrative, cultural, ecological, recreation, social and spatial information is gathered. Sources of information include interviews with DCR staff, site visits, administrative files and reports, legal documents, map data and municipal and regional plans. An initial public meeting is convened to provide an opportunity to discuss the properties included in the RMP and to solicit public input for the plan. The public meeting is announced in the Environmental Monitor and advertised electronically and through local media outlets.

An inventory of available information on natural, cultural, recreation and operational resources and an assessment of their existing conditions is the foundation of an RMP, from which recommendations for stewardship can be made. The draft is distributed within the DCR for internal review, and is repeatedly reviewed and revised to produce a draft RMP for public review and comment.

A second public meeting is convened to present an overview of the draft RMP's findings and recommendations and solicit input. Once again, the public meeting is announced in the Environmental Monitor and advertised electronically and through local media outlets. After the second public meeting, the draft RMP is made available to the public via the DCR website and local libraries. The meeting is followed by a 30-day public comment period. Comments made during the meeting and written comments received during the public comment period are taken into consideration and used to further develop the RMP.

Once revised, a final draft RMP is submitted to the DCR Stewardship Council for review and adoption. The Stewardship Council is a 13-member citizen advisory board (appointed by the Governor) that works with the Department to provide a safe, accessible, well-maintained and well-managed system of open spaces and recreation facilities that are managed and maintained on behalf of the public.

Once adopted, the Commissioner of the Department of Conservation and Recreation files copies with the Secretary of State and the Joint Committee on Environment, Natural Resources and Agriculture of the Massachusetts General Court and posts the adopted RMP on the DCR website for use. The adopted RMP provides structure and guidance for the operation and management of properties included in the plan.

1.4. Public Participation

Notice of a public meeting and the DCR's intent to prepare a Resource Management Plan for the Lowell/Great Brook Planning Unit appeared in the July 11, 2012 issue of the Environmental Monitor. Additional announcements were posted on the DCR

website and press releases were provided to the local media. Announcements were also directly distributed to individuals, statewide, regional and local stakeholder organizations and local officials. An initial public meeting occurred on July 23, 2012 in the Hart Barn at Great Brook Farm State Park in Carlisle. Approximately 20 people attended this initial meeting. Public input was received at the meeting and through e-mail received during a 30-day public comment period after the meeting.

To promote greater citizen participation and obtain additional information about visitor use, an online survey was created using Survey Monkey. Announcements of this survey were distributed electronically to stakeholders and signs were posted at individual properties. Surveys were created and made available in English and Spanish, in an effort to reach out to a broad constituency. One hundred and sixty one (161) surveys were submitted, nearly all of which were related to Great Brook Farm State Park and Lowell-Dracut-Tyngsborough State Forest.

A public meeting to present an overview of the draft RMP held on July 21, 2014 in Alumni Hall at the University of Massachusetts Lowell; it was attended by [#] people. Notice of the meeting was published in the July 9, 2014 issue of the Environmental Monitor and posted on the DCR website. Press releases were provided to local media and notices were sent directly to individuals, stakeholder organizations and local officials. The draft RMP was made available on the DCR website, at the Powell Memorial Library in Lowell, Gleason Public Library in Carlisle, Billerica Public Library, Parker Memorial Library in Dracut, and Tyngsborough Public Library, as well as at the Great Brook Farm State Park headquarters on [DATE].

The public comment period on the draft RMP ran from July 22, 2014 to August 29, 2014. [#] sets of comments were received and incorporated into the final RMP (see Appendix B). This Resource Management Plan was submitted to the DCR's Stewardship Council on [DATE] and was adopted by the Council on [DATE].

1.5. Properties Included in this RMP

This plan covers the Lowell/Great Brook Planning Unit, which includes:

- Lowell-Dracut-Tyngsborough State Forest
- Three Conservation Restrictions abutting Lowell-Dracut-Tyngsborough State Forest
- Lowell Heritage State Park
- Great Brook Farm State Park
- Carlisle State Forest
- Warren H. Manning State Forest
- Billerica State Forest
- Governor Thomas Dudley State Park

A Conservation Restriction is a legal document that limits the uses of a property to protect specific open space values of that land. Locations of these properties are indicated on Figure 1. Although these properties are not owned in fee by the DCR, they are included in the plan because of their physical proximity to Lowell-Dracut-Tyngsborough State Forest and the DCR's responsibility for overseeing the stipulations of the restrictions.

1.6. Defining Characteristics

The Lowell/Great Brook Planning Unit is very diverse and can be viewed as a microcosmic representation of the DCR state park system as a whole. From the collection of highly significant cultural resources and urban greenspaces that make up Lowell Heritage State Park, to the historic working agricultural landscape of Great Brook Farm State Park, to the roughly 1,500 acres encompassing the five other heavily wooded properties in this planning unit, and a range of recreational uses in between, there are few characteristics that can be applied to the planning unit as a whole. In addition, there are several complex partnerships and co-management relationships to balance at many of these facilities. The defining characteristics for the individual properties are as follows:

Lowell-Dracut-Tyngsborough State Forest

A large swath of protected open space that is predominantly wooded, with many low wet areas and little park infrastructure, Lowell-Dracut-Tyngsborough provides miles of trails and recreational access for the nearby urban population, along with habitat protection that is regionally important. There are also three Conservation Restrictions associated with the forest, totaling approximately 73 acres.

Placeholder for Figure 1.

Lowell Heritage State Park

An urban park encompassing a variety of parcels within the City of Lowell and operated through multiple and complex shared management systems, this property was established to help showcase the history of the city. The DCR owns numerous historic and a few more recently constructed buildings, including four gatehouses that are a part of canal operations and the Mack building; greenspaces ranging from a small Victorian garden to the one-mile-long Vandenberg esplanade along the river; and some unusual resources, including air rights over many of the city's canals. Lowell Heritage State Park provides both interpretive opportunities and recreational access in a dense urban environment.

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A working dairy farm connected to miles of trails that are used for a variety of recreational activities, Great Brook Farm includes historic buildings and resources alongside a new "smart" barn with a robotic milking system, interpretive programming and a cross-country ski concession.

Carlisle State Forest

A small wooded property protected from forestry activities at the turn of the 20th century to conserve an older stand of exceptionally large white pines. Undeveloped and used primarily by local residents, this small gem provides recreational access and habitat protection.

Warren H. Manning State Forest

A largely wooded property with a small recreation area, complete with a spray deck, picnic area and fitness trail. Named for the preeminent landscape architect that advocated (and donated land for) the protection of public woodlands in the Town of Billerica, this property provides recreational opportunities and habitat protection in a suburban environment.

Billerica State Forest

An undeveloped and largely wooded property bordering Route 3, this property provides recreational access and habitat protection.

Governor Thomas Dudley State Park

The smallest facility within the planning unit, this 11-acre park is a small wooded parcel that provides access to the Concord River and links to other protected open space.

1.7. Management Principle and Goals

Through the Resource Management Planning process, a principle for managing the Lowell/Great Brook Planning Unit was established and four associated goals developed.

Management Principle

Protect the natural and cultural resources of the planning unit and provide enhanced recreational and educational opportunities for visitors through the creative use of state resources and partnerships.

Management Goals

The following four management goals have been developed to achieve the management principle. These goals are of equal importance, and are not presented in order of priority.

Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.

Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.

Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.

Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.

1.8. Regional Context

The Lowell/Great Brook Planning Unit is located within Middlesex County; the towns of Billerica, Chelmsford, Dracut and Tyngsborough and the City of Lowell are all in the northern section of Middlesex County, while the Town of Carlisle is in the southern portion of the county. Lowell is the urban focus for this region, while Carlisle provides a rural respite. The towns of Billerica, Chelmsford, Dracut and Tyngsborough are all suburban in character.

Rivers have indelibly influenced the settlement, land use and development of the communities in this region from pre-historic times through today. The City of Lowell is located at the confluence of the Merrimack River and the Concord River. The mighty Merrimack River, flowing from Franklin,

New Hampshire to the Atlantic Ocean is the engine that drove the industrial development of the City of Lowell. Flowing through Tyngsborough and Lowell, the river also serves as the southern boundary of Dracut. The smaller Concord River, a tributary of the Merrimack, flows through Lowell and Billerica, and is the southeast boundary for Carlisle.

The pre-contact Native American population in this region utilized these rivers for travel and subsistence, with major anadramous fish runs on the Concord and Merrimack. The region's landscape provided additional resources for subsistence through freshwater ponds and fertile soils ideal for agricultural use, particularly along the rivers. Traditional hunting and gathering likely occurred in the upland areas, and supported other subsistence activities.

Pawtucket Falls on the Merrimack River served as a regional focus of settlement (MHC 1980*a*). The falls became a regionally important fishing ground and the Merrimack River served as a trade corridor. The area appears to have been extensively settled by native peoples and may have served as a population core area.

The Merrimack River was first visited by the French explorer Samuel de Champlain in 1605 as he explored the New England coast. A Praying Indian town, Wamesit, was established by John Eliot by the 1640s in what is now Lowell in an effort to Christianize native peoples. European settlement in this region started in earnest in the mid 17th century. Settlement through the second half of 17th century was dispersed, with small clusters of colonists in frontier communities relying primarily on subsistence farming, fishing and small mills set up on the rivers and streams in the region.

Population in the region began to uptick in the early to mid 18th century, as villages began to take shape in town centers and near mills, and transportation improvements made in the region helped facilitate travel and trade. By the turn of the 19th century, small scale granite quarrying and early manufacturing started to develop. Construction began on the Middlesex Canal in 1794, connecting Lowell and the Merrimack Valley to Boston, opening for use in 1804. Twenty-seven miles in length, running through several communities including Billerica, Chelmsford, Tyngsborough and current day Lowell, the Middlesex Canal provided a transportation connection to haul goods and passengers from Boston to New Hampshire (Middlesex Canal Association 1993).

A range of small industries began to develop and take advantage of both the local water power and the proximity to the Middlesex Canal, and the textile industry in Lowell began in the 1820s with the establishment of the first major textile mill, the Merrimack Manufacturing Company. Others quickly followed over the course of the next dozen years, building off the early success and the application of the innovative system of manufacturing utilized here and the development of a system of power canals to run large mills. Additional industrial development also began in Chelmsford and to a smaller degree in Dracut.

The City of Lowell was established in 1826, from parts of Chelmsford, Dracut, and Tewksbury (MHC 1980*a*). Rapid growth ensued in Lowell, with the manufacturing base downtown and a series of suburban outlying neighborhoods. Railroads were introduced to the region, providing a more effective (and non-seasonal) form of transportation, and the Middlesex Canal was closed in 1853 (Middlesex Canal Commission n.d.).

Many nearby communities also experienced population growth and new immigrant populations headed to the region to work in manufacturing in Lowell (facilitated by streetcar lines providing access) and nearby towns. Carlisle however remained very rural throughout the 19th century, with agriculture remaining as the dominant focus of the local economy.

The Great Depression impacted the textile industry and the region saw a big decline in manufacturing. New highways provided enhanced regional access and with the exception of a population decline in Lowell, the nearby communities continued to grow. Post WWII suburban expansion impacted much of the region, however the City of Lowell struggled and the Town of Carlisle maintained its rural economy and character. The 1970s saw the establishment of Lowell Heritage State Park and brought the National Park Service to Lowell, as well as renovated mills, new immigrant communities and a growing interest in urban areas, which brought revitalization to downtown Lowell.

Table 1.1. Physical, Ecological and Political Settings of the Lowell/Great Brook Planning Unit

Planning Unit: Lowell/Great Brook

Location:

City of Lowell	Middlesex County
Town of Dracut	Middlesex County
Town of Tyngsborough	Middlesex County
Town of Carlisle	Middlesex County
Town of Chelmsford	Middlesex County
Town of Billerica	Middlesex County

DCR Management Structure: Walden Complex
Metro West District
North Region

Properties:	***Landscape Designation***	***City/Town***	***Area (acres)[a]***	***Perimeter (miles)[a]***
Lowell-Dracut-Tyngsborough State Forest	Parkland	Lowell	320	15
		Dracut	554	
		Tyngsborough	236	
Lowell Heritage State Park	Parkland	Lowell	87	18
Great Brook Farm State Park	Parkland	Carlisle	907	16
		Chelmsford	23	
Carlisle State Forest	Parkland	Carlisle	25	1
Warren H. Manning State Forest	Parkland	Billerica	183	5
Billerica State Forest	Parkland	Billerica	141	3
Governor Thomas Dudley State Park	Parkland	Billerica	11	1

Ecoregion: Southern New England Coastal Plains and Hills

Watersheds: Sudbury-Assabet-Concord (SuAsCo)
Merrimack River

Legislative Districts:

Senate District	First Middlesex	*House District*	Second Middlesex
	Second Essex and Middlesex		Fourteenth Middlesex
	Third Middlesex		Sixteenth Middlesex
	Fourth Middlesex		Seventeenth Middlesex
			Eighteenth Middlesex
			Twenty-second Middlesex
			Thirty-sixth Middlesex

Conservation Restrictions:

Property	***City/Town***	***Area (acres)[a]***	***Fee Interest***
Lowell-Dracut-Tyngsborough State Forest	Lowell	17	Northeast Radio, Inc.
Lowell-Dracut-Tyngsborough State Forest	Dracut	9	Boisvert Family
Lowell-Dracut-Tyngsborough State Forest	Tyngsborough	47	Town of Tyngsborough

Designations:

Property	**Designations**
Lowell-Dracut-Tyngsborough State Forest	Priority Habitat
	BioMap2 Core Habitat
	BioMap2 Critical Natural Landscape

Continued on next page.

Table 1.1. Physical, Ecological and Political Settings of the Lowell/Great Brook Planning Unit (Continued)

Designations:	Property	Designations
	Lowell Heritage State Park	Priority Habitat
		BioMap2 Core Habitat
		BioMap2 Critical Natural Landscape
		Downtown Lowell Local Historic District
		City Hall District
		Locks and Canals National Register Historic District
		Locks and Canals National Historic Landmark
		Lowell National Historical Park and Preservation District
		Historic Civil Engineering Landmark
		Historic Mechanical Engineering Landmark
		Environmental Justice Population
	Great Brook Farm State Park	Priority Habitat
		BioMap2 Core Habitat
	Carlisle State Forest	National Wild & Scenic River
	Warren H. Manning State Forest	Priority Habitat
		BioMap2 Core Habitat
	Billerica State Forest	Priority Habitat
		BioMap2 Core Habitat
	Governor Thomas Dudley State Park	BioMap2 Core Habitat
		BioMap2 Critical Natural Landscape

a. These values were calculated in GIS and rounded to the nearest whole number.

1.9. VISITATION

Visitation information for the planning unit is negligible, due in part to reduced DCR staffing and established management agreements with other entities, as well as physical constraints that make it difficult to capture the information (e.g., little or no infrastructure at a property, multiple entry points for a property, etc.).

The online survey that was undertaken as part of this RMP (see Section 1.4. Public Participation) did not provide a lot of information that could objectively be drawn from in order to get a sense of the complete visitor profile and experience for individual properties, or the planning unit as a whole. While there was a high response rate for both Lowell-Dracut-Tyngsborough State Forest and Great Brook Farm State Park, 78 responses for each, the remaining properties had minimal response rates, ranging from zero to three. This is due to the fact that the survey was very well publicized within the mountain biking community, and many members of that community responded to the survey for the two properties in the planning unit that are utilized the most for mountain biking. Despite promoting the survey to a wide variety of stakeholders, without active park friends groups for these properties to help promote the survey within other user communities, responses from outside the mountain biking community were low.

Lowell-Dracut-Tyngsborough State Forest

The state forest is not staffed and, as a result, there are no visitor estimates; however, the property is well-known as a popular mountain biking destination. Respondents to the online survey, most of whom were part of the mountain biking community, identified the state forest's convenient location and trail network as characteristics of the property that they liked the best. Among the ways that the state forest could be improved, respondents indicated enforcing regulations related to off-highway vehicle (OHV) use, adding more parking and trail signage, naming more trails and updating the trail map.

Lowell Heritage State Park

Although Lowell Heritage State Park is staffed, as an urban property with individual parcels spread across the city, visitor data is especially difficult to capture. Fortunately, the National Park Service (NPS), a partner in Lowell through their Lowell National Historical Park, collects and publicizes annual visitation data based on the number of visitors that enter their visitor center and exhibits,

and attend special events on park property. While these estimates do not provide any insight into the level of visitorship on the DCR's Vandenberg esplanade, they do highlight the number of people who view, and in some cases tour, DCR property in downtown Lowell (see Section 4 for more information).

Since 1982, annual visitation rates at Lowell National Historical Park have exceeded 400,000 (NPS 2014*a*). In 2013, over 500,000 visitors enjoyed the park (NPS 2014*a*). Half of those individuals visited the park in July and August, with July being the most popular month (174,530 visitors; NPS 2014*a*). The majority of July visitors were "Special Event Visitors," and likely participated in the Lowell Folk Festival, a very popular event held in downtown Lowell each year (NPS 2014*a*). Peak visitation for the DCR's Francis Gate Park and Pawtucket Gatehouse were in August (2,022 visitors) and September (1,292 visitors), respectively (NPS 2014*a*).

Great Brook Farm State Park

Visitation increased ten-fold at Great Brook Farm State Park between the establishment of the park (1974) and mid-1990s, but it is now on a downward slope. In the early 1980s, the annual visitation rate was approximately 20,000 – 25,000, while in 1996 car counters recorded approximately 205,000 visitors enjoying the park. In the late 1990s staffing and programming began to decrease and in the early 2000s a parking fee was established, collectively leading to a decline in visitation. By 2010, annual visitation decreased to roughly 120,000. Although the completion of the Smart Barn in 2011 seems to have generated a small spike in visitation, recent estimates are steadily decreasing, and are now at approximately 100,000 visitors per year.

Due to the wide range of activities available, unlike some of the other properties in this planning unit, Great Brook Farm State Park has high year-round visitation. The online survey indicated little seasonal variation in park use by regular visitors. Mid-week visitation includes a fair amount of older visitors, primarily active retirees who like to walk the trails. Through the online survey, park users provided high praise for the variety and quality of trails, as well as the appeal of the active farm and ice cream stand for visiting with children.

Carlisle State Forest

In the absence of a formal parking lot and on site staff, visitation estimates are not available for Carlisle State Forest. Visitation is believed to be quite low, and primarily by local residents.

Warren H. Manning State Forest

The DCR does not have estimates on visitation for this property. The spray deck area is very popular with young families during the summer, and the Town of Billerica, who manages the spray deck area, reports that on hot days, the parking lot often reaches capacity (Hannon-Rizza 2013).

Billerica State Forest

Without a formal parking lot and the presence of on site staff, visitation estimates are not available for Billerica State Forest.

Governor Thomas Dudley State Park

As a facility that is managed by the Town of Billerica and not staffed, the DCR does not have estimates of visitation levels at Governor Thomas Dudley State Park.

In a survey conducted during the preparation of the 2008 update to the Billerica Open Space and Recreation Plan, only three of the 68 respondents included Dudley Park, as it is locally known, as one of the open space or recreation properties that their family utilized in town (Northern Middlesex Council of Governments 2008).

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Park Serve Day at Lowell-Dracut-Tyngsborough State Forest (DCR)

SECTION 2. MANAGEMENT RESOURCES AND PRACTICES

2.1. INTRODUCTION

The Lowell/Great Brook Planning Unit contains a diverse set of natural, cultural and recreation resources. Managing these resources can be challenging, due to the competing demands of resource protection and providing public access to recreational opportunities. Effective management of this two-pronged goal requires an understanding of various laws, regulations, policies and legal agreements, while working with limited operational resources.

This section describes the resources available to the planning unit, as well as relevant management practices, regulations, policies and legal considerations. Variations to these resources and practices, which occur at the property-level, are addressed in Section 3 through Section 9.

2.2. NATURAL RESOURCES

Research Permits are required for all ecological research on DCR property. Additional state (e.g., Scientific Collecting) and federal (e.g., Bird Banding and Marking) permits may be required, depending on the nature of research. Research within wetland and river jurisdictional areas may also require regulatory review and approval from the local conservation commission.

Water Resources

Storm Water Management

Activities on DCR properties that affect the quantity or quality of storm water are regulated by a National Pollutant Discharge Elimination System (NPDES) storm water management plan (DCR 2007*a*). The plan describes control measures that the DCR uses to satisfy NPDES Phase II permit requirements for transportation and non-traditional Municipal Separate Storm Sewer Systems (MS4s). Best Management Practices (BMPs) are also identified in the plan, some of which are implemented at the agency-level (e.g., the detection and elimination of illicit discharges, catch basin cleaning), while others are implemented at the facility-level (e.g., the stenciling of catch basins).

Wetlands Protection

Activities within a wetland resource area or buffer are regulated by the Massachusetts Wetland Protection Act. (See Appendix F for additional information.)

Rare Species

The Massachusetts Endangered Species Act (MESA) protects rare species and their habitats by prohibiting the "take" of any plant or animal listed as Endangered, Threatened or Special Concern. Projects within Priority Habitat of Rare Species must undergo review by the Natural Heritage & Endangered Species Program (NHESP), unless otherwise exempted under the law.

The term "project" refers not only to the construction of buildings and infrastructure, but also to activities that involve grading or the destruction of plant life. (See 321 CMR 10.00 for the full definition of "project.") Many staff and volunteer activities that take place within the planning unit (e.g., invasive species removal, trail construction and maintenance, and habitat improvement activities) meet the definition of "project" and must go through regulatory review, if they occur in Priority Habitat.

State agencies, such as the DCR, have special obligations under MESA. First, agencies are directed to use their authorities in furtherance of the purposes of MESA and "use all practicable means and measures to avoid or minimize damage." Next, they are required to submit draft management plans, such as RMPs, to the NHESP for review. Finally, state-owned lands "that provide habitat for state-listed species shall be managed for the benefit of such listed species;" agencies "shall give management priority to the protection, conservation, and restoration of" state-listed species on state-owned lands. All "practicable means and measures shall be taken to resolve conflicts between the protection, conservation, and restoration of state-listed species…and other uses of such lands in favor of the listed species."

Additional information on MESA and its implementing regulations is available on the NHESP's website: http://www.mass.gov/eea/agencies/dfg/dfw/natural-heritage/regulatory-review/mass-endangered-species-act-mesa.

Vegetation

There is no single management plan for the planning unit's vegetation. The *de facto* management policy is to permit populations of most species of plants to increase or decrease without human intervention. Exceptions include the maintenance of lawns and other turf areas, removal of hazardous trees and vegetation cutting associated with the management of plant or wildlife habitat.

Continuous Forest Inventory (CFI) monitoring plots are located throughout the planning unit. The number of these one-fifth acre, circular plots varies by property. A series of forestry related metrics, including the number of trees five or more inches in diameter, tree regeneration, amount of coarse woody debris and presence of invasive plants and tree diseases, are collected at each plot. On average, each plot is visited, and data collected, once every ten years.

Wildlife

There is no single wildlife management plan for the planning unit. The *de facto* management policy is to permit most wildlife populations to increase or decrease without human intervention. Exceptions to this include the hunting of game species and fishing at select properties. Hunting, trapping, and fishing are managed through a variety of regulations (see Section 2.4, below).

2.3. Cultural Resources

The DCR's Office of Cultural Resources (OCR) provides technical assistance on issues relating to archaeology and the preservation of landscapes, buildings, structures and objects. It also conducts a coordinated program of basic and applied research to support planning for, and management of, cultural resources on DCR properties through project management and resource management planning. The OCR also nominates properties for inclusion on the State and National Registers. A copy of the DCR Cultural Resources Policy has been included as Appendix D.

The OCR is also responsible for overseeing the historic preservation regulatory compliance responsibilities of the agency. It assesses regulatory needs and, when applicable, notifies the Massachusetts Historical Commission (MHC) through the filing of a Project Notification Form or Environmental Notification Form for any proposed projects undertaken, funded, permitted or licensed, in whole or in part, by the agency. This is done so that the MHC may make a Determination of Effect of the project on historic and archaeological

resources. Finally, the OCR coordinates all archaeological survey, testing and excavation with the State Archaeologist at the MHC through an archaeological permit.

Buildings, structures, landscapes, sites and objects that are a minimum of 50 years old, retain historic integrity and are of significance on the local, statewide or national level may be listed on the National Register of Historic Places. Repairs, rehabilitation and other preservation activities on listed and eligible resources follow guidelines in the *Secretary of the Interior's Standards for the Treatment of Historic Properties* (Weeks and Grimmer 1995).

Massachusetts law requires the review of all subsurface disturbances on state property. The DCR's Archaeologist holds an archaeological permit from the MHC that allows them to provide initial review of activities that result in subsurface disturbance. They are the primary reviewer of such projects and activities in the Lowell/Great Brook Planning Unit.

The inspection, investigation or removal of underwater archaeological resources is also regulated under Massachusetts law (M.G.L. 6:179–180). No person may remove, displace, damage or destroy any underwater archaeological resource, except in conformity with permits issued by the Massachusetts Board of Underwater Archaeological Resources. This applies to both inland and coastal waters. All archaeological resources in the waters of the planning unit are subject to this law.

Two of the properties within this planning unit are part of the OCR's Historic Curatorship Program, a program in which curators are selected through a competitive process to rehabilitate and maintain historic buildings in exchange for long term leases. The Historic Curatorship Program Manager is responsible for ensuring compliance with work and maintenance plans; maintaining investment accounting totals from curator reports; ensuring up to date insurance coverage; scheduling annual or bi-annual inspections; coordinating public benefit activities; and enforcing compliance with other lease terms and responsibilities.

2.4. Recreation Resources

Regulations guiding the recreational use of forests and parks may be found in 304 CMR 12.00. (See Appendix F for a summary of these regulations.) In general, all public use of DCR property must take place from dawn through dusk.

Permits

Special Use Permits are required for "any commercial or special activity or event upon the lands or waters" of all DCR properties (304 CMR 12.17; Appendix F). Non-commercial activities requiring a Special Use Permit include, but are not limited to: concerts, charity walks, road races, cultural festivals, community service projects, small weddings and gatherings with amplified sound. Research on recreation and recreationists requires a Research Permit. Commercial filming, photography, and videography are regulated through Filming and Photography Permits. Additional information on these permits, and how they may be obtained, is available on the DCR's website: http://www.mass.gov/eea/agencies/dcr/massparks/permits-rentals/dcr-permits.html.

Camping

Camping on DCR property is restricted to designated campsites or cabins; there are no permanent camping areas in the planning unit.

Geocaching

There is no Massachusetts regulation or agency policy on the placement of geocaches on DCR property. In their absence, geocaches may be placed at any location not identified as closed to the public.

Hunting and Fishing

Hunting and freshwater fishing are addressed in Massachusetts regulations 304 CMR 12.00, 321 CMR 3.00 and 321 CMR 4.00, and the official Massachusetts hunting, freshwater fishing and trapping regulations that are published annually. In general, all DCR properties are open to hunting, fishing and trapping unless otherwise specified in the Forests and Park Rules (304 CMR 12.00). Summaries of these and other applicable regulations are presented in Appendix F.

Officers from the Executive Office of Energy and Environmental Affairs' Office of Law Enforcement (i.e., Massachusetts Environmental Police officers) enforce hunting, fishing and off-highway vehicle (OHV) use.

Trail Use

Dogs may accompany trail users provided the animals are kept under control and do not interfere with any other visitor's enjoyment of DCR property (304 CMR 12.00; Appendix F).

With the exception of DCR, public safety and utility company vehicles, motor vehicles are generally not permitted on the trails in the planning unit.

A March 15, 2011 Department of Justice ruling allows individuals with mobility disabilities to use "other power-driven mobility devices" on trails. Such devices include any device powered by batteries, fuel or other engines that are used by individuals with mobility disabilities for the purpose of locomotion. Use of such devices may be restricted on trails due to factors such as: the type, size, weight and speed of the device; the volume of pedestrian traffic; the design and operational characteristics of the device; whether or not the device may be operated safely; and the potential for substantial risk of serious harm to the environment or natural and cultural resources. None of the trails within the planning unit have been assessed for their compatibility with these devices.

2.5. INFRASTRUCTURE

Property Boundary

The Management Forester or Assistant Management Forester attempts to locate and mark property boundaries in association with forest inventory activities. They also mark the boundaries of new properties as they are acquired. Boundary marking typically involves locating and painting cement bounds or pipes, and posting boundary signs.

Buildings and Structures

The management of DCR-owned buildings is performed by DCR employees or contractors. Minor maintenance and repair is performed by on-site staff. More technical repairs (e.g., plumbing and electrical) are performed by DCR in-house trades staff or by trade or engineering contractors (e.g., well repair) whose activities are coordinated through the agency's Parks Support Operation Program. Major repairs are performed solely by licensed contractors.

Roads

The DCR maintains and repairs forest and park roads, and parkways. Management of traffic and related systems is supervised by the Parkways Section of the DCR's Division of Engineering and guided by American Association of State Highway and Transportation Officials standards, the *Manual on Uniform Traffic Control Devices* (FHA 2012) and the *Historic Parkway Preservation Treatment Guidelines* (DCR 2007*b*), if applicable. Public roads adjacent to DCR properties are maintained and repaired by either local municipalities or the Massachusetts Department of Transportation (MassDOT).

Snow removal is performed by the DCR, MassDOT and local municipalities. In general, the municipalities or MassDOT plow the public roads adjacent to forests and parks, and the DCR is responsible for plowing internal roads.

Parking

The DCR is responsible for maintaining and repairing its parking areas. Most snow removal is performed by the DCR.

Trails

A variety of regulations and policies guide the management of trails. The design, management and marking of trails are guided by the DCR *Trails Guidelines and Best Practices Manual* (DCR 2012*a*). Additional regulations, such as the Massachusetts Endangered Species Act and Wetlands Protection Act, and the DCR Cultural Resources Policy may also apply, depending on location. These regulations and policies apply to DCR employee, partner and volunteer activities.

In accordance with DCR practices, trail maintenance and construction activities should be implemented in the following order, in accordance with the regulations, policies and guidance identified above:

1. Maintain appropriate existing trails and fire roads.
2. Close or improve existing trails with known public safety hazards.
3. Close or relocate existing trails that adversely impact documented state-listed species, in consultation with the DCR's Bureau of

Planning, Design and Resource Protection and NHESP staff.

4. Close, relocate or improve existing trails that impact vernal pools.
5. Close, relocate or improve wetland crossings on existing trails that impact wetlands, streams or ponds.
6. Close redundant, dead end and unauthorized trails.
7. Close, relocate or improve existing eroded and poor condition trail segments.
8. Construct new trail connections to enhance desired, authorized recreational experiences; create additional loop opportunities; and form new connections between access points and important features.

Signs and Kiosks

The format and placement of regulatory and informational signs are governed by the *Manual of Uniform Traffic Control Devices* (FHA 2012) and guided by the DCR *Graphics Standards Manual* (DCR n.d.). The design and construction of kiosks are solely governed by the graphics manual.

Informational kiosks are managed by park staff as new information becomes available; they also perform kiosk installation and repair.

Memorials and Markers

The placement of markers or plaques is not explicitly addressed in the Forests and Park Rules (see 304 CMR 12.00; Appendix F).

2.6. Interpretive Services

Regional interpretive staff provides programming in the planning unit. There is no Comprehensive Interpretive Plan (CIP) for the entire planning unit, nor are there programs offered at every property in the planning unit.

2.7. Operational Resources

DCR Staffing

The DCR manages its forests, parks and reservations through the Division of State Parks and Recreation, otherwise known as the MassParks Division. Resources within the MassParks Division, including finances, staffing and physical equipment, are organized by regions, districts and complexes. Under this organizational structure, the Lowell/Great Brook Planning Unit is within the North Region, Metro West District and Walden Complex.

North Region

The North Region is comprised of three districts: Metro West, Middlesex Essex and Coastal. Specialized staffing resources assigned to the North Region are available on an as needed basis to the planning unit. This includes services related to interpretation, public outreach and safety, and engineering. The region is headed by a North Region Director who reports to the Deputy Director of MassParks.

Metro West District

The Metro West District is comprised of two complexes: Walden and Hopkinton. The district includes a functionally and geographically varied set of properties in the DCR system. Management is provided by a Metro West District Manager who reports to the North Region Director.

Walden Complex

The Walden Complex includes Walden Pond State Reservation in Concord and Lincoln; Carlisle State Forest and Great Brook Farm State Park in Carlisle; Billerica State Forest, Warren H. Manning State Forest and Governor Thomas Dudley State Park in Billerica; Lowell Heritage State Park, the John J. Janas Skating Rink and Raymond J. Lord Memorial Swimming Pool in Lowell; and Lowell-Dracut-Tyngsborough State Forest.

The Forest and Park Supervisor at Walden Pond State Reservation also serves as the Walden Complex Field Operation Team (FOT) Leader. The team leader is responsible for coordinating the operational needs for each facility in the Walden Complex, through the use of Field Operation Teams. The Walden Complex FOT Leader reports to the Metro West District Manager.

Table 2.1. DCR Staffing Resources in the Walden Complex, by Reporting Location[a]

Job Title[b]	Type[c]	Reporting Location
Walden Pond State Reservation		
Walden Complex FOT Leader	Y	Concord
Forest and Parks Supervisor II	Y	Concord
Clerk I	Y	Concord
Visitor Services Supervisor I	Y	Concord
Park Interpreter (2)	S	Concord
Forest and Parks Supervisor I (3)	S	Concord
Summer Worker (4)	S	Concord
Laborer I (8)	S	Concord
Recreation Facility Supervisor I	S	Concord
Park Ranger	S	Concord
Lifeguard II	S	Concord
Lifeguard I (12)	S	Concord
Great Brook Farm State Park		
Forest and Parks Supervisor III	Y	Carlisle
Laborer II	Y	Carlisle
Laborer I (3)	S	Carlisle
Park Interpreter	S	Carlisle
Park Ranger	S	Carlisle
Lowell Heritage State Park		
Forest and Parks Supervisor I	Y	Lowell
Laborer I (2)	S	Lowell
Raymond J. Lord Memorial Swimming Pool		
Recreation Facility Supervisor III	S	Lowell
Recreation Facility Supervisor I	S	Lowell
Lifeguard II	S	Lowell
Lifeguard I (10)	S	Lowell
Summer Worker (2)	S	Lowell

a. Includes staff from the Division of State Parks and Recreation who worked exclusively within the Walden Complex in 2013.
b. The number of multiple employees with the same job title are indicated in parentheses.
c. Type: Y = Year-round; S = Seasonal.

Park staff are responsible for a number of management activities in order to keep the properties clean and accessible for use year round. Duties include cleaning bathrooms, picking up litter and emptying trash barrels. Due to current limited staffing levels, these activities are not always able to be performed on a daily basis. Mowing and trimming is performed on an as needed basis, typically weekly, during the warmer months of the year.

Bureau of Forestry and Fire Control

The Bureau manages a variety of programs, including management forestry, forest fire control, forest health and urban/community forestry, that provide technical assistance and services on forestry related issues to DCR forests, parks and reservations. Bureau staff and assets are organized into districts that generally follow county boundaries.

Middlesex County is divided into two fire districts; the Lowell/Great Brook Planning Unit falls within Fire District 6, which is based out of Great Brook Farm State Park. Beyond fighting fires and managing prescribed burns, the fire staff does a lot of fire road maintenance.

Bureau of Ranger Services

The Bureau of Ranger Services includes field ranger staff who provide outreach related to Massachusetts regulations and public safety services. While other DCR districts have an assigned District Ranger, the Metro West District does not.

Division of Engineering

The Division of Engineering is responsible for the engineering and construction of parkways, dams, buildings and recreation facilities. It also provides a Regional Engineer to oversee day-to-day repair and construction projects, and to maintain a working relationship with the Regional Director in identifying capital improvement priorities. The Division also provides catch basin cleaning at Lowell Heritage State Park in support of park operations.

Bureau of Planning, Design and Resource Protection

This Bureau prepares RMPs and Trail System Plans; develops and updates GIS data; provides technical assistance with the management of archaeological and historic resources; identifies and acquires properties to be added to the DCR system; maintains an archive of park documents; provides technical support on ecological resources and the monitoring of CRs; and designs and manages projects to enhance DCR properties.

Office of External Affairs and Partnerships

The Office of External Affairs and Partnerships works to enhance DCR's constituency of supporters and users by: working in partnership with park users and supporters to develop and sustain community-based stakeholder groups; facilitating external financial assistance for the planning, design and construction of capital projects; managing the DCR partnerships Matching Funds Program, which leverages private contributions to improve DCR-

owned and managed facilities; and serving as a dedicated point of contact for individuals and nonprofit, institutional and community-based organizations.

Supplemental Staffing

Volunteers

Volunteers can provide a variety of human and intellectual resources to support the management and maintenance of the properties in the Lowell/Great Brook Planning Unit. Volunteer services include clean-ups, trail maintenance, monitoring, botanical surveys, grant writing, interpretive programming and others. Volunteers may be individuals or members of groups, businesses or organizations, and may be organized by DCR staff or partner organizations.

All volunteer activities must be conducted with prior approval and supervision of the DCR, and in accordance with DCR standards and volunteer policies, including documentation through a Volunteer/Stewardship Agreement Form, Volunteer Release Form and Volunteer Service Log (DCR 2013).

Law Enforcement and Public Safety

The Massachusetts State Police has primary law enforcement authority on state-owned lands. Local police provide additional law enforcement in the planning unit, within their respective jurisdictions. The Executive Office of Energy and Environmental Affairs' Office of Law Enforcement (i.e., the Massachusetts Environmental Police) provides primary enforcement of hunting, fishing, boating, OHV and snowmobile regulations.

DCR Rangers are not law enforcement officers, but have the authority to enforce DCR regulations and issue citations (i.e., parking tickets and dogs off leash) on DCR property. They also coordinate search and rescue activities in forests, parks and reservations.

Municipalities provide emergency fire and medical response to incidents on state lands. DCR Forest Fire Control District 6 provides assistance to Municipalities in the detection, suppression and prevention of wildfires. DCR Rangers may provide first aid.

General Budgetary Info

Operating Budget

The annual operating budget supports daily operations and maintenance, including utilities, supplies, equipment leases, administration, and the maintenance and minor repair of facilities, vehicles and equipment. In Fiscal Year 2013, the Lowell/Great Brook Planning Unit operating budget, excluding personnel costs, was $16,725. Funds are also available from the region for specific projects or activities within the planning unit.

Capital Budget

The capital budget supports projects (e.g., construction and repair) and items (i.e., equipment) with a per-unit cost of at least $5,000 and an expected lifespan of at least seven years.

Capital projects are identified and funded through a five-year capital plan. These plans identify proposed capital projects, their costs and the year in which they are to be funded. In fiscal years 2012 through 2014, improvements to the Mack building and Rynne bathhouse were completed at Lowell Heritage State Park. These projects cost $134,471. At Great Brook Farm State Park, the Fiscal Year 2012 projects were related to the design of the dairy barn and construction of a modular storage building, which cost $110,096. An additional project in Fiscal Year 2013 involved masonry work at the Hart Barn and cost $9,320.

Capital plans are extensively reviewed within the DCR, approved by the Commissioner and included in the DCR's annual budget. This budget is then reviewed by the Executive Office of Energy and Environmental Affairs, the Executive Office of Administration and Finance, and the Governor. Additional capital initiatives may be identified and added to the budget by the Commissioner, Secretary or the Governor during this review process.

Deferred Maintenance

These funds are used for infrastructure repair that exceed typical maintenance, but do not rise to the level of a capital project. They may also be used to address emergency capital projects for which funds have not been allocated. Each region is allotted deferred maintenance funds on an annual basis; the Regional Director determines how these funds are to

be used. Recent deferred maintenance projects within the planning unit include $4,500 to bring the fire security system in buildings along the Vandenberg esplanade up to compliance; $1,000 to fix the communication and video system at the Mack building; and approximately $3,000 to repair trails and build boardwalks at Great Brook Farm State Park.

Supplemental Funding

Grants

Federal and private funds, in the form of grants, are periodically awarded on a competitive basis to the DCR for park maintenance and operation activities (e.g., recreational trails grants). There have been no recent grants awarded to the planning unit.

Earmarks

Earmarks are funds directed to specific projects by the Massachusetts General Court via the annual state budget. There have been no recent earmarks for the planning unit.

Conservation Trust Fund

This trust fund uses donations to support special initiatives that go above and beyond basic property maintenance. It is funded through charitable contributions to the DCR, including those donations placed into the "iron rangers" (i.e., a secure metal donation box) located at Lowell Heritage State Park (1) and Great Brook Farm State Park (2). In 2013, Lowell Heritage State Park received over $1,000 in charitable contributions, while Great Brook Farm State Park received over $225. As of February 11, 2014, there is approximately $2,915 in the Conservation Trust Fund for Lowell Heritage State Park and $5,550 in the fund for Great Brook Farm State Park.

Heritage Parks Fund

In Fiscal Year 2014, 20 benches within the Mack plaza at Lowell Heritage State Park were replaced using approximately $45,000 from this fund.

Dedicated Funds

Dedicated property funds may come from a variety of sources (e.g., telecommunication tower fees), and are limited to use at the property on which they are derived. There are no sources of dedicated funds for any property within the planning unit.

Retained Revenues

The state operating budget specifies the maximum amount of park revenue from fees, licenses and rents charged by DCR that may be retained by the agency in a given FY (the amount changes yearly). Revenue is deposited in the state's general fund. DCR may then use (or retain) up to 80% of this revenue statewide for its operating expenses and improvements to DCR facilities statewide.

Great Brook Farm State Park is the only property in this planning unit that currently generates any retained revenue. Revenue is collected from a number of different sources, including parking, annual pass sales, rental fees and event permits. In calendar year 2013, Great Brook Farm State Park collected $33,580 in parking fees, $12,240 in annual pass sales, $1,126 in event fees, and $16,680 in rental income (from lease holders), for a total of $63,626. This total does not include revenue or in-kind investments from the farm lease or the ski concession.

In-kind Contributions

In-kind contributions are the donation of goods or services, rather than funds. The Student Conservation Association (SCA) has provided work crews to assist with trail maintenance activities at Great Brook Farm State Park, contributing their time and labor. The New England Mountain Bike Association (NEMBA) also holds annual trail days at both Great Brook Farm State Park and Lowell-Dracut-Tyngsborough State Forest. NEMBA members assist with the maintenance of trails used for mountain biking purposes, providing labor and materials.

Spruce Swamp (DCR)

SECTION 3. LOWELL-DRACUT-TYNGSBOROUGH STATE FOREST

3.1. INTRODUCTION

Lowell-Dracut-Tyngsborough State Forest (1,109 acres) is a natural treasure of the Merrimack Valley. Its location between the urban centers of Lowell, MA and Nashua, NH make it unique and valuable, in terms of the recreational and educational opportunities available. The forest's network of trails provides access to largely undisturbed woodlands and wetlands, as well as several noteworthy cultural sites, for hikers, horseback riders and mountain bikers alike. It is an ideal location to discover the rich history of the region, from the influence of retreating glaciers to the course of human settlement over the last nine thousand years.

3.2. HISTORY OF PROPERTY

The history of Lowell-Dracut-Tyngsborough State Forest dates back thousands of years to Native American settlements along the Merrimack River. The principal tribe of the Merrimack Valley was the Pennacook, who were led by Passaconaway, and later by his son Wonalancet, two of the most renowned chiefs in New England. Both men were known for their mild dispositions, "preferring the ease and comforts of peace to the hardships and deprivations of war," and were respected by all of the smaller tribes in the region (Piotrowski 2002, 17).

At the start of King Philip's War in 1675, the Pennacook fled the Merrimack Valley to avoid having to take a side in the conflict. When Wonalancet returned to the area 10 years later, he sold all of his tribe's homelands to Jonathan Tyng and his partners, reserving only the right to fish and hunt. Soon after this "million-acre" sale, Wonalancet joined a tribe in Quebec, Canada and did not return to the area until 1692 (Crowley 1904; Piotrowski 2002, 18). It was at the request of a few hardy colonists, who were comforted by his presence, that Wonalancet moved back to Tyngsborough, where he lived with Jonathan Tyng in the Tyng Mansion until his death in 1696.

The area surrounding the state forest was slow to develop through the early decades of the 18th century, primarily due to unstable frontier conditions. After 1730, increased settlement took place throughout the area, especially along the riverine lowlands of the Merrimack. By 1800, Chelmsford (part of which would become Lowell), Dracut and Tyngsborough were flourishing. Farms,

quarries, mills and other small-scale manufacturing industries supported the regional economy. A series of transportation improvements throughout the 19th century, including roads and bridges, river ferries, canals and railroad corridors, maintained the vitality of the Merrimack Valley.

During the 19th century, the character of Dracut and Tyngsborough began to shift as Lowell established itself as the industrial powerhouse in the region. Both towns became popular vacation communities with established waterfront parks and resorts attracting seasonal visitors from Boston and New York. Lakeview Park (Dracut), Willowdale and Mount Rock (Tyngsborough) were just a few of the more popular destinations in the area, all of which were situated around Lake Mascuppic.

Land for Lowell-Dracut-Tyngsborough State Forest was first acquired by the Commonwealth between 1933 and 1936. During that time, federal Works Progress Administration projects were carried out in the forest, including the reconstruction of Trotting Park Road (Lowell and Tyngsborough); creation of scenic vistas from Whortleberry Hill; improvement of timber stands on Gage Hill; and construction of a tool shed and blacksmith shop. An old spring water bottling building, remnants of a company once located on the land, was repurposed as a forest headquarters (Stone & Webster Environmental Technology & Services 1998). In 1937, a 16- by 30-foot single-story woodshed and public comfort station was built at the headquarters site, which was located on the east side of Trotting Park Road (Lowell), south of the current main entrance to the state forest (Stone & Webster Environmental Technology & Services 1998).

By the early 1950s, there was considerable interest in developing the state forest into a major facility (see Appendix H). However, early efforts to act on this interest, such as the small recreation area and ski trail established near Whortleberry Hill, never became popular with visitors (Lambert 1972). For the next 20 years, the forest remained largely undeveloped; hiking and "some" snowmobiling were the principal recreation uses (DNR 1970, 2).

In 1970, the Department of Natural Resources (DNR) wrote a plan for the state forest to "help meet the increasing need for a variety of recreation and natural experiences in the rapidly suburbanizing Lowell region" (DNR 1970, 2). According to the plan, much of the forest was "to be left in its natural state, protected and enhanced as resource management areas" (DNR 1970, 2). However, specific recommendations were made for an organized interpretive trail system, an environmental education or visitor's center, a day use area for swimming and picnicking, and a group camping area. The plan also recommended acquiring an additional 300 acres of land to provide a larger buffer between the proposed development and more natural areas of the forest.

Several years after the DNR plan was written, but before any of its recommendations were implemented, Lowell-Dracut-Tyngsborough State Forest fell into a state of disrepair. The buildings at the headquarters site were boarded-up and the forest was "ravaged by vandalism" (Sylvester 1977). "Stripping and torching" cars was one of the more notorious activities that took place within the forest; in 1976, 85 burnt cars were found in the Dracut portion alone (Sylvester 1977). The lack of supervision over the forest's Cut-A-Cord Program led to further abuse, with permit holders reportedly taking three or four times their share of wood from the forest and reselling it at a much higher price (Sylvester 1977).

One bright spot in the forest's history during this time period was the partnership and agreement between the Department of Environmental Management and Greater Lowell Indian Cultural Association (GLICA). In 1978, an initial three-year Memorandum of Understanding was signed, which granted the GLICA access to 150 acres of the state forest where the group erected temporary wigwams and teepees, laid out a ceremonial circle and held cultural festivals (Anonymous 1981). The GLICA's presence enhanced the state forest's natural and cultural resources and helped curb some of the vandalism taking place there (Anonymous 1981).

In 1996, all of the buildings associated with the headquarters site were removed and forest operation and maintenance responsibilities shifted to eight year-round and seasonal staff based out of Lowell Heritage State Park (Stone & Webster Environmental Technology & Services 1998). Today, the state forest remains largely undeveloped and staff are based out of both Great Brook Farm State Park and Lowell Heritage State Park.

3.3. EXISTING CONDITIONS

Natural Resources

Physical Features

Topography. The state forest is shaped roughly like a bowl, with a large wetland near its center and several drumlins, or elongated hills, situated around its perimeter. The highest points within the forest are atop Whortleberry Hill (364 feet) and Gage or Huckleberry Hill (324 feet), both of which are located in the northernmost portion of the forest (see Figure 2).

Geology. The bedrock in the area of Lowell-Dracut-Tyngsborough State Forest is largely comprised of calcareous sandstones, siltstones and shale, with Ayer granite and Dracut diorite intruding near the Town of Dracut (Skehan 2001). The best examples of these formations fall outside of the forest, underlying the Merrimack River, near the University Avenue Bridge in Lowell (calcareous sandstones, siltstones and shale) and at Nickel Mine Hill, north of Methuen Street in Dracut (Dracut diorite; Skehan 2001).

Within the state forest itself, several large glacial erratics, or boulders, are recognized as significant natural and cultural resources (e.g., Horsehead Rock, Sheep Rock and Indian Head Rock). There is also evidence of multiple stone quarries within the forest, where granite and gneiss were collected as building material for Lowell's canal system and textile mills (Ali and Hudon n.d.).

Soils. Soils within the forest vary based on the topography. Poorly and very poorly drained sandy loams and Freetown or Swansea mucks are associated with the low-lying wetlands. These soils are considered severely limited for picnic areas, paths and trails (Peragallo 2009). Well to excessively drained sandy loams and exposed stones or boulders dominate the rolling to moderately steep hills. These soils range from being severely to slightly limited for picnic areas, paths and trails (Peragallo 2009). The severe limitations are strictly related to picnic areas and the soils being too sandy, too rocky or too steep.

Table 3.1. Soils of Lowell-Dracut-Tyngsborough State Forest

Soil Series	% of Forest	Drainage Class
Canton fine sandy loam	18.4	Well drained
Montauk fine sandy loam	14.0	Well drained
Freetown muck	13.8	Very poorly drained
Charlton-Hollis-Rock outcrop complex	7.0	Well to somewhat excessively drained
Hollis-Rock outcrop-Charlton complex	6.6	Well to somewhat excessively drained
Deerfield loamy sand	6.0	Moderately well drained
Narragansett silt loam	5.3	Well drained
Birdsall mucky silt loam	4.4	Very poorly drained
Scituate fine sandy loam	4.4	Moderately well drained
Scarboro mucky fine sandy loam	2.9	Very poorly drained
Merrimac fine sandy loam	2.8	Somewhat excessively drained
Swansea muck	2.8	Very poorly drained
Water	2.6	N/A
Ridgebury fine sandy loam	2.4	Poorly drained
Whitman fine sandy loam	1.6	Very poorly drained
Wareham loamy fine sand	1.4	Poorly drained
Windsor loamy sand	1.1	Excessively drained
Paxton fine sandy loam	1.0	Well drained
Tisbury silt loam	0.8	Moderately well drained
Sudbury fine sandy loam	0.5	Moderately well drained
Hinckley loamy sand	0.2	Excessively drained
Woodbridge fine sandy loam	0.2	Moderately well drained
Merrimac-Urban land complex	0.0	Somewhat excessively drained

Water Resources

Ponds. There is only one named pond in Lowell-Dracut-Tyngsborough State Forest; it serves as a portion of the property's northeastern boundary (see Figure 2). Althea Lake is a relatively small, 43-acre pond with a maximum depth of 15 feet (MassWildlife 1993*a* and MassGIS 2009). The DCR owns approximately 1,735 feet of the shoreline; the remaining portion is lightly developed. Emergent

Placeholder for Figure 2.

aquatic vegetation has historically been very heavy at Althea Lake, making it difficult to fish (MassWildlife 1993*a*).

There are approximately 33 acres of other smaller, unnamed pools and ponds within the forest.

A second named pond abuts the DCR's Conservation Restriction in Tyngsborough (see Figure 2). Long Pond is a 158-acre interstate pond with a maximum depth of 25 feet (MassWildlife 1993*b* and MassGIS 2009). The DCR has an interest in approximately 1,200 feet of the shoreline; the remaining portion is heavily developed. Long Pond is an infertile body of water; it contains very little aquatic vegetation or sizeable fish (MassWildlife 1993*b*).

Wetlands. Wetlands account for nearly one-quarter of the forest's acreage (approximately 244 acres or 22%). Spruce Swamp is the largest wetland within the forest (approximately 107 acres; see Figure 2). It contains areas of deep marsh, shrub swamp and wooded swamp, as well as acidic shrub fen, a rare Priority Natural Community. Before the construction of Carney Road (Dracut and Lowell), which dammed a small stream, Spruce Swamp was known as Indian Head Lake.

Vernal Pools. There are 31 certified and 15 potential vernal pools within the state forest, several of which are Civilian Conservation Corps (CCC) water holes (see Cultural Resources, below, for more information).

Streams. There are three named streams within the forest, all of which flow into the Merrimack River (see Figure 2). Scarlet Brook flows out of a wetland southeast of Althea Lake, towards Sherburne Avenue in Lowell, and enters the Merrimack River near Greater Lowell Technical High School. Claypit Brook originates from a wetland south of Spruce Swamp. The stream flows south towards Varnum Avenue in Lowell, where it turns east and enters the Merrimack River near Pawtucket Falls. Flagg Meadow Brook is located in the easternmost portion of the forest and flows south towards Lowell General Hospital before entering the Merrimack River downstream of Claypit Brook.

Groundwater. There are no aquifers beneath the state forest.

Flood Zones. The 100-year flood zone overlaps with the wetland immediately east of Althea Lake (18 acres), the western edge of Spruce Swamp (22 acres) and portions of Scarlet Brook (29 acres). The 500-year flood zone overlaps with the northern edge of Spruce Swamp, near Forest Park Road in Dracut (six acres).

Rare Species

Lowell-Dracut-Tyngsborough State Forest is home to three state-listed species. One of these species is susceptible to collection and is not identified in this plan.

Table 3.2. State-listed Species of Lowell-Dracut-Tyngsborough State Forest, as identified by the Natural Heritage & Endangered Species Program (NHESP)

Species	Type	MESA[a]
Blanding's turtle	Reptile	T
Blue-spotted salamander[b]	Amphibian	SC
Data sensitive species[c]	Insect	T

Source: Harper 2013

a. Status of species listed under the Massachusetts Endangered Species Act (MESA): SC = Special Concern and T = Threatened.

b. Blue-spotted salamander has not been re-observed at the state forest since 1989 and will be considered to be historic at this location at the end of 2014.

c. This species is not identified in accordance with the NHESP's policy of withholding, in site-specific documents, the name or location of rare species susceptible to collection.

Blanding's turtles use a variety of habitats, including vernal pools, marshes, scrub-shrub wetlands and open uplands, during their life cycle (NHESP 2007*a*). Blue-spotted salamanders, on the other hand, rely solely on moist, moderately shaded habitats and vernal pools, in particular, for breeding (NHESP 2007*b*). The data sensitive species can be found in the forest's wetlands and nearby wooded areas.

Nearly 90% of the forest (995 acres) has been designated as Priority Habitat under the Massachusetts Endangered Species Act (321 CMR 10.00; see Appendix F). Approximately 79% of the lands on which the DCR holds a Conservation Restriction are also designated as Priority Habitat (56 acres). These same areas have been identified as Core Habitat in the MassWildlife and The Nature Conservancy publication "BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World" (MassWildlife and TNC 2010).

BioMap2 highlights two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is "important to conserve the full suite of biodiversity" in Massachusetts (MassWildlife and TNC 2010).

Within Lowell-Dracut-Tyngsborough State Forest, there are also 260 acres (23%) of Critical Natural Landscape, which encompass Spruce Swamp and adjacent wetlands to the north and west.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified nine forest sub-types within Lowell-Dracut-Tyngsborough State Forest.

Table 3.3. Forest Sub-types of Lowell-Dracut-Tyngsborough State Forest

Forest Sub-type	Acres	% of Forest
Mixed oak	299.2	27.0
Eastern white pine-oak	274.9	24.8
Eastern white pine	72.1	6.5
Oak-hardwoods	64.3	5.8
Eastern white pine-hardwoods	36	3.2
Red maple-swamp hardwoods	33.9	3.1
Red pine plantation	30.8	2.8
Grey birch-red maple	10.8	1.0
Eastern hemlock-hardwoods	6.8	0.6
Total	*828.8*[a]	*74.8*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the forest's boundaries since 2003.

More recently (2010-2011), specific areas within the forest were visited by DCR Management Foresters as part of the Massachusetts Continuous Forestry Inventory (CFI). The CFI is a network of permanent, one-fifth-acre plots on state forest lands that are routinely monitored for sivicultural purposes. The measurements and observations made within each CFI plot are recorded in a database that dates back to 1960, when the CFI was created. Approximately 10% of the state's CFI plots are inventoried each year, on an on-going basis. As of 2010, there were 1,768 CFI plots statewide (Goodwin 2014).

There are seven CFI plots within Lowell-Dracut-Tyngsborough State Forest. They range in age from approximately 70 to 100 years and are comprised of mostly white or red pine, pitch pine, oak or swamp hardwoods. As part of the CFI process, DCR Management Foresters also look for signs of disturbances that affect the development of vegetation in the vicinity of each CFI plot. Since 2010, four disturbance agents have been observed in the forest's CFI plots. These agents, in decreasing order of occurrence, are: fire, clearing for pasture, insects and beavers.

Priority Natural Communities. One Priority Natural Community, acidic shrub fen, has been identified within Lowell-Dracut-Tyngsborough State Forest. Acidic shrub fens are typically found along wet pond margins in the eastern half of Massachusetts and consist primarily of low-growing, interwoven shrubs, with patches of Sphagnum moss growing at the shrub bases (Swain and Kearsley 2001). Acidic shrub fens have a state ranking of S3, which means that they are neither rare (S1) nor common (S5), however their conservation is encouraged. The biggest threats to this natural community are hydrological alterations that affect either water quality or quantity (Swain and Kearsley 2001).

Invasive Species. Since 2010, five invasive species have been observed by DCR Management Foresters in the forest's CFI plots. These invasive species are: common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*Frangula alnus*), garlic mustard (*Alliaria petiolata*), oriental bittersweet (*Celastrus orbiculatus*) and black locust (*Robinia pseudoacacia*). Japanese knotweed (*Fallopia japonica*) was also observed in the former headquarters site while conducting fieldwork for this plan.

Pests and Disease. Since 2010, DCR Management Foresters have observed, as part of the CFI process, several biological agents responsible for tree loss. These agents are: heart rot, black knot of cherry (*Apiosporina morbosa*), white pine weevil (*Pissodes strobe*), borers, gypsy moth (*Lymantria dispar*) and other unknown insects and biological agents.

It is also worth noting that Emerald Ash Borer, an invasive wood boring insect that was first identified in Massachusetts in 2012 and adversely affects all genera of ash trees, has recently been discovered in the neighboring town of Methuen (Church 2014).

Wildlife

Birds. Approximately 150 species of birds have been recorded on, or over, the state forest in recent years (see Appendix G). Of these species, 23 are classified as Species in Greatest Need of Conservation (MassWildlife 2006).

Mammals. There is little current information on the forest's mammals. Sixteen species confirmed to occur within the forest and an additional 26 species that may possibly occur within the forest are identified in Appendix G.

Reptiles. There is little current information on the forest's reptiles. Seven species confirmed to occur within the forest, three of which are classified as Species in Greatest Need of Conservation, and an additional nine species that may possibly occur within the forest are identified in Appendix G (MassWildlife 2006).

Amphibians. There is little current information on the forest's amphibians. Eight species confirmed to occur within the forest, one of which is classified as a Species in Greatest Need of Conservation, and an additional 10 species that may possibly occur within the forest are identified in Appendix G (MassWildlife 2006).

Fish. There is no current information on the forest's fish. Surveys conducted by MassWildlife in 1978 at Althea Lake identified the following seven species: largemouth bass (*Micropterus salmoides*), chain pickerel (*Esox niger*), yellow perch (*Perca flavescens*), pumpkinseed (*Lepomis gibbosus*), bluegill (*Lepomis macrochirus*), yellow bullhead (*Ameiurus natalis*) and brown bullhead (*Ameiurus nebulosus*; MassWildlife 1993*a*). A separate MassWildlife survey at Long Pond in 1981 found these same seven species, plus white sucker (*Catostomus commersonii*) and golden shiner (*Notemigonus crysoleucas*; MassWildlife 1993*b*).

Cultural Resources

Pre-Contact Archaeological Sites

Two pre-Contact sites are documented within the state forest. During an archaeological survey, a camp site was uncovered on an upland terrace in Dracut dating to the Early Archaic Period (10,000-7,500 B.P.; Before Present). Many stone tools were recorded, as well as a unique feature unlike any other documented in the northeast. A small pit containing 1,200 fragments of calcined (burned) deer bone was located on a steep slope making this site potentially eligible for listing on the National Register of Historic Places. In another area of the forest (Lowell), a Late Archaic Period (5,000-3,000 B.P.) camp site was recorded. No archaeological sites have been recorded in the Tyngsborough section of the forest, however it has not been systematically surveyed. The physical characteristics, regional setting and known pre-Contact occupation in the area all confer a high archaeological potential for the state forest.

Historic Archaeological Resources

Timothy Coburn reportedly operated one of the earliest mills in Lowell (Richardson 1978). The remnants of this mill site may fall within the southern portion of the forest, along Claypit Brook. The remnants of a dam (see Structures, below) suggest that there was also some small scale industrial activity located along the brook. However, more research is needed to determine the nature and extent of the site, to identify any additional features, and to confirm its association with one of the six men named Timothy Coburn who resided in the area in the 18th and 19th centuries (Richardson 1978).

A spring water bottling company was established at the former headquarters site in the late 19th century, operating until c1920. When the state forest was established in the 1930s, at least one building from the former bottling plant, a pump house, was renovated for forest use. The site was utilized as the forest headquarters until the 1970s, and then left vacant until the buildings were removed in 1996. A concrete pad, the foundation from the former headquarters building and a depression with stones that is likely the cellar hole of the former pump house, are still present on site. The pump house cellar hole is currently filled with branch debris. A trash pile that contains glass bottle debris, as well as

a terra cotta pipe sticking out of the ground (possibly a part of the former bottling works), was also located nearby.

Earlier research on the history of the state forest indicates that there are at least two additional cellar holes that are expected to exist on the property (Richardson 1978). These resources were sought during the fieldwork for this plan, but could not be confidently located; additional research is needed.

Historic Resources

Buildings. There are no historic buildings within the state forest.

Structures. There are five Civilian Conservation Corps (CCC) water holes within the state forest. These water holes, typically small, stone lined ponds, were developed by the CCC in larger state forests and used as a source of water for forest fire control purposes. Two of the water holes within Lowell-Dracut-Tyngsborough State Forest are adjacent to Trotting Park Road (Lowell): one is near the former headquarters site and the other is on the edge of Spruce Swamp. A third water hole is just north of Trotting Park Road (Tyngsborough), adjacent to an unnamed administrative road and Spruce Swamp. The fourth is adjacent to Totman Road (Dracut) and is notable for being encircled by a pathway, providing more access to the resource than is typical. The fifth water hole is located north of Totman Road (Dracut) and is notable for being rectangular in shape, where the others within the forest are round. In general, the water holes are all in fair to poor condition, with some of the side walls settling and vegetation creeping in from the edges. All have drainage issues.

CCC Water Hole (DCR)

There are three stone slab bridges of unknown age located in the forest. This simple bridge type utilizes a single large, relatively flat stone, supported on either side by earth or stone abutments, to cross a small stream or brook. Two of the bridges are located in the southern portion of the forest, not far from the former headquarters site, and serve as part of the current trail system. One bridge is small, while the other is larger and covered by earth that has been held in place by wooden side rails, making the slab construction only visible from the side view. Both are in good condition. The third stone slab bridge is located off-rail, near intersection D3 on Carney Road (Dracut). This bridge is in fair condition and has some vegetative growth on it.

Stone Slab Bridge (DCR)

Four stone culverts were located during the fieldwork for this plan. One is located beneath Trotting Park Road (Lowell), adjacent to Spruce Swamp; another is located beneath the unnamed administrative road in Tyngsborough; a third culvert is located on Carney Road (Dracut), near intersection D3; and the fourth culvert is located on the former headquarter site's entrance loop road, adjacent to the CCC water hole. These culverts, which facilitate the flow of water beneath a roadway, were constructed utilizing small stones. The culvert beneath the former entrance loop road is also lined with a metal pipe, while the others are all stone. They may have been constructed as part of the Works Progress Administration improvements to the forest. All of the culverts are in poor condition, with some blockage and/or minor collapse impeding full flow.

The remnants of a dam, constructed of stone, can be found in the southern portion of the property, along

Claypit Brook. This dam may be associated with the Timothy Coburn mill site. See Historic Archaeological Resources, above, for more information on this resource.

Objects. There are four stone markers located within the state forest, identifying property and/or town boundaries.

- Located near an entrance to the forest on Trotting Park Road in Tyngsborough, this stone is leaning significantly and has some paint remnants on the top. The stone is inscribed with:

  T
  ARD
  1822

- A small property boundary marker inscribed with a "C," located in the southern portion of the forest.
- A town boundary marker with a "T" inscribed on one side and an "L" inscribed on the other. This stone is located at intersection of all three towns; it is leaning and covered in lichen.
- A town boundary marker with an "L" inscribed on one side and a "D" inscribed on the other. This stone is located just off of Trotting Park Road, near the boundary of all three towns. Despite some remnants of paint, it is in the best condition of any boundary marker in the forest.

Stone Boundary Marker (DCR)

Sheep Rock is located in the southern portion of the forest, not far from the former headquarters site. It is a large glacial erratic, approximately 10 feet long, 6 feet wide and 12 feet tall. A large split cuts through the rock and lichen is growing on some of the surface. The north face of Sheep Rock has been vandalized by graffiti and the south face contains the following inscription, in block letters:

SHEEP ROCK
IN MEMORY OF GEORGE J. CARNEY
BORN JUNE 13, 1835
DIED APRIL 24, 1906

Local legend states that Sheep Rock saved a flock of sheep owned by William Parham, a local farmer. During a blizzard, the flock found shelter under an overhang of the boulder. There, they were able to survive for several days until being rescued. The land where Sheep Rock lies was formerly owned by George Carney.


Sheep Rock (DCR)

Stone walls can be found throughout the state forest; they are remnants of the historic land use and ownership in the area, and also reflect the geology of the region. The walls are all dry laid, rubble walls that are generally in fair to poor condition. The walls were not mapped as part of this plan.

Several of the roads in the forest pre-date the establishment of the state forest itself, including Trotting Park Road (Lowell and Tyngsborough) and Totman Road (Dracut). Totman Road, in particular, has been identified as being an older road that may have been laid out along an established Native American pathway. Today it is a typical wide, unpaved forest road that is enjoyed by hikers and mountain bikers.

Landscapes. Remnants of quarrying activity dot the forested landscape, where early settlers took advantage of both the underlying geology of the area and the large collection of glacial erratics. It is a fascinating collection that ties the natural and cultural history of the forest together, and provides a connection to the industrial heritage of Lowell, as stone from the forest was reportedly utilized as building material for Lowell's canal system and textile mills (Ali and Hudon n.d.).

Most of the quarrying activity that was located during the fieldwork for this plan appears to be very small scale; five areas were identified where one or two stones retain visual evidence, in the form of drill scars, of past use for quarrying. Three of these sites are located in the northern portion of the forest, near Trotting Park Road (Tyngsborough) and an unnamed administrative road (Dracut), while the other two are located in the southern portion of the forest, not far from the former headquarters site.

Two other areas were identified where larger scale quarrying took place. One of these quarries is located on the eastern edge of the forest, not far from Gumpus Road in Dracut, and is the only area where a quarry pit, now filled with water, was observed. The other area has evidence of quarrying from exposed ledge. This area, near Sheep Rock, includes a collection of ledge rock and boulders that display drill scars and drill holes.

A boulder that has been worked for quarrying stone. (DCR)

There is undoubtedly evidence of other quarrying activity elsewhere in the forest that was not captured during the fieldwork for this plan. Richardson (1978) noted that he located 73 individual quarry works, the extent of which is unclear, between the former headquarters site and Carney Road (Dracut and Lowell), an area that is popular for mountain biking. However, only one quarry site is recorded on an MHC Inventory form (MHC #LOW.30).

The former entrance loop road that leads to the old headquarters site is a U-shaped drive located in the southern portion of the forest. It is defined by the placement of medium-sized rocks set on either side of the roadbed, approximately five feet apart. It is not known if these rocks were placed during the development of a spring water company in the late 19th century or during the transformation of the area into the state forest headquarters by the Works Progress Administration in 1936-1937.

Recreation Resources

Lowell-Dracut-Tyngsborough State Forest is primarily accessed via motor vehicle. Individuals who live nearby may also choose to walk or ride their bicycle to any one of the trailheads. The Lowell Regional Transit Authority offers an additional, likely underutilized, means of accessing the forest. There are two bus routes, 7 and 10, that run along Varnum Avenue (Lowell) and Tyngsboro Road (Dracut), respectively, and serve downtown Lowell, local high schools and universities, and suburban shopping centers. However, there are no bus stops adjacent to the forest on either bus route.

Recreation at the state forest includes trail-based activities such as hiking and running, horseback riding, mountain biking, snowmobiling and cross-country skiing. Geocaching also occurs throughout the forest, with participants both on and off trails. As of May 2013, there were 13 known geocaches at Lowell-Dracut-Tyngsborough State Forest and two geocaches on the DCR's Tyngsborough Conservation Restriction. Evidence of off-highway vehicle (OHV) use, paintball games, alcohol consumption and campfires, which are in violation of DCR regulations, have also been found along the forest's trails.

Hunting is permitted at the state forest; however there are two designated "No Hunting Areas" (see Figure 2). The first area (approximately 173 acres) is located in the western half of the forest, south of Althea Lake, and overlaps with the portion of the forest that was formerly under agreement with the Greater Lowell Indian Cultural Association (see Section 3.4. Management Resources and Practices). The second area (approximately 36 acres) is located east of Totman Road (Dracut) and south of the

Dracut town line. Neither area is clearly marked in the field.

The Greater Lowell Indian Cultural Association (GLICA) holds several annual recreation events at the state forest each year. The events range from seasonal cleanups to traditional ceremonies that are educational in nature. Each event is open to the public and held within a designated area of the forest, south of Althea Lake in Tyngsborough. Portable sanitary facilities are routinely rented by the GLICA for these events and, in the past, were permitted through a Memorandum of Understanding (MOU) with the DCR; that MOU has expired. Open fires, cooking and camping occasionally take place at GLICA-sponsored events; these activities were also permitted per the expired MOU with the DCR. For more information on the expired MOU, see Section 3.4. Management Resources and Practices.

The Merrimack Valley Chapter of the New England Mountain Bike Association (MV-NEMBA) devotes most of its resources to trail construction and maintenance in the Greater Lowell area. The primary focus of the MV-NEMBA is Lowell-Dracut-Tyngsborough State Forest, but the group is also active at other properties within the Lowell/Great Brook Planning Unit. In addition to their trail work, the MV-NEMBA organizes several group riding and cleanup events within the state forest each year. The majority of the group's activities are approved and permitted, via a Recreational Use Permit, by the Forest and Parks Supervisor.

Infrastructure

Property Boundary

Fee Interest Land. The 1,109-acre state forest is situated northeast of the Merrimack River, between Route 113 in Lowell and Mammoth Road in Dracut, where the City of Lowell and towns of Dracut and Tyngsborough meet. The forest can be reached by car in less than 15 minutes from Lowell, MA and less than 30 minutes from Nashua, NH.

Conservation Restrictions. There are three Conservation Restrictions (CRs) associated with the forest; one each in the towns of Tyngsborough and Dracut, and one in the City of Lowell (see Figure 2).

A 47-acre CR is located off of Autumn and Alden streets in the Town of Tyngsborough. The fee interest is held by the town and its Conservation Commission is responsible for the care and control of the property. The purpose of the CR is "…to retain the premises predominantly in its natural, scenic and open condition; to protect and promote the conservation of forests, wetlands, soils, natural watercourses, ponds, water supplies and wildlife thereon; to allow public access to Long Pond (a Great Pond) for fresh-water recreation and to the premises for the enjoyment of wildlife, natural resources, and passive recreation." Activities that are detrimental to the property's water and soil resources, including the use of motorized vehicles, are prohibited. The construction of two public parking areas, one on Alden Street for not more than 10 cars and one on Autumn Street for not more than five cars, is permitted.

A nine-acre CR is located off of Lakeview Terrace in the Town of Dracut. The fee interest is held by the Boisvert family. The purpose of the CR is "to retain the premises predominantly in its natural, scenic and open condition; to protect and promote the conservation of forests, wetlands, soils, natural watercourses, ponds, water supplies and wildlife thereon; to protect the horticultural resources of the premises; to protect and enhance the value of the abutting conservation areas; and to allow public access for enjoyment of wildlife and open space resources of the premises as specifically provided for herein." Activities that are detrimental to the property's water and soil resources, including the use of motorized vehicles, are prohibited.

A 17-acre CR is located off of Totman Road in the City of Lowell. The fee interest is held by Northeast Radio, Inc. There are existing structures, including four towers for radio transmission, on the property. The purpose of the CR is to allow the DCR to inspect the property on foot; to selectively cut and/or prune trees and erect signs interpreting or regulating access to the land; and to enter and pass through on foot to access the state forest. The property is not open to the public. In addition, activities that are detrimental to the property's water and soil resources are prohibited.

Buildings and Structures

On November 29, 1935, the Town of Dracut granted the Dracut Water Supply District (DWSD), an independent entity, the right to construct and maintain water supply infrastructure on its land. According to the deed, the exact location of the

infrastructure was to be determined by the Commissioners of the DWSD at the time of construction (Middlesex County Registry of Deeds, Northern District, Book 872, Page 85). However, the next day, November 30, 1935, the town conveyed approximately 335 acres to the Commonwealth, reserving the "…rights of the Dracut Water Supply District to construct and maintain a reservoir or standpipe on parcel four (4)…together with all rights necessary and incidental thereto" (Middlesex County Registry of Deeds, Northern District, Book 876, Page 228).

Parcel four includes most of Whortleberry Hill; the reservoir and related infrastructure described below are located on the eastern side of Gage Hill (or parcel five, as described in the deed; see Figure 2). To date, neither the DWSD nor the DCR have found any correspondence regarding the construction of a reservoir, or related infrastructure, on parcel five instead of parcel four. There is also no Memorandum of Agreement, or similar document, between the DWSD and DCR that guides access to and maintenance of the infrastructure on parcel five.

Reservoir. The one million gallon water supply reservoir, constructed in 1939, is located on the eastern side of Gage Hill, near the summit (Riopelle 2013*a*). It is covered by a 93-foot square concrete slab and surrounded by a six-foot tall chain-link fence topped with barbed wire. The fence features two gates that are secured with padlocks and one sign that reads: "Public Water Supply No Trespassing." The DCR is currently reviewing a proposal by the DWSD to replace the reservoir, due to the fact that it is undersized and nearly 75 years old.

Pump House. Down slope of the reservoir is a 15- by 24-foot windowless, single-story, masonry block building with a wood framed roof and asphalt shingles. The building, which was constructed within the last 10 years, serves as a pump house; it has electricity and is serviced by propane gas and fuel oil providers (Riopelle 2013*b*). A single, double-wide, locking metal door secures the building. Next to the entrance, and affixed to the exterior of the building, is a secure propane tank storage area.

At the rear of the building are one of two fire hydrants on site and a raised, circular concrete slab, approximately six feet in diameter. On top of the concrete slab is a secure access panel. Before the pump house was built, this structure was used to access and maintain critical water supply infrastructure. In the future, this structure will be removed and the area resurfaced to match the material and grade of the surrounding access road (Riopelle 2013*b*).

On the north side of the pump house are the second fire hydrant and a four- by five-foot secure, metal electrical transformer box, which is owned by National Grid. The transformer box sits on a five- by six-foot concrete slab and is surrounded by three, four-foot tall concrete bollards for safety and security purposes.

Dam. An illegal dam is located on the northeast side of Trotting Park Road (Tyngsborough), approximately 200 feet southeast of a DCR gate that separates the public and private portions of the road. The dam limits the flow of water from a wetland into Scarlet Brook through a culvert under Trotting Park Road (Tyngsborough). The dam primarily consists of logs greater than 12 inches in diameter and over 10 feet in length. It is not known when the dam was constructed or by whom.

Over time, water and sediment have collected behind the dam, creating a pond-like environment and promoting the growth of leafy vegetation on the dam itself. Water frequently overflows the dam, which floods and erodes portions of Trotting Park Road (Tyngsborough). At times, the erosion is significant enough to prevent DCR staff and emergency vehicles from entering the forest through the nearby DCR gate.

Trash Dumpsters. In the southern portion of the forest, within the former headquarters site, there are four large trash dumpsters that are in fair to poor condition. The dumpsters are primarily used by DCR staff to dispose of trash and larger debris collected at the state forest and nearby Lowell Heritage State Park.

Roads

Althea Avenue (Tyngsborough) is the only public road that runs through Lowell-Dracut-Tyngsborough State Forest; approximately 0.3 miles of the dead end, residential street are located within the northern section of the forest.

Trotting Park Road is the forest's primary administrative road (0.8 miles; see Figure 2). It is oriented in a north-south direction and connects the public portions of Trotting Park Road in Lowell and Tyngsborough. The paved portion of this road (0.6 miles) runs from the main entrance (Trotting Park Road, Lowell) to the northwest corner of Spruce Swamp. From Spruce Swamp to Trotting Park Road in Tyngsborough, the road surface is bank run gravel (0.2 miles).

The paved portion of Trotting Park Road continues north from Spruce Swamp to Dexter Avenue (Dracut) as an unnamed administrative road (0.5 miles; see Figure 2). An additional unnamed administrative road, located off of Tyngsboro Road (Dracut), provides access to the Dracut Water Supply District reservoir and related infrastructure (paved 0.2 miles; processed gravel 0.1 miles).

Parking

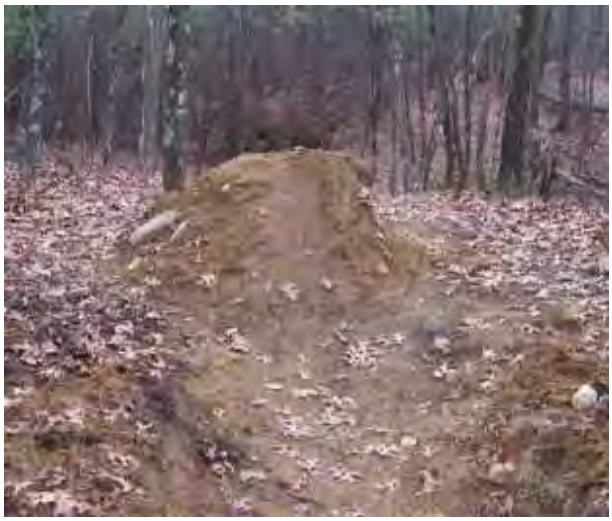
The forest has two small parking areas (see Figure 2). The first is located at the main entrance on Trotting Park Road in Lowell. It is a paved lot with a shared entrance and exit, and can accommodate approximately six vehicles. Individual spaces are not marked and there are no designated accessible spaces.

This parking area is the most popular with visitors. Vehicles are routinely parked on either end of the paved portion of the lot when there are no other spaces available. Further south on Trotting Park Road (Lowell), approximately 40 feet from the designated parking area, an "overflow" lot has been created. This unofficial parking area can accommodate three or four vehicles.

The second parking area, as indicated on the current state forest trail map, is located at the end of Trotting Park Road in Tyngsborough. It is unclear where to park when visiting this area of the forest. The most obvious location is in front of a forest gate on the west side of the road; however, this prevents DCR staff and first responders from being able to enter the forest in the event of an emergency.

Trails

There are approximately 27 miles of trails within the state forest, nearly all of which are official. An assessment of trail condition, conducted in 2009, indicated that 95% of the official trails were in good or fair condition and only 1.3 miles (5%) were in poor condition. Several official trails include technical features (e.g., banked or bermed corners, jumps and ramps), which are constructed to increase the technical challenge for mountain bike riders. It is unclear whether these features were subject to all applicable regulatory reviews and approved by the reviewing authorities and the DCR.



A mountain bike jump constructed in the forest. (DCR)

There is one, 1.5-mile long Healthy Heart Trail within the forest; it is located between the main entrance in Lowell and Spruce Swamp. Healthy Heart Trails are pathways used for hiking or walking that are easy to moderate in activity level and promoted by the DCR as a way to improve health through routine use.

The current version of the state forest trail map indicates four other named trails within the state forest (Thompson Lane, Totman Road, Carney Road and Gumpus Road), as well as "Public Safety Markers," or trail intersection numbers, that correspond to the town in which they are located (e.g., "L1" in Lowell, "D1" in Dracut, "T1" in Tyngsborough, etc.). Signs for these features are largely missing from the trail network. There are also more trails in the network than indicated on the current version of the state forest trail map.

Signs and Kiosks

There is one Main Identification Sign for the state forest. It is set back from, and parallel to, the north side of Varnum Avenue (Lowell), near the intersection of Trotting Park Road (Lowell). The orientation, material and design of this sign do not

meet DCR signage standards (DCR n.d.). There are no Road Marker Signs that lead visitors to the state forest from the surrounding communities.

There are six kiosks located within the state forest; each is constructed of wood framing and has an asphalt shingle roof. Two kiosks are near the forest's parking areas and do not meet DCR signage standards for Welcome Wayside Signs (DCR n.d.). Only one kiosk, at the main entrance on Trotting Park Road in Lowell, features the current state forest trail map. Four of the six kiosks feature information on hunting (e.g., seasons, rules and regulations). The two kiosks closest to the parking area on Trotting Park Road in Tyngsborough are completely blank.

All six kiosks are in fair to good condition. Moss is growing on the roof of the kiosk at the main entrance on Trotting Park Road in Lowell. The two kiosks on Totman Road in Dracut have been vandalized with permanent marker and paint.

Memorials and Markers

Sheep Rock is the only known memorial within the state forest. (See Section 3.3. Existing Conditions, Cultural Resources, for additional information.)

3.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Vegetation

The Dracut Water Supply District (DWSD) maintains the vegetation along the access road leading to the summit of Gage Hill, as well as around the water supply infrastructure there. (See Section 3.3. Existing Conditions, Buildings and Structures, for additional information.) The DWSD also maintains an approximately 20-foot-wide vegetated corridor that runs from the pump house north to Tyngsboro Road (Dracut). The purpose of this corridor is to prevent woody or deep-rooted vegetation from disturbing the underground pipelines in the area (Riopelle 2013*c*). There is no Memorandum of Agreement, or similar document, between the DWSD and DCR that guides this maintenance activity.

Wildlife

For the most part, the DCR does not actively manage wildlife at the state forest. However, when beaver activity becomes a problem (e.g., it threatens public health or safety), a wildlife specialist is called upon to install one or more beaver deceivers, or to trap the animal(s). In addition, the hunting of game species is permitted outside of the forest's "No Hunting Areas" (see Section 3.3. Existing Conditions, Recreation Resources).

Cultural Resources

There are no cultural resource management activities that are unique to the state forest.

Recreation Resources

Greater Lowell Indian Cultural Association (GLICA) Memorandum of Understanding (MOU)

The purpose of the expired MOU between the DCR and the GLICA was to "authorize the GLICA to use approximately two hundred and fifty-two (252) acres of the Lowell-Dracut-Tyngsboro [sic] State Forest…for temporary American Indian cultural activities and special events…to promote understanding of American Indian people and customs." The document largely outlined the GLICA's responsibilities related to the use and maintenance of the agreed upon area. Permissible activities, public access to events and circumstances requiring advanced or immediate notification to the DCR were addressed, among other topics.

On April 13, 2012, the GLICA notified the DCR, in writing, of their interest in renewing the MOU that was scheduled to expire on July 1, 2012. The DCR sent a new five-year MOU (valid through July 1, 2017) to the GLICA for their signature on July 6, 2012, but that document was never signed and returned to the DCR.

Camping

There are no permanent campsites or cabins at Lowell-Dracut-Tyngsborough State Forest; however, temporary campsites have been designated in the past, by the Forest and Parks Supervisor, for events sponsored by the Greater Lowell Indian Cultural Association.

Hunting and Fishing

Hunting is not permitted in two separate areas of Lowell-Dracut-Tyngsborough State Forest (see Section 3.3. Existing Conditions, Recreation Resources). The Greater Lowell Indian Cultural Association was responsible for posting and maintaining DCR approved "No Hunting" signs within the portion of the forest that was under agreement.

Trail Use

Snowmobiles may be used on any unplowed forest road or way at Lowell-Dracut-Tyngsborough State Forest, provided that: the vehicle is registered; sub-surface soil is "solidly frozen and completely covered with a minimum of four inches of hard packed snow or ice;" and the vehicle is carrying a spare spark plug, flashlight, drive belt and "sufficient tools to effect minor repairs." Snow vehicles may operate on frozen waters when there are five or more inches of frozen ice and in "fields, gravel banks or similar open areas where such use is permitted by appropriate signage." (See 304 CMR 12.29; Appendix F.)

Infrastructure

Buildings and Structures

The Dracut Water Supply District (DWSD) manages the majority of the infrastructure near the summit of Gage Hill; National Grid is responsible for the maintenance of the electrical transformer box (see Section 3.3. Existing Conditions, Buildings and Structures). There is no Memorandum of Agreement, or similar document, between the DWSD and DCR that guides this management activity.

DCR staff maintain the culvert and leafy vegetation associated with the illegal dam on Trotting Park Road in Tyngsborough (see Infrastructure, above, for more information). Staff have also added a layer of course gravel to the surface of the road, however flooding remains an issue.

The four large trash dumpsters located within the former headquarters site are routinely serviced by a disposal company that is under contract with the DCR.

Roads

The DCR's Forest Fire Control District 6 provides forest road maintenance (e.g., roadside mowing, tree removal and road repairs) on an annual basis.

The Dracut Water Supply District (DWSD) plows the access road leading to the summit of Gage Hill. (See Section 3.3. Existing Conditions, Roads, for additional information.) There is no Memorandum of Agreement, or similar document, between the DWSD and DCR that guides this maintenance activity.

Trails

The Merrimack Valley Chapter of the New England Mountain Bike Association performs volunteer trail work, including trail maintenance, repair and construction, and bridge building for trails, within the state forest. In the past, this work has primarily been done in consultation with the Forest and Parks Supervisor; a more formal agreement for this work is needed to ensure compliance with any required regulatory reviews. All trail work, whether performed by DCR employees or others, must be performed in accordance with general regulations and policies identified in Section 2.

Interpretive Services

Interpretive service programming is not offered at the state forest, nor is any other interpretive information provided.

Operational Resources

DCR Staffing

The state forest is operated as a satellite of Lowell Heritage State Park and does not have any dedicated on site staff.

Supplemental Staffing

Members of the Greater Lowell Indian Cultural Association and Merrimack Valley Chapter of the New England Mountain Bike Association routinely volunteer their time at the state forest for various general cleanup and trail maintenance activities. The potential exists for members of the Friends of the Forest, a group that has been inactive for several years, and students at the Greater Lowell Regional Technical High School to become more involved in organized activities at the state forest.

Public Safety

Local emergency response and law enforcement support within the state forest is complicated by the fact that the forest occurs in three municipalities. Recent efforts to improve communication between the DCR, local responders and visitors include: adopting a town-specific trail intersection numbering system (see Section 3.3. Existing Conditions, Trails) and distributing a "safety map" of the forest to pertinent DCR staff and local officials. The safety map includes information on the forest's trails, fire roads, major trail intersections and access gates, as well as neighboring access roads and municipal boundaries.

DCR Rangers issue citations for violations of various forest and park rules. A summary of incident reports recorded in the state forest during 2013 is provided below.

Table 3.4. Lowell-Dracut-Tyngsborough State Forest Incident Reports, January 1 through December 31, 2013

Incident	Number
Illegal dumping	1
Property damage	1
Violation of DCR regulations[a]	2
Total	*4*

a. These violations were related to off-highway vehicle (OHV) use and a campsite/fire within the state forest.

Vandenberg Esplanade (Peter E. Lee; CC BY-NC 2.0; cropped from original)

SECTION 4. LOWELL HERITAGE STATE PARK

4.1. INTRODUCTION

Forty years ago, the Department of Natural Resources proposed the Commonwealth's first heritage state park in Lowell. The purpose of the park was twofold: to preserve the cultural heritage of the city and surrounding region, and to increase public appreciation and enjoyment of the area's natural and cultural resources. Through an ambitious plan of acquisition, conservation and development, the agency and its partners were able to bring their vision of urban recreation and a revitalized industrial city to life.

Lowell Heritage State Park (87 acres) is comprised of linear greenways along the Merrimack River and Lowell Canal System, and a collection of historic buildings and structures related to the industrial development of the city. The park provides much needed open space in the city's downtown; showcases the city's history, with a focus on the canal system and associated mills; and serves as an important venue for a variety of civic and social functions.

4.2. HISTORY OF PROPERTY

The story of Lowell Heritage State Park is closely tied to that of the Merrimack River. The river originates in Franklin, New Hampshire and runs southward for 116 miles, reaching the Atlantic Ocean in Newburyport, Massachusetts. Although the Merrimack descends "a modest average of 2.6 feet per mile," there are several waterfalls where the river drops more rapidly in elevation (Steinberg 1991, 50). Prior to the construction of dams, a total of 14 waterfalls existed along the course of the Merrimack. Both Native Americans and European colonists established settlements near many of these falls.

Native Americans were drawn to Lowell because of its natural resources and strategic location. Pawtucket Falls slowed the progress of migrating Atlantic salmon, American shad, lamprey and alewife, allowing them to be caught in large numbers (Stolte 1981). This abundant and predictable seasonal food supply, along with easy access to coastal and forest resources, attracted the Pennacook Tribe, who established a populous settlement downstream of the falls. In 1653, the Massachusetts General Court authorized John Elliot

to establish Wamesit, a praying village for the Pennacook, at the confluence of the Merrimack and Concord rivers (Hudon 2004). Twenty-three years later, however, the Pennacook abandoned Wamesit due to King Phillip's War.

As European settlements expanded, colonists sought ways to move timber and crops to coastal cities, and imported goods inland. However, Pawtucket Falls impeded the flow of river traffic, requiring goods to be shipped over land around the falls. In 1792, a group of wealthy Newburyport businessmen, known as the Proprietors of Locks and Canals on the Merrimack River (the Proprietors), constructed the Pawtucket Canal to solve this problem. The canal, which ran from upstream of the falls to the confluence of the Merrimack and Concord rivers, bypassed both the falls and a near 90-degree bend in the Merrimack. In 1801, five years after the Pawtucket Canal opened, work began on a competing canal. Beginning in 1803, the Middlesex Canal, which connected Chelmsford to Charlestown, moved raw materials and goods to the port of Boston. Although the Middlesex Canal outcompeted the Pawtucket Canal, its success was short-lived due to the arrival of the railroad in the 1830s.

The industrial development of Lowell began in 1821 when a second group of businessmen visited Pawtucket Falls to assess its potential for industrial water power (Hudon 2004). Within a month they had purchased over 350 acres of land between the bend in the river and the Pawtucket Canal, in what was then East Chelmsford. In 1822, they purchased water power rights from the Proprietors, the company that constructed the Pawtucket Canal 30 years earlier. This established the Proprietors as the developer and power broker of the city, selling land and leasing mill power to textile manufacturers for years to come (Hudon 2004).

In 1825, the Merrimack Canal, the city's first power canal, was completed. Four additional power canals were constructed between 1826 and 1835; by 1840 these canals were distributing power to 32 mills (Hudon 2004). One additional canal and an underground connector between canals were built in the late 1840s. A permanent dam across the Merrimack, constructed in 1830 and increased in height in 1833, created an 18-mile stretch of river as a water holding area to ensure an adequate supply of water for the mills. In 1845, the Proprietors bought outlets to several bays and lakes in New Hampshire to further ensure sufficient water to power the mills.

As the mills grew, so too did the city. In 1826, the site of the mills in East Chelmsford became the town of Lowell. Ten years later, Lowell was given a city charter and in three short years, it was the third largest city in Massachusetts. This rapid population growth was driven by the arrival of mill workers. Initially, most mill workers were single, young females from the Merrimack Valley who lived in boarding houses owned by the mills. However, immigration soon changed the demographics of mill workers.

A massive influx of immigrants, from Ireland and other parts of Europe, took place in the 1840s. By 1850, the population of Lowell was 33,000. According to the 1915 state census, one-third of Merrimack Valley residents were foreign born (Hudon 2004). These immigrants remained the major source of labor until the 1920s (Forrant and Strobel 2011). Fewer immigrants made their way to Lowell between the mid-1920s and mid-1960s due to changes in immigration laws and the closing of mills. It was at the end of this period of decline, amid a 13% unemployment rate and a surplus of abandoned, deteriorating infrastructure, that an interest in revitalizing the city first took hold.

In 1974, the Department of Natural Resources (DNR) developed a nine million dollar proposal for Lowell Heritage State Park, the first of its kind in the state system. The following year, the Department of Environmental Management (DEM), a successor to the DNR, announced the completion of a Memorandum of Understanding with the City of Lowell and an accelerated development schedule for two "nodes" within the park: Francis Gate and Pawtucket Boulevard. A few years later, in 1978, President Carter signed legislation dedicating $40 million to the creation of Lowell National Historical Park, which spurred a unique preservation partnership between local, state and federal governments, and later, the private sector.

By the mid-1980s, the DEM had exceeded its original acquisition, conservation and development goals for the park. It also created an ambitious and successful year-round interpretive program, including a living history component, which was fully integrated with the efforts of the National Park Service. At its peak in 1987, Lowell Heritage State

Park employed 16 full-time and 17 seasonal staff, and had an annual operating budget of $480,000.

Over the next five years, the DEM's budget was greatly reduced and the agency was forced to cut personnel and park budgets. Lowell Heritage State Park presented a particular challenge, since it served as the model for the heritage park concept, and was the largest and most complex heritage park in the state system. At the request of then Commissioner Peter Webber, an intradivisional task force was convened to review the status of the park and develop recommendations for its future. The task force's report concluded that the DEM should "concentrate on maximizing the riverfront component and minimizing, but not eliminating, [its] position in the downtown" (DEM 1993, ES).

Today, the Department of Conservation and Recreation (DCR), successor to the DEM, retains an ownership interest in most of the land that once comprised Lowell Heritage State Park. However, under even greater budget constraints, the DCR continues to focus its resources on the riverfront portion of the park and uses legal agreements with its original partners, the City of Lowell and National Park Service, to operate and maintain facilities park-wide.

4.3. Existing Conditions

In this section and the following, 4.4. Management Resources and Practices, the park's resources are presented in order, from west to east. In other words, under each heading (e.g., Natural Resources), resources related to the Vandenberg esplanade are presented first, followed by resources related to the downtown portion of the park. The descriptions of the downtown resources are further organized by the flow of water. In general, resources related to the Pawtucket and Northern canals are present first, followed by resources related to the remaining canals, in the same order as the water flows through the system today.

Natural Resources

Physical Features

Topography. The Merrimack and Concord rivers are the defining features of Lowell Heritage State Park (see Figure 3). The Merrimack River flows easterly through the northern portion of Lowell, dropping approximately 60 feet in its eight-mile course through the city. The Concord River flows northerly through the eastern half of the city and enters the Merrimack near Bridge Street. In general, the Concord River is fairly level and its floodplain is mostly broad. However, within the city, the Concord River drops rapidly, due to three sets of falls, and has a relatively narrow floodplain.

Geology. The City of Lowell is located within the northern portion of the Nashoba terrane, a rock formation that consists of interlayered gneisses and schists. The Clinton-Newbury fault zone forms the northern boundary of the Nashoba terrane and is believed to have played a role in changing the course of the Merrimack River at the western limits of the city. The river originally flowed southeast through Woburn and into Boston Harbor. The buried bedrock valley from this original course provides valuable resources for the region. For example, wells that supply Lowell, Winchester and Woburn with abundant groundwater are situated along the former course of the river. In addition, glacial outwash deposits within the buried valley are mined for concrete aggregate and other building purposes.

Soils. Soils within Lowell Heritage State Park vary based on the topography and level of development near the Merrimack River. Very poorly to excessively drained silt and sandy loams are associated with the wide floodplain and limited development between the river and Varnum Avenue. These soils are considered severely limited for playgrounds and moderately limited for picnic areas, paths and trails (Peragallo 2009). Well to excessively drained glacial deposits, most of which have been disturbed by heavy development, dominate the remaining portion of the park. These soils range from being moderately to slightly limited for picnic areas, playgrounds, paths and trails (Peragallo 2009).

Table 4.1. Soils of Lowell Heritage State Park[a]

Soil Series	% of Park	Drainage Class
Udorthents	17.1	N/A
Urban land	16.1	N/A
Suncook loamy sand	12.8	Excessively drained
Merrimac-Urban land complex	10.8	Somewhat excessively drained
Occum very fine sandy loam	9.9	Well drained
Limerick silt loam	8.5	Poorly drained
Water	7.0	N/A
Winooski very fine sandy loam	7.8	Moderately well drained
Scio very fine sandy loam	3.6	Moderately well drained
Birdsall mucky silt loam	3.5	Very poorly drained
Windsor loamy sand	1.7	Excessively drained
Scio-Urban land complex	0.8	Moderately well drained
Canton-Charlton-Urban land complex	0.3	Well drained

a. Excluding the Lord swimming pool and Janas skating rink.

Water Resources

Ponds. There are no ponds within the park.

Wetlands. There are approximately 11 acres of wetlands along the Vandenberg esplanade, immediately upstream of the Rourke Bridge and north of regatta field. In addition, there is a small (0.5 acres) wetland in between the Janas skating rink and Douglas Road. (See Figure 3.)

Vernal Pools. There are no certified or potential vernal pools within the park.

Streams. There are three named streams or rivers within Lowell Heritage State Park (see Figure 3). Claypit Brook, the smallest of the water bodies, originates in Lowell-Dracut-Tyngsborough State Forest. The stream flows south from the forest towards Varnum Avenue in Lowell, where it turns east and runs near regatta field before entering the Merrimack River.

The next water body is the heart of the park and the city. Once considered one of the most polluted rivers in the country, the Merrimack River's water quality has improved greatly in the last 40 years. However, it is still considered "impaired" by the United States Environmental Protection Agency (EPA), due to a variety of chemical and biological contaminants that are routinely detected in present day water quality assessments.

Table 4.2. Causes of Impairment for Select Segments of the Merrimack River, Reporting Year 2012

Segment Location	Cause of Impairment
NH/MA State Line to Pawtucket Dam, Lowell	Fecal coliform, mercury in fish tissue
Pawtucket Dam, Lowell to Duck Island, Lowell	E. Coli, mercury in fish tissue, total phosphorus
Duck Island, Lowell to Essex Dam, Lawrence	E. Coli, mercury and PCBs in fish tissue, total phosphorus

Source: EPA 2014

The remaining water body, located on the easternmost side of the park, is the Concord River. It originates at the confluence of the Sudbury and Assabet rivers and flows north, approximately 16 miles, through Concord, Carlisle, Bedford and Billerica before entering the Merrimack River in Lowell. The EPA also considers a portion of the Concord River in Lowell, from the Rogers Street Bridge to the Merrimack River, to be "impaired." The causes of impairment are: excess algal growth, fecal coliform, mercury in fish tissue and total phosphorus (EPA 2014).

Groundwater. A portion of two medium-yield aquifers and one high-yield aquifer occur beneath two sections of the park (see Figure 3). Near the Rourke brothers boat ramp, approximately 16 acres of the park overlap with both a high- and medium-yield aquifer that follows Stony Brook and Black Brook south, past Route 3 in Chelmsford. Further east, at the bend in the Merrimack River, between Pawtucket Falls and Aiken Street, a medium-yield aquifer extends south from Pleasant Street, along Beaver Brook, to the northern shoreline of the river. Approximately two acres of the park overlap with this aquifer.

Flood Zones. The 100-year flood zone covers 64 acres (73%) of the park; its boundary approximately parallels the Merrimack River and each of the canals, where the DCR has an ownership interest. All of the developed areas along the Vandenberg esplanade are included in the 100-year flood zone. In addition, many of the historic buildings within downtown Lowell are included in the 100-year flood zone. However, it should be noted that water levels

Placeholder for Figure 3 (front).

Placeholder for Figure 3 (back).

within the canal system are regulated to reduce the likelihood of flooding in this portion of the park.

The 500-year flood zone covers an additional nine acres (10%) of the park, including the majority of the Rynne bathhouse and its parking area. In downtown Lowell, the Gatekeeper's Barn is the only historic building included in the 500-year flood zone. Further east, the 500-year flood zone also extends across the Janas skating rink parcel, impacting approximately 22% of the property (one acre), but not the skating rink itself.

Rare Species

Lowell Heritage State Park is home to three state-listed species.

Table 4.3. State-listed Species of Lowell Heritage State Park, as identified by the Natural Heritage & Endangered Species Program (NHESP)

Species	Type	MESA[a]
Bald eagle	Bird	T
Cobra clubtail	Insect	SC
Umber shadowdragon	Insect	SC

Source: Harper 2013

a. Status of species listed under the Massachusetts Endangered Species Act (MESA): SC = Special Concern and T = Threatened.

While occasionally spotted over the park, bald eagles are more common near the mouth of the Merrimack River, where there is more suitable nesting and wintering habitat (NHESP 2012). The cobra clubtail and umber shadowdragon can also be found in the park, on occasion, primarily along the Merrimack River. Both species of dragonflies prefer large, unvegetated rivers and lakes for breeding, and the surrounding upland borders for feeding, resting and maturing (NHESP 2008*a* and NHESP 2008*b*).

Nearly half of Lowell Heritage State Park (42 riverfront acres) has been designated as Priority Habitat under the Massachusetts Endangered Species Act (321 CMR 10.00; see Appendix F). Most of this same area (39 riverfront acres) has also been identified as Core Habitat in the MassWildlife and The Nature Conservancy publication "BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World" (MassWildlife and TNC 2010).

BioMap2 highlights two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is "important to conserve the full suite of biodiversity" in Massachusetts (MassWildlife and TNC 2010).

Within the park, there are also 35 acres (40%) of Critical Natural Landscape adjacent to the Merrimack River.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified three forest sub-types along the Vandenberg esplanade.

Table 4.4. Forest Sub-types of Lowell Heritage State Park[a]

Forest Sub-type	Acres	% of Park
Oak-hardwoods	3.3	3.8
Mixed oak	3.2	3.7
Scots pine plantation	2.7	3.1
Total	*9.2*[b]	*10.6*

a. Excluding the Lord swimming pool and Janas skating rink.

b. Only the park's riverfront acres were included in the analysis. Of those acres, wetlands, areas of open water and day use and administrative areas were removed from the total.

There is also one Continuous Forest Inventory (CFI) plot within the park. The CFI is a network of permanent, one-fifth-acre plots on state forest lands that are routinely monitored for sivicultural purposes. The measurements and observations made within each CFI plot are recorded in a database that dates back to 1960, when the CFI was created. Approximately 10% of the state's CFI plots are inventoried each year, on an on-going basis. As of 2010, there were 1,768 CFI plots statewide (Goodwin 2014).

Unfortunately, the plot within Lowell Heritage State Park is located within a grassy area of the Vandenberg esplanade, so it does not provide any additional information about the health of the park's limited forest.

Priority Natural Communities. There are no Priority Natural Communities within the park.

Invasive Species. Japanese knotweed (*Fallopia japonica*) was observed along the western half of the Vandenberg esplanade, between the river and the retaining wall, while conducting fieldwork for this plan.

Pests and Disease. None has been identified at the park.

Wildlife

Birds. There is little current information on the park's birds. Five species confirmed to occur within the park are identified in Appendix G. Of these species, one is classified as a Species in Greatest Need of Conservation (MassWildlife 2006).

Mammals. There is little current information on the park's mammals. Fourteen species that may possibly occur within the park are identified in Appendix G.

Reptiles. There is little current information on the park's reptiles. One species confirmed to occur within the park and an additional four species that may possibly occur within the park are identified in Appendix G.

Amphibians. There is little current information on the park's amphibians. Five species confirmed to occur within the park and an additional three species that may possibly occur within the park are identified in Appendix G.

Fish. The Massachusetts Office of Fishing & Boating Access lists largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), northern pike (*Esox lucius*), white perch (*Morone americana*), chain pickerel (*Esox niger*), black crappie (*Pomoxis nigromaculatus*) and walleye (*Sander vitreus*) as fish species that are typically caught in the Merrimack River (OFBA 2014).

In addition, the Department of Public Health lists American eel (*Anguilla rostrata*) and white sucker (*Catostomus commersonii*) as part of the public health fish consumption advisories for the Merrimack River and canal system (DPH 2014). (See Recreation Resources, below, for more information about the advisories.)

Finally, the United States Fish & Wildlife Service, through its Central New England Fishery Resources Office, monitors migratory fish populations in the Merrimack River. Fish passage data for the Pawtucket Dam indicate American shad (*Alosa sapidissima*), blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*) and sea lamprey (*Petromyzon marinus*) also occur in the park (USFWS 2014).

Cultural Resources

Pre-Contact Archaeological Site

Although only three pre-Contact sites are recorded in the park, many more exist along the Merrimack River both downstream and up. Many Archaic Period village sites, camp sites and fishing grounds are documented nearby along the banks of the river. Archaeological testing along the river clearly revealed it has been reconfigured and straightened. Above Pawtucket Dam, which was constructed at the naturally occurring Pawtucket Falls, the shoreline had to be raised and straightened and Pawtucket Boulevard was constructed on the fill afterwards. Despite land modification and filling, there is a moderate potential for the complex.

Historic Archaeological Resources

The Tremont Mills powerhouse, formerly located in Tremont Yard, on the Western Canal where it meets Father Morissette Boulevard, was partially demolished when it became a part of Lowell Heritage State Park. The single-story ruin was in a state of serious deterioration when it was completely demolished in 2008, as part of a lease for redevelopment (see Infrastructure, below, for more information). The stipulations for redevelopment included preserving the historically significant below grade features, such as the original turbine pits dating from 1847-1854. It was within this powerhouse that James B. Francis, chief engineer for the Proprietors of Locks and Canals on the Merrimack River, conducted experiments that allowed for the development of a more powerful and efficient turbine technology. The original turbine pits are viewable within the office building that is now located on the site and interpretive information is provided.

Historic Resources

This section provides information on Lowell Heritage State Park's historic buildings, structures, objects and landscapes (see Figure 3). See Infrastructure, below, for information on the park's non-historic buildings and structures.

Designations

With the exception of the Rynne bathhouse, all of the resources within Lowell Heritage State Park fall within the Downtown Lowell Local Historic District. This district, initially established on December 13, 1983, and later expanded in 1986 and 2004, "…seeks to ensure that development activities within the district are consistent with the preservation of its 19th century setting" (City of Lowell 2014). More protective than a National Register of Historic Places designation, the local historic district requires review of alterations to any exterior feature by the Lowell Historic Board for compliance with the design review standards and policies that have been established for this district. The DCR has a seat on the Lowell Historic Board.

There are also three National Register Districts, with some overlaps, and a National Historic Landmark designation that apply to the DCR properties within Lowell Heritage State Park:

- The City Hall District, of which only the Mack building is a part, was listed on the National Register on April 21, 1975.
- The Locks and Canals Historic District was listed on the National Register on August 13, 1976 and became a National Historic Landmark on December 22, 1977. With the exception of the Rynne bathhouse, all of Lowell Heritage State Park falls within this district.
- The Lowell National Historical Park and Preservation District was listed on the National Register on June 5, 1978. This much larger district includes all of Lowell Heritage State Park.

The Lowell Canal System has also been recognized for its significance within the field of engineering. The American Society of Civil Engineers designated the "Lowell Waterpower System" as a Historic Civil Engineering Landmark in 1984, and the American Society of Mechanical Engineers (ASME) designated the "Lowell Power Canal System and Pawtucket Gatehouse" as a Historic Mechanical Engineering Landmark in 1985 (Reese 2014; ASME 2014).

Buildings

The ***Michael Rynne Bathhouse*** is the lone historic building on the Vandenberg esplanade. Located at 160 Pawtucket Boulevard, the building was constructed sometime between 1906 and 1924. It is named for Mike Rynne, a former Lowell police officer and highly regarded athlete that excelled in swimming. The bathhouse is a brick building with a flat roofed, square central core, flanked by two gable roofed wings, each three bays in length. Architectural details include brick piers on the wings, round headed door and window openings in the central core and a small, low parapet on the center of the street façade of the building. The wings of the building have wood trim, an asphalt shingle roof and the upper portion of the gable ends are sheathed in unpainted clapboard. Some of the former openings have been filled in with brick and some of the wood trim is exhibiting signs of deterioration or missing. Water damage to the roof framing is also evident on the interior of the building.

The bathhouse is open year-round. The central core contains public restrooms and each wing is used for office and storage space. DCR staff use one wing and the City of Lowell uses the other for their seasonal lifeguards and waterfront equipment (see Recreation Resources, below, for more information). The building has electricity, a phone line, domestic water and waste water disposal; it is in fair condition.

Rynne Bathhouse (DCR)

The majority of the park's historic buildings are located in downtown Lowell and associated with the city's canal system (see Figure 3). The National Park Service maintains these resources as part of an expired Memorandum of Understanding with the Department of Environmental Management, Boott Hydropower, Inc. and the Proprietors of Locks and Canals on the Merrimack River (see Section 4.4. Management Resources and Practices for more information). The Gatekeeper's House and barn are excluded from this arrangement, as the buildings are

part of the DCR's Historic Curatorship Program. The Mack building is also excluded because it is not directly associated with the canal system.

The ***Pawtucket Gatehouse***, located at the eastern edge of the Pawtucket Dam and the head of the Northern Canal, was constructed in 1847. The gatehouse contains the machinery designed by James B. Francis to operate 10 sluice gates via a turbine and hoisting screws. Constructed of brick, on top of the granite dam, and extending 11 bays long, the Italianate style gatehouse has a gabled slate roof. Architectural details include denticulated cornices, pediment returns, round headed door openings and recessed, round headed, six-over-six double-hung sash windows. Twin end interior chimneys complete the picture. One corner of the building is rounded, a detail that is seemingly part of the original design, but the purpose is unclear. A navigational lock, not used since 1871, is located next to the gates. One end wall of the gatehouse has experienced some cracking, but it is otherwise in good condition. The building has electricity.

Pawtucket Gatehouse (DCR)

Next to the Pawtucket Gatehouse, at 23 School Street, is the ***Gatekeeper's House***, historically home to the operator of the Pawtucket Gate. The Gatekeeper's House is a two-story, side gabled, wood frame house built in 1847, in the Italianate style. It is three bays wide by two bays deep, with a hipped roof section at the rear and a one-story kitchen ell. The projecting center entrance with enclosed pediment is an addition made sometime before 1890, and the front façade windows have round arched trim. The house is clad in wooden clapboards, has a stone foundation, asphalt shingled roof, two interior brick chimneys and wood cornerboards with a boxed cornice. The building has electricity, a phone line, domestic water and waste water disposal; it is in good condition.

Gatekeeper's House (DCR)

Behind, and perpendicular to, the Gatekeeper's House is the ***Gatekeeper's Barn***. Constructed in three separate phases (dates unknown), the barn has two gable roofed sections with a smaller, shed roofed component. Clad in a combination of clapboards and vertical board sheathing, the barn has an asphalt shingle roof and is in good condition. The building also has electricity. The oldest section of the barn, located in the center, is set up as a one car garage. Due to the slope of the surrounding land, the rear façade of the building is a full story higher than the front, which provides storage space below the garage.

Gatekeeper's Barn (DCR)

The gatekeeper's property was acquired by the DCR in 1977 and housed a staff interpreter until 1986. After being vacant for 15 years, it was included in the DCR's Historic Curatorship Program and leased by curators from 2001 through 2011. The house and barn are once again vacant and available for curatorship; proposals are currently being solicited.

Located beyond the Gatekeeper's Barn is the ***Blacksmith Shop***. Primarily utilized by the Proprietors of Locks and Canals on the Merrimack River as a boathouse and blacksmith shop, to fix and

maintain flashboard hardware, this building was brought or built on site in 1884. Clad in vertical board sheathing and clapboards, the Blacksmith Shop has a hipped roof covered with asphalt shingles and a brick chimney that pierces the roof line. A large exterior sliding door provides access. The building has electricity and is in excellent condition.

Blacksmith Shop (DCR)

Francis Gate Park is located on the Pawtucket Canal near Broadway Street and includes a series of resources associated with the Guard Locks. The first navigational lock was built in 1796-1798, with the development of the canal. This lock was subsequently rebuilt and several other features were added to the site over the course of the 19th century, including a dam, power canal, second navigational lock and flood gate. A manmade island separates the dam and sluice gates from the navigational locks and flood gate.

The oldest extant resource within Francis Gate Park is the ***Great Gate***, also known as the Francis Gate or Francis' Folly. Constructed in 1848-1850, this Portcullis gate was designed by James B. Francis for flood control purposes. The gate itself is made of wood, constructed of 17-inch-wide southern pine timbers that are held together with vertical iron rods; it is in excellent condition. The gate protected the city from serious flood damage in 1852, and again in 1936. The Great Gate is sheltered by the ***Guard Locks Great Gate Gatehouse***; a tall, narrow, wood frame building sheathed in clapboard with a cedar shingle roof. Buttresses support the building, tying it to the granite abutments. The gatehouse has electrical service, and is also in excellent condition.

Great Gate and Gatehouse (DCR)

The ***Guard Locks Gatehouse*** contains the hydraulic machinery for operating the sluice gates located at the dam, in the easternmost section of Francis Gate Park. Constructed in 1870, predominantly of brick with a single wood frame wall, this one-story building has a full height basement level on the upstream side of the dam. The gatehouse is sheathed in brick and clapboard, and has a slate roof. Italianate details include denticulated cornices; pediment returns; round headed, recessed, four-over-four, double-hung sash windows; and round headed door openings. Twin end interior chimneys complete the picture. The gatehouse has electricity, and it is in excellent condition.

Guard Locks Gatehouse (DCR)

The ***Guard Locks Lock House*** is located just north of the Guard Locks Great Gate Gatehouse, where it shelters the equipment that mechanically assists with opening the gates of the lock. Constructed in 1881, this single-story, seven-bay-long building is sheathed in clapboard and has a two stage hipped roof sheathed with slate; it is in excellent condition. Italianate architectural details include round headed,

four-over-four, double-hung sash windows; round headed door openings; projecting wooden lintels; and paneled trim along the lower portion of the building, where some of the projecting lock mechanisms are accommodated. The lock house also has electricity.

Guard Locks Gatehouse, left, and Guard Locks Lock House, right (DCR)

The ***Hadley House***, located at 719 Broadway Street, was originally located in Middlesex Village. In 1990, the Federal style home was moved from 1708 Middlesex Street by the Jaycees of Lowell in an effort to save it from demolition and restore it, possibly for housing. The building has been vacant since the move and is presumably owned by the Jaycees, who may now be incorporated as the Lowell Jaycees Housing Corporation, Jaycee-Lowell Limited Partnership, or Jaycee-Lowell, LLC. There is no Memorandum of Agreement, or similar document, between the Jaycees and the DCR that describe the terms under which the Hadley House was moved to, and remains at, Francis Gate Park.

Hadley House (DCR)

The ***Northern Canal Wasteway Gatehouse*** was constructed in 1872, when the waste gates that are part of the Northern Canal Great Wall dam were modified to be mechanically operated by a turbine. It is the only gatehouse without electricity. Accessed by a walkway, the building sits on top of the Great River Wall and was built to shelter the mechanical equipment. The gatehouse is a rectangular, two-story timber frame building with a very low pitched shed roof. Four window bays are located on the river side of the building. The gatehouse is sheathed in clapboard and has a membrane roof; it is in excellent condition.

Northern Canal Wasteway Gatehouse (DCR)

The ***Tremont Gatehouse*** is located at the intersection of the Northern and Western canals; it controls the flow of water from the Northern Canal into the lower Western Canal by a pair of offset sluice gates. These gates are operated electrically, but the manual operation equipment is still located in the building. Constructed c1855, this gatehouse is in excellent condition, reflecting maintenance work that was done to remove the extensive ivy growth that covered the building in the 1970s.

This single story, gable roofed gatehouse has a granite foundation, walls constructed of brick and a slate roof. Italianate details include denticulated cornices; pediment returns; round headed, recessed, six-over-four, double-hung sash windows; and round headed doors. Twin end interior chimneys complete the picture. One corner of the building has an unusual taper, where the corner itself has been removed in what appears to be a modification of the original design.

Tremont Gatehouse (DCR)

The ***Swamp Locks Gatehouse*** was first constructed on the crest of the Swamp Locks dam and south sluice gate in 1859, to provide some shelter and protection for the dam. The gatehouse, a wood framed, single-story, interlocking gable roofed structure, has walls sheathed in a combination of clapboard and vertical boards, and an asphalt shingle roof. The wood windows are six-over-six, double-hung sash. The gatehouse has electricity.

Four different sections currently connect across the length of the dam. The longest section, located above the flashboard crest of the dam, is present in a historic photo from 1922, but was removed years later, as it is not present in DCR file photos from 1979. This section was reconstructed sometime after 1994, as it was not present when the National Park Service documented the site in the List of Classified Structures at that time. The gatehouse is in excellent condition.

Swamp Locks Gatehouse (DCR)

The ***Hamilton Wasteway Gatehouse***, located at the head of the Hamilton Wasteway, was constructed in 1872 when the wasteway itself was rebuilt, replacing an earlier gatehouse and wasteway dating from 1850. The purpose of the wasteway was to remove ice from the Hamilton Canal and divert it into the Pawtucket Canal. The gatehouse was manually operated until an electric motor drive was installed in the early 20th century. The small, single-story hipped roof building has rolled asphalt roofing and is clad with metal panels that have been pressed to resemble brick. The three windows that overlook the visible portion of the wasteway have four-over-four, double-hung sash windows; the remaining openings are boarded up. Vegetation is encroaching on the building, some of the cladding has been peeled away and a few pieces of the simple wood trim are missing. Unlike the other gatehouses in the park, this building is in very poor condition and lacks interpretive information.

Hamilton Wasteway Gatehouse (DCR)

Two buildings have been in place at the Lower Locks Dam since the mid-19th century; they provide shelter for the dam and house some of its mechanical components. The ***Lower Locks Gatehouse***, a one-by-one-bay building clad in clapboards with a cedar shingle roof, is located at the edge of the dam, at the upstream entry to the lock. An enclosed pediment on the gable end and a diamond pane, double-hung, sash window adorn the building.

A larger, single-story, wood framed, gabled roof building is located on top of the dam. A cross gabled component of this building, known as the ***Watch House***, shields the deep gate control housing. A gabled cupola sits atop the Watch House. The walls of this building are clad with vertical board siding, the windows are fixed 12-light windows and the roof is sheathed with cedar shingles.

Both of these buildings have electricity and are in excellent condition.


Lower Locks Gatehouse and Watch House (DCR)

The ***Massachusetts Wasteway Gatehouse*** is located at the turn in the Eastern Canal and sits slightly below Bridge Street. Built in 1862, in conjunction with the wasteway, the gatehouse protects the flashboard controls that direct water through the wasteway. The wasteway connects the Eastern Canal to the Merrimack River and assisted with ice removal in the canal.

The gatehouse is a single-story, five-by-one-bay building with a gabled roof and an inaccessible center entrance that faces the canal. Clad in clapboards, the roof is sheathed with cedar shingles and the windows are four-over-four, double-hung sash with hood moldings. The roof of the building has changed over time. Photographs from 1979 show a flat roof with a slight pitch, possibly a modification of an original gabled roof that was then rebuilt sometime between 1979 and 1994 to reflect its presumably historic appearance. The gatehouse has electricity and is in excellent condition.


Massachusetts Wasteway Gatehouse (DCR)

The ***Boott Dam Gatehouse***, built above the Boott Dam in 1892 as part of a rebuilding effort, provides shelter for the dam and houses hydraulic equipment to lift the sluice gate, which controls the level of water in the Eastern Canal. The gatehouse, which has electricity, is composed of two single-story, gable roofed sections that are situated at a slight angle to each other, probably to accommodate the infrastructure below. One section, attached to the sidewall of the Boott Mills, is slightly wider and taller than the other section. The building is clad in corrugated metal sheathing and it has a rolled asphalt roof. The only architectural detailing includes a plain vergeboard made of corrugated metal. A set of seven, six-over-six, vinyl windows stretch across the side of the building facing the canal. A brick chimney extends from the center of the building. Boston ivy has started to drape itself over part of the roof of the smaller section. The building is otherwise in good condition.


Boott Dam Gatehouse (DCR)

The ***W.A. Mack & Company Building***, located at 25 Shattuck Street, is the current home of the National Streetcar Museum (first and second floors) and DCR's North Region Headquarters (third and fourth floors). The museum utilizes space within the building through an expired Memorandum of Understanding with the DCR (see Section 4.4. Management Resources and Practices for more information).

The Mack building was constructed in 1886 by Sewall Mack for the W. A. Mack & Company on land they originally leased, and later purchased, from the Proprietors of Locks and Canals on the Merrimack River. The Queen Anne style brick building, with a cast iron storefront, served as the retail arm for their ironworks. Originally a three-story building, with decorative panel brick details on the second and third floors, a fourth story was added sometime between 1890 and 1905. Four-over-two, double-hung sash windows are located in the upper stories of the façade; all 38 of the building's double-hung windows are scheduled to be replaced in the fall of 2014 (see Section 2 for more information).

A full height brick and glass, stair and elevator tower was added to the north side of the building in 1979, when it was being renovated to serve as the visitor center for Lowell Heritage State Park. The building has electricity, telephone and internet service, domestic water and waste water disposal; it is in good condition.

The Mack building, prior to the window replacement project. (DCR)

Structures

The ***Lowell Canal System*** evolved steadily from 1821, when the old Pawtucket transportation canal was purchased and, a few years later, used to channel water into a series of new power canals. These virtually unaltered waterways, together with the remaining mills and their machinery, form what is "the most historically significant extant aggregation of early 19th century industrial structures and artifacts in the United States" (NPS 2014*b*).

Table 4.5. Power Canals within Lowell Heritage State Park[a]

Name	Date(s) of Construction
Merrimack Canal	1821-1823
Hamilton Canal	1825-1826
Lowell Canal[b]	1828
Western Canal	1831-1832
Lawrence Canal[c]	1831-1832
Eastern Canal	1835
Northern Canal	1846-1847

a. See Infrastructure, below, for more information on the DCR's ownership interest in the power canals.
b. The Lowell Canal was covered in 1880 (NPS 2014*b*).
c. Most of the Lawrence Canal is covered; sections of the canal have also been filled in (Herlihy 2014).

Each canal is unique, from the Pawtucket Canal, which follows the features of the surrounding landscape, to the Northern Canal, which is the deepest and widest canal, and perfectly straight. The canals are generally eight to 20 feet deep and 30 to 100 feet wide (NPS 2014*b*). The canal walls are constructed of natural materials, ranging from earth to granite, and the canal bottoms are mostly wood (Lowell Canalwaters Cleaners 2014). The canals are generally in good condition, however some vegetative growth and localized deterioration was observed in the canal walls while conducting fieldwork for this plan.

Table 4.6. Dams within Lowell Heritage State Park, by the DCR's Ownership Interest[a]

Dam	Class[b]	Last Inspection[c]	Condition	DCR Interest
Northern Canal Great Wall	S	6/18/2012	Satisfactory	Fee and Ease
Guard Locks	S	6/18/2012	Satisfactory	Ease
Swamp Locks	S	6/18/2012	Fair	Ease
Lower Locks	L	6/1/2006	Satisfactory	Ease
Boott[d]	N/A	N/A	N/A	Ease
Rolling[d]	N/A	N/A	N/A	Ease

a. See Infrastructure, below, for more information on the DCR's ownership interest in the dams. In this table, ownership is summarized as: Fee = fee interest; Ease = easement interest.
b. Hazard Class: Low (L) = the dam is located where failure may cause minimal property damage to others and the loss of life is not expected; Significant (S) = the dam is located where a failure may cause the loss of life and damage to homes, industrial or commercial facilities, secondary highways or railroads, or cause interruption of use or service of relatively important facilities (MassGIS 2012).
c. Low hazard potential dams are inspected every 10 years; significant hazard potential dams are inspected every 5 years.
d. The DCR's Office of Dam Safety defines the Boott and Rolling dams as canal gates, which are not classified or inspected.

Northern Canal Great Wall Dam. The Northern Canal Great Wall Dam (MA-00833), also known as the Great River Wall, is an approximately 2,000-foot-long earthen island and stone wall that runs along the south side of the Merrimack River, near Pawtucket Falls. The DCR holds a fee interest in approximately 1,000 feet of the upstream portion of the dam, which consists of a naturally deposited earthen and bedrock island, as well as some man placed earth. Downstream of the island, the dam transitions into a cut granite stone wall for a length of about 1,000 feet; the DCR holds an easement interest in this portion of the structure.

The dam was constructed in 1846-1847 to provide additional water power to downstream mills and the canal system in Lowell. Today, it continues to supply water to the canals, as well as a hydroelectric power plant owned by Boott Hydropower, Inc. Sudden gate closures at the power plant can cause the water in the Northern Canal to rise rapidly and overtop the Great River Wall. Due to this threat, the walkway along the wall and island is generally closed to the public; however the National Park Service does offer periodic guided tours along the walkway.

The most recent inspection of the dam determined that the structure was in good condition, identifying excessive vegetation on the great wall and island, and voids in between the cut granite stones along the crest of the great wall. An estimated $204,000 in additional analysis, maintenance and repairs is needed to correct these issues (Haley & Aldrich, Inc. 2012*a*).

Guard Locks Dam. The Guard Locks Dam (MA-00834) includes a lock, earthen embankment, gatehouse and spillway with hydroelectric power mechanisms. The dam and lock system was constructed in 1848 to regulate water levels in the Pawtucket Canal for mills in the center of Lowell. Today, the locks are used by the National Park Service for tourism and the dam is used to regulate water levels in the canal for hydroelectric power and flood control purposes.

While the dam is in good condition, the following issues were identified during a recent inspection of the structure: vegetation in the walls and downstream earthen embankment, debris in the spillway area, and voids in between the granite stones. The total estimated repair cost for the Guard Locks dam is $120,000 (Haley & Aldrich, Inc. 2012*b*).

Swamp Locks Dam. The Swamp Locks Dam (MA-00836) was originally constructed as part of the development of the Pawtucket Canal in the 1790s. The 1822-1823 reconstruction of the Pawtucket Canal reworked the lock system from a navigational system to a power system, creating a two-tiered power canal network and placing the Swamp Locks Dam centrally within this system. This configuration was retained through several subsequent rebuilding efforts. Many of the existing components of the dam (e.g. the lock, gates, spillway and weirs) date back to those reconstruction periods in 1839-1841, 1859, 1892, 1928, 1942 and 1946. The original purpose of the dam was to regulate the flow of water as a power source for downstream mills. Today the structure is used to impound water for boat tours of the canal system and flood control purposes.

The most recent inspection of the dam identified areas of broken and missing concrete, vegetation in the stone block walls, leakage and wear on the broad crested weir and gatehouse structure. An estimated $665,000 in additional analysis, maintenance and repairs is needed to correct these issues (Haley & Aldrich, Inc. 2012*c*).

Lower Locks Dam. The Lower Locks Dam (MA-00835) was constructed in the late 18th century as part of the Pawtucket transportation canal, which allowed boat access around Pawtucket Falls. It was rebuilt in 1822-1823 and consists of two gatehouses, a primary spillway, low level outlet (deep gate), two-bay lock chamber, canal drain pipe and valve, and a culvert system that drains excess flow from the adjacent Eastern Canal into the discharge channel downstream of the dam. Today, the dam is primarily used for flood control purposes.

During a 2006 inspection of the dam, vegetation and debris were identified as minor deficiencies. The canal drain valve control platform upstream of the dam was also noted as being potentially unstable. An estimated $27,000 to $42,000 in additional analysis, maintenance and repairs was needed to correct these deficiencies (Weston & Sampson 2006).

Since the inspection, the vegetation on the spillway has been removed and the canal drain valve control platform has been stabilized with guy wires; it is

unclear whether this is a temporary or permanent solution.

Objects

Boston & Maine (B&M) Railroad No. 410, a steam locomotive built in 1911 by the American Locomotive Company's Manchester, NH works, is on permanent display at the corner of Merrimack and Dutton streets in downtown Lowell. Engines like No. 410 were used by the B&M Railroad to move freight cars around train yards throughout New England; in Lowell, the engine shuttled cars between textile mills for nearly 40 years.

In 1950, No. 410 was sold to H.E. Fletcher Company, where it was used in a quarry for approximately 30 years before being retired. In 1993, the engine was moved to its current location and is part of the interpretive components of the park. No. 410 is in excellent condition due to over 20 years of restorative work and routine annual maintenance by volunteers (see Section 4.4. Management Resources and Practices for more information). A restored 1907 Pullman Coach, owned by the National Park Service, is on display with No. 410.

Landscapes

The Lowell Canal System and its associated buildings and structures, while discussed individually in this section for inventory and management documentation purposes, collectively form a historic landscape that needs to be considered as a whole. These resources shaped the historic development and growth of the city, and continue to do so today. The canal system defines the character of downtown Lowell, and together with the remaining mills, provides a physical connection to the city's illustrious industrial past.

The parcel known as Tremont Yard, located on the Western Canal between Hall Street and Father Morissette Boulevard, is the site of the former Tremont Mills. Now predominantly paved over for parking, with remnants of the tailraces below it, the only above ground feature remaining is a one-story segment of brick wall with a concrete cap that runs along the north and east edges of the property. This wall, containing arched window openings that have been bricked in, serves as an important landscape feature and a reminder of what was once located on the site. By the late 1990s, the northern section of the wall, adjacent to Hall Street, had become a serious safety hazard, so it was dismantled by hand and partially rebuilt with the salvaged brick. The eastern section of the wall has a significant amount of vegetation growth.

The eastern section of the wall in Tremont Yard. (DCR)

Recreation Resources

Visitors to Lowell Heritage State Park can drive, bike or walk to the various facilities and points of interest within the park. In addition, the Lowell Regional Transit Authority operates buses that circulate through downtown. However, there are only three bus routes (1, 7 and 8) that cross the Merrimack River and provide indirect access to the Vandenberg esplanade. The closest bus stop to the concentration of recreation resources on the western half of the esplanade is located in front of Lowell General Hospital on Varnum Avenue.

There are a variety of active and passive recreational opportunities within Lowell Heritage State Park, including:

- Bicycling
- Boating, motorized and non-motorized
- Events (e.g., concerts, movies)
- Field sports (e.g., soccer, flag football)
- Fishing
- Geocaching
- Interpretive displays and programs
- Nature study
- Pet walking
- Photography
- Picnicking
- Swimming
- Walking/jogging/running

Boating takes place in the Merrimack and Concord rivers and, to a limited extent, in the canal system (see Figure 3). Motorized and non-motorized boats are launched into the Merrimack River from the Rourke brothers boat ramp; there are no fees charged at this facility. Non-motorized boats are also launched into the Merrimack at the Bellegarde boathouse. The Merrimac River Rowing Association (MRRA) and University of Massachusetts Lowell offer a variety of kayaking and rowing programs to the public at the boathouse; some of these programs are free of charge, while others require a fee. On a much larger scale, the MRRA also hosts two regattas, the Festival Regatta and the Textile River Regatta, at the boathouse each year.

Motorized and non-motorized boats can also be found on the Concord River. Every spring, the Lowell Parks & Conservation Trust, in partnership with Zoar Outdoor, offers a unique whitewater rafting opportunity on the Concord River, for a fee. Each trip concludes with passing through the Lower Locks Lock Chambers. Finally, the National Park Service offers motorized boat tours of the entire canal system for a nominal fee. The canal system is not open to the public for boating, aside from these two opportunities.

Fishing takes place in the rivers and canal system too. The Department of Public Health alerts the general public to the possible dangers of eating fish caught in Massachusetts waters through a public health fish consumption advisory. There are several advisories for the Merrimack River and canal system; there are no advisories for the Concord River in Lowell.

Table 4.7. Fish Consumption Advisories for the Merrimack River and Lowell Canals

Water Body	Hazard	Advisory[a]	Fish Species
Merrimack River	Mercury	P1, P3	Largemouth bass, white sucker
Canals[b]	Mercury, lead, PCBs, DDT	P1	All fish
Canals[b]	Mercury, lead, PCBs, DDT	P2, P4	American eel

Source: DPH 2014

a. P1 = Children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant, and nursing mothers should not consume the affected fish species; P2 = The general public should not consume the affected fish species; P3 = The general public should limit consumption of the affected fish species to two meals per month; P4 = The general public should limit consumption of non-affected fish species to two meals per month (DPH 2014).

b. For the canals, the general public is advised to consume only the fillet of non-affected fish species (DPH 2014).

Special events, such as carnivals, and athletic events take place at the Anne Dean Welcome Regatta Field (see Figure 3). The City of Lowell sells permits for the use of the field through an expired Memorandum of Understanding with the DCR (see Section 4.4. Management Resources and Practices for more information). In 2013, the city issued 46 permits; the months of May and September were the most popular for events (Faticanti 2014).

Walks for charity, large cultural events, like the Southeast Asian Water Festival, and DCR-sponsored programming also take place along the Vandenberg esplanade. In a typical year, there is a special event on the esplanade every weekend from April through October. Many of these events are coordinated from the Sampas pavilion; there are fees to use the lawn in front of the stage and the stage itself. Permits for the esplanade are issued by the Forest and Parks Supervisor or the DCR's Office of Special Events, for a fee.

Guarded, freshwater swimming is available at the Rynne beach in July and August, every year, free of charge. The City of Lowell manages the beach through an expired Special Use Permit that was issued by the Department of Environmental Management (see Section 4.4. Management Resources and Practices for more information). During the swimming season, water quality is tested weekly; if poor water quality becomes a problem,

tests are conducted daily until the results indicate improved water quality (Faticanti 2014).

Table 4.8. Water Quality Results for the Rynne Beach, May 2013-August 2013

Sample Date	*E. coli* per 100ml[a]	Days Since Last Rainfall	Amount of Last Rainfall (inches)
5/31/13	30	1	0.6
6/6/13	0	2	0.4
6/12/13	60	1	1.0
6/20/13	50	3	0.3
6/25/13	10	8	0.3
7/2/13	210	1	0.9
7/4/13	150	3	0.9
7/9/13	80	1	0.3
7/15/13	30	6	0.1
7/22/13	110	11	0.1
7/29/13	30	8	0.5
8/6/13	50	5	0.5
8/12/13	100	2	1.0
8/19/13	60	6	0.1

a. Limit = 235 *E. coli* per 100 ml.

The Merrimack River Watershed Council (MRWC) also monitors the river's water quality through its Safe Beaches Project. The closest sampling location to the Rynne beach is upstream, at the Bellegarde boathouse. The MRWC did not sample in 2013, due to a lack of volunteers (O'Mara 2013).

The Lord pool is another location within the park for visitors to enjoy guarded swimming (see Figure 3). The pool is open from June through August, every year; there are no fees charged at the facility. DCR staff are responsible for managing the pool and testing its water quality during the swimming season. In addition, the Department of Public Health (DPH) inspects the pool once each year as part of a Memorandum of Agreement with the DCR (see Section 4.4. Management Resources and Practices for more information). The DPH provides a brief report on the water quality, health and safety, and general sanitation conditions of the pool to DCR staff after the inspection.

Table 4.9. DPH Water Quality Results for the Lord Pool, August 8, 2013

Test	Allowable Result[a]	Test Result[a]
pH	7.2-7.8	7.6
Alkalinity	50-150	70
Calcium Hardness	150-1,000	210
Free Chlorine	1.0-3.0	4.2[b]
Combined Chlorine	0.0-0.2	0.0
Secchi Disk	Clearly visible	Clearly visible

a. Results are reported in parts per million (ppm), except for the pH and Secchi disk tests.
b. Additional testing was conducted 45 minutes later, after corrective actions were taken. The second test result, 3.8ppm, exceeded the allowable range, and the pool was closed until the free chlorine reading was brought into compliance.

The following health and safety, and general sanitation violations were also noted as part of the 2013 DPH inspection:

- The water depth is not marked at or above the water surface on the pool wall.
- A gap in the outside fence of greater than three inches.
- A broken step on the ladder in the deep end.
- An insufficient emergency communication system in the first aid room.
- The log book indicated the pool was not closed with free chlorine reading of 13.8ppm.
- The paint on the pool floor is peeling.
- A portion of the cement deck is raised, creating a tripping hazard.

Many of these violations, such as the broken step ladder, were addressed during the 2013 season and the remaining items, such the raised cement deck, will be addressed as part of the fall 2014 modernization project (see Infrastructure, below for more information).

Visitors to the Lord pool enjoy biking to the property; however there are no bike racks available for storing and securing their bikes. Social gatherings are also popular on the lawn and at the picnic tables that surround the pool. Two mature trees, near the corner of Cross and Fletcher streets, are the only source of shade in this open space.

The National Park Service (NPS) provides most of the interpretive programming within the downtown portion of the park. Visitors can participate in a free ranger-guided walking or trolley tour of the historic sites. A variety of indoor exhibits are open to the

public too, including the NPS's visitor center at Market Mills, the Boott Cotton Mills Museum (fees apply), the Patrick J. Morgan Cultural Center and the Wannalancit Mill. The NPS also co-sponsors one of the largest, free folk festivals in the world; the Lowell Folk Festival is held each summer and over 100,000 people come to Lowell and the park to celebrate traditional music, ethnic foods and crafts (NPS 2014*c*).

Geocaching also occurs in the park. As of March 2014, there were three known geocaches along the Vandenberg esplanade and two known geocaches in the downtown portion of the park.

Infrastructure

Property Boundary

Fee Interest. Lowell Heritage State Park (87 acres) is situated in the northern half of Lowell, adjacent to the Merrimack River and the city's historic power canals. The majority of the parcels that comprise the park are linear in nature, and most were acquired between 1976 and 1986.

By 1980, the Department of Environmental Management (DEM) purchased a fee interest in a portion of the Vandenberg esplanade, from the Rourke Bridge to the intersection of Pawtucket Boulevard and Varnum Avenue; a portion of Francis Gate Park, north of Broadway Street; the gatekeeper's property; Tremont Yard; and the Mack building. Over the next five years, the agency added a few more parcels to the Vandenberg esplanade, near the intersection of Pawtucket Boulevard and Varnum Avenue, and Francis Gate Park, south of Broadway Street.

In 1986, the DEM obtained a fee interest in the park's remaining parcels through a complicated and lengthy Order of Taking, recorded in the Middlesex County Registry of Deeds, Northern District, Book 3830, Page 70. This legal action completed the Vandenberg esplanade, from the intersection of Pawtucket Boulevard and Varnum Avenue to Pawtucket Falls, and further east, along VFW Highway. It also created a network of protected land, in combination with property owned by the National Park Service and City of Lowell, along each of the city's canals. Finally, it established the DEM's ownership interest in 13 buildings associated with the canal system (see below). Only one of these buildings, the Rolling Dam Gatehouse, has been demolished.

1. Pawtucket Gatehouse
2. Blacksmith Shop
3. Guard Locks Great Gate Gatehouse
4. Guard Locks Gatehouse
5. Guard Locks Lock House
6. Northern Canal Wasteway Gatehouse
7. Tremont Gatehouse
8. Swamp Locks Gatehouse
9. Hamilton Wasteway Gatehouse
10. Lower Locks Gatehouse
11. Massachusetts Wasteway Gatehouse
12. Boott Dam Gatehouse
13. Rolling Dam Gatehouse (demolished)

The Janas rink and Lord pool parcels were acquired before the 10-year effort to establish Lowell Heritage State Park. In 1972, the Department of Natural Resources (DNR) purchased the two-acre Lord pool parcel from the City of Lowell; the deed is recorded in the Middlesex County Registry of Deeds, Northern District, Book 2211, Page 558. The following year, the city sold the Janas rink parcel (4.5 acres) to the DNR; the deed is recorded in the Middlesex County Registry of Deeds, Northern District, Book 2091, Page 58.

Other Legal Interests. The DEM also obtained a number of other legal interests through its 1986 Order of Taking (see Middlesex County Registry of Deeds, Northern District, Book 3830, Page 70). These easements and other rights are the most complicated, and confusing, parts of the taking.

With respect to the 13 canal system buildings, the DCR holds a permanent easement in the canal walls and beds or bottoms that support each building, and the associated structures and fixtures. The Proprietors of Locks and Canals on the Merrimack River (the Proprietors), and their successors and assigns, retain the right to access the buildings in order to maintain and operate the gates and canals for hydroelectric power production. In addition, the Proprietors, their successors and assigns reserve an easement for access and the right to use the Blacksmith Shop for maintaining and operating the Pawtucket Dam for hydroelectric power production.

The DCR also holds a permanent easement in the following structures, which are specifically named in the taking:

- Pawtucket Gatehouse Wall and Lock Chamber;
- Guard Locks Lock Chambers;
- Northern Canal Walkway;
- Swamp Locks Dam;
- Swamp Locks Chamber;
- Lower Locks Dam;
- Lower Locks Lock Chambers;
- Boott Dam;
- Rolling Dam; and
- YMCA Gates.

The permanent easement is for the following purposes, provided that the Proprietors, their successors and assigns are able to use, maintain and operate the structures and surrounding property for hydroelectric power production without interference.

- Support of all fixtures or structures of the Commonwealth;
- Preservation and conservation;
- Supplemental maintenance in addition to that performed by the Proprietors, their successors and assigns;
- Landscaping and erection of exhibits and structures;
- Placement of barriers and fences;
- Placement and attachment of docks, wharves, walls and boat ramps of a temporary or permanent nature;
- Placement of lighting and other utilities;
- Operation and maintenance of boat locking chambers, if any, for any and all purposes; and
- Any and all other uses consistent with the operation of the canal system as a park.

In addition to the permanent easements described above, the DCR has an interest in the following:

1. An overarching "…permanent and exclusive easement in all canal walls and beds or bottoms and in all dams and boat lock chambers located in said canals and not otherwise referred to in [the taking]…" (Book 3830, Page 102). This permanent easement is for the same purposes as described immediately above.
2. "All air rights over the canals, including the canal walls and any dams thereon, to the extent not already lawfully obstructed or occupied, for so long as such lawful obstruction or occupation continues uninterrupted in its present form" (Book 3830, Page 103).
3. "The exclusive right to use the water in the entire canal system and the Merrimack River for recreational, educational and navigational purposes, which use shall be nonconsumptive with respect to hydroelectric power generation, except for reasonable amounts to operate locking gates" (Book 3830, Page 103).

In 2001, the Highway Department (MassHighway) granted the DEM possession, care, custody and control of Anne Dean Welcome Regatta Field through a license agreement (see Section 4.4. Management Resources and Practices for more information). The DCR's use of the property is restricted to passive recreation. MassHighway reserved the right to utilize the property, in whole or in part, for highway purposes.

Pocket Parks

The two smaller "pocket parks" within the downtown portion of Lowell Heritage State Park, the Mack plaza and Victorian garden, were designed by Carr, Lynch Associates, Inc. in 1982. The firm received multiple awards for their work, including a:

- Citation for Excellence in Urban Design from the American Institute of Architects (1990);
- Mayoral Proclamation for the Preservation of Lowell's Historic Architecture (1990);
- Citation from the American Society of Landscape Architects (1987); and
- Massachusetts Governor's Design Award (1986).

Mack Plaza. The Mack plaza is located next to the Mack building, on the corner of Shattuck and Market streets. Nineteen linden trees and 20 new benches enhance the brick plaza as a relaxing oasis in an otherwise busy section of the city. (See Section 2 for more information on the bench replacement project.) The fountain component of "The Worker" sculpture, when functioning, adds to the ambiance of the space (see Buildings and Structures, below, for more information).

An approximately three-foot-tall steel rail and granite post fence encloses the plaza along Market Street. For several decades, the condition of the granite posts has been deteriorating. Today, 11 of the 13 posts are badly cracked; several posts are being held in place by a temporary wooden support structure. In 2007, a close inspection of the fence identified the pin mounting system and temperature changes in the steel as the likely causes of cracking (DCR 2007*c*).

A cracked granite post and temporary wooden support structure in the Mack plaza. (DCR)

Mary J. Bacigalupo Victorian Garden. The Victorian garden is also located next to the Mack building, at the intersection of Shattuck and Middle streets. Raised beds dominate the space and support a variety of mature evergreen and deciduous trees, as well as smaller, shade-tolerant perennial and annual plantings. Seven benches situated along the garden's brick pathways offer a welcoming respite from city life. An approximately seven-foot-tall fence, identical to the one in the Mack plaza, surrounds the entire garden. There are 25 granite posts in this fence and 22 are badly cracked. One post that supported the garden's western gates was recently removed for public safety reasons (DCR 2007*c*).

In 2005, the garden was dedicated to Mary Bacigalupo, a Lowell citizen who was instrumental in the beautification of the City of Lowell (see Appendix H). A large granite marker bearing Mary's name is located within the garden (see Memorials and Markers, below, for more information).

Victorian Garden (DCR)

Buildings and Structures

This section provides information on Lowell Heritage State Park's non-historic buildings and structures. See Cultural Resources, above, for information on the park's historic infrastructure.

Rourke Brothers Memorial Boat Ramp. The Rourke brothers boat ramp is located at the western end of the Vandenberg esplanade, upstream of the Rourke Bridge (see Figure 3). The concrete ramp, which is approximately 45 feet wide, leads from an access road and parking area off of Pawtucket Boulevard into the Merrimack River. The ramp was constructed by the Office of Fishing and Boating Access (OFBA) in 2002 and is in good condition (Sheppard 2013). Extensive regulations govern the use of OFBA sites; see Section 4.4. Management Resources and Practices for more information.

Edmund A. Bellegarde Boathouse. The Bellegarde boathouse, situated on a parcel of land between Pawtucket Boulevard and the Merrimack River, was once the headquarters for Lowell Heritage State Park between 1993 and 2002, but is now under the care and control of the University of Massachusetts Lowell (see Section 4.4. Management Resources and Practices for more information).

Charles G. Sampas Pavilion. The Sampas pavilion is located on the Vandenberg esplanade, near the intersection of Pawtucket Boulevard and Delaware Avenue (see Figure 3). The 30- by 50-foot open-air, poured concrete and steel frame structure has functioned as the park's performing arts stage for 37 years. The stage is equipped with electricity and limited performance lighting; it is in good condition.

Merrimack River Retaining Wall. A riprap and poured concrete retaining wall is located along the Vandenberg esplanade, from the Rourke Bridge to the Sampas pavilion. It is not known when the wall was constructed. Woody vegetation, some of which is an invasive species, is growing in the riprap portion of the wall. Many sections of the poured concrete wall are also misaligned. Overall, the retaining wall is in fair condition.

Raymond J. Lord Memorial Swimming Pool. The Lord swimming pool, located at 81 Cross Street, is a complex of one pool, one spray deck (formerly a wading pool), one bathhouse and one outbuilding, constructed in 1972 (see Figure 3). The pool has a maximum depth of 12 feet; a set of stairs provides access to the shallow end of the pool. In 2010, the wading pool was converted into a spray deck with one centrally located spray feature. Both the pool and the spray deck are in good condition. Pending approval and funding, plans are in place to modernize the structures in the fall of 2014 by reducing the maximum depth of the pool to five feet; replacing the stairs in the shallow end of the pool with a "zero entry" ramp; adding more spray features to the spray deck; and constructing a shade shelter.

The bathhouse, approximately 3,300 square feet, is a single-story, masonry block building with a wood framed gabled roof clad with asphalt shingles. The 983-square-foot outbuilding, which houses pool equipment (e.g., pumps, filters and chemicals), a first aid station and staff restroom, is constructed of similar materials; however it has a flat, tar and gravel roof. Both the bathhouse and outbuilding received new roofs in 2009, and new epoxy floors and fresh interior and exterior paint in 2012. The pool's filtration system was also replaced 2012. Both buildings have electricity, domestic water and waste water disposal. In addition, the outbuilding has a phone line. Both buildings are in good condition.

Tremont Yard. For many years, the predominant feature on the Tremont Yard parcel, located at 257 Father Morissette Boulevard, was the one-story ruin of a brick powerhouse with below grade water power features (see Cultural Resources, above, for more information). In 2003, the Legislature authorized the DCR to lease the property (see Appendix H) and two years later, a Request for Proposals (RFP) was issued. In 2008, a 25-year lease was signed by Tremont Yard, LLC (see Section 4.4. Management Resources and Practices for more information). That same year, construction began on a modern, five-story office building; the ruin was demolished as part of that process, but the historic power system features were preserved. Today, the site is the headquarters for the Jeanne D'Arc Credit Union, which includes a first-floor interpretive display (see Figure 3). Although this preservation effort is open to the public, there is little promotion of the space.

Trolley Tracks. The National Park Service (NPS) operates a free trolley service for visitors to Lowell National Historical Park. The trolleys run on approximately one-mile of track that is laid out in a "T" shape within downtown Lowell. The western terminus of the track is located on the DCR's Tremont Yard parcel. The Department of Environmental Management granted the United States of America, through the Lowell Historic Preservation Commission, an easement for the construction of the tracks and associated fixtures. The easement is recorded in the Middlesex County Registry of Deeds, Northern District, Book 6249, Page 209.

Lowell Public Art Collection. From 1984 to 1995, former U.S. Senator and Lowell resident Paul Tsongas, along with staff from the Lowell Historic Preservation Commission, led the development of the Lowell Public Art Collection (Marion 2014). During that time, a series of permanent sculptures were placed throughout the downtown area, but generally within sight of the National Park Service's canalway walking path. Each work of art addresses a theme of the federal and state park systems: the industrial city, labor, machines, power and capital.

While a few of the sculptures are located on DCR property, e.g., "The Worker" in the Mack plaza, the collection is owned by the City of Lowell, through its Cultural Affairs and Special Events Department, and the National Park Service, both of whom are responsible for its ongoing maintenance. However, oversight of the collection is limited, due to a lack of resources at the municipal and federal levels (Marion 2014).

John J. Janas Memorial Skating Rink. The Janas skating rink, located at 382 Douglas Road, is managed and operated by the North Shore Rink

Management Associates, Inc. through a 25-year lease (see Section 4.4. Management Resources and Practices for more information).

Roads

Public roads, which are owned and maintained either by the City of Lowell or Department of Transportation, surround the park. Pawtucket Boulevard, or Route 113, and VFW Highway border, and provide primary access to, the riverfront portion of the park. In downtown Lowell, Broadway Street and Fletcher Street provide access to the DCR's westernmost historic resources and Lord pool, respectively. Dutton Street and Father Morissette Boulevard are the highest-capacity roads that lead to the concentration of the DCR's historic resources.

Parking

Along the Vandenberg esplanade, there are five DCR-owned parking areas (see Figure 3). The first is a paved lot, with a shared entrance and exit, located next to the Rourke brothers boat ramp. It can accommodate 64 vehicles; 44 spaces are reserved for vehicles with trailers, while the remaining 20 spaces are reserved for vehicles with car-top boats. All of the spaces are well marked, including the lot's four accessible spaces. The parking area is signed as being DCR property and gated.

The second parking area is located next to the Bellegarde boathouse; it is not under the care and control of the University of Massachusetts Lowell (see Section 4.4. Management Resources and Practices for more information). Forty-one vehicles can park in this paved lot, which has a separate entrance and exit. All of the spaces are well marked, including the four accessible spaces. The parking area is not signed as being DCR property or gated.

A third, unpaved parking area is located next to the regatta field. This unlined lot, with a shared entrance and exit, is heavily used during events and is showing serious signs of wear and tear. Vehicles, up to 40 at one time, are sometimes forced to park haphazardly due to deep ruts that fill with rain water and small patches of shrub-like vegetation. While the regatta field itself is signed as being DCR property, the parking area is not signed. The lot is also not gated.

The remaining two parking areas are located near the Sampas pavilion. Both lots are paved and marked, and utilize shared entrances and exits. The lot upstream of the pavilion has 22 spaces, including two accessible spaces. The lot downstream of the pavilion has 14 spaces, two of which are designated as accessible. Neither lot is signed or gated.

Visitors to the downtown portion of Lowell Heritage State Park most likely utilize the National Park Service's (NPS) visitor center parking lot, located near the intersection of Broadway and Dutton streets, or municipal parking options throughout the city (see Figure 3). The NPS's visitor center parking lot was formerly owned by the Department of Environmental Management (DEM). Upon selling a portion of the property to the NPS, the DEM established a Memorandum of Understanding (MOU) with the NPS regarding the use of the parking lot (see Section 4.4. Management Resources and Practices for more information). The remaining portion of the property was sold to the City of Lowell; there is no record of an MOU, or similar document, between the city and the DEM.

The DCR leases one parking area within Tremont Yard to the University of Massachusetts Lowell (see Section 4.4. Management Resources and Practices for more information). The other three DCR-owned parking areas within downtown Lowell are located outside of the concentration of historic resources (see Figure 3).

The first of these parking areas is located on Cross Street, next to the Lord pool. It is a paved lot, with a shared entrance and exit, and can accommodate approximately 40 vehicles. The majority of the individual spaces are not marked, however there are two accessible spaces that are well marked. The parking area is not signed as being DCR property or gated and, as a result, it is heavily used by residents and visitors in the immediate area.

The second downtown parking area is located on Broadway Street, near the Pawtucket Canal. Approximately 15 vehicles can park in this gravel lot, which has a separate entrance and exit. Individual spaces are not marked and there are no designated accessible spaces. Like the parking area at the Lord pool, this lot is not signed or gated and is routinely used by students, residents and visitors in the immediate area.

The final parking area is associated with the Janas skating rink, which is under the care and control of the North Shore Rink Management Associates, Inc. as part of a 25-year lease (see Section 4.4. Management Resources and Practices for more information). This lot is paved and can accommodate 80 to 90 vehicles. Individual spaces are well marked, including two designated accessible spaces. The lot's shared entrance and exit features a large DCR sign, as well as a gate.

Trails

There is one trail within Lowell Heritage State Park; it is a 10-foot-wide paved path located along the northern shoreline of the Merrimack River. The first section of the path, designated as the Scott Finneral Memorial Riverwalk, is approximately one mile long (see Appendix H). It runs from the Rourke Bridge to the Sampas pavilion on the Vandenberg esplanade. Portions of this path have been damaged by tree roots lifting and cracking the pavement. Sinkholes also appear along the path on occasion, due to water undermining the Merrimack River retaining wall (see Buildings and Structures, above, for more information).

The second, unnamed section of the path is approximately two miles long. It runs from Beaver Brook to near the Duck Island Wastewater Treatment Facility. Only the upstream portion, ending near the Hunts Falls Bridge, is on DCR property (approximately one mile of path). Small sections of this path can become overgrown, due to the dense vegetation that grows on both sides. Currently, the only connection between this section of the path and the Scott Finneral Memorial Riverwalk is the public sidewalk along VFW Highway.

Signs and Kiosks

There are very few DCR signs within Lowell Heritage State Park and there are no kiosks. Five separate Site/Facility Identification Signs exist for the Rourke brothers boat ramp, regatta field, Vandenberg esplanade, Francis Gate Park and Lord pool.

- The sign for the boat ramp, located at the ramp's main entrance, does not meet DCR signage standards (DCR n.d.).
- The regatta field sign, located on the north side of Pawtucket Boulevard near the sidewalk, within the larger of the two playing fields, meets all DCR signage standards (DCR n.d.).
- The sign for the Vandenberg esplanade, which is located on the south side of Pawtucket Boulevard near the intersection of Varnum Avenue, should be double-sided in order to meet DCR signage standards (DCR n.d.).
- The Francis Gate Park sign, located near the Guard Locks Lock House, does not meet DCR signage standards (DCR n.d.).
- The sign for the Lord pool meets all DCR signage standards (DCR n.d.).

A standard Rink Identification Sign is located at the main entrance of the Janas rink (DCR n.d.).

There is one Road Marker Sign that leads visitors to Lowell Heritage State Park from the Lowell Connector. The sign reads: "Lowell National and State Parks Exit 5B;" it does not meet DCR signage standards.

A small identification sign is attached to each of the DCR-owned buildings that the National Park Service maintains (see Section 4.4. Management Resources and Practices for more information). Although these signs do not meet DCR signage standards, they are consistent in appearance and placement, and thus easily recognizable as a component of Lowell National Historical Park.

National Park Service Identification Sign (DCR)

Within the last 10 years, Lowell General Hospital constructed a three-sided directional sign on DCR property located on the corner of Pawtucket

Boulevard and Varnum Avenue. There is no record of a legal document (e.g., permit, Memorandum of Understanding, etc.) being issued or a bill being passed that authorized the construction of this sign.

Memorials and Markers

There are five known memorials within Lowell Heritage State Park. The first, a large granite marker, is located at the entrance to the Rourke brothers boat ramp. It is inscribed with the names of three Rourke brothers, Steve, Cliff and Bud, all of whom served in World War II.

The second memorial is dedicated to Charles G. Sampas, a former columnist for the Lowell Sun. An approximately four-foot-tall, one-foot-square granite post, topped with a bronze plaque, is located near the Sampas pavilion. The plaque includes the names of the state and national parks.

Another bronze plaque, the third memorial, is mounted directly to the front of the Rynne bathhouse. It pays tribute to Michael Rynne, a former Lowell policeman and athlete, and also includes the names of the state and national parks.

The fourth memorial, located at the eastern end of the Vandenberg esplanade, is dedicated to George Scott Finneral, who was killed in action during the Persian Gulf War. It, too, is a bronze plaque mounted atop an approximately four-foot-tall, one-foot-square granite post. However, the plaque does not match the design of the other memorials.

The fifth and final memorial is small granite marker located within the Victorian garden. It is inscribed with Mary J. Bacigalupo's name and reads, in part: IN RECOGNITION FOR HER LEADERSHIP AND DEDICATION TO THE PEOPLE AND CITY OF LOWELL.

There are at least nine other bronze plaque markers, either mounted on a granite post or directly to a building, placed throughout the park. These markers provide information about the nearby buildings and objects. Each marker includes the name of the state and national parks. The plaque for the brick vault, located near the Victorian garden, was stolen and has not been replaced.

Bronze Plaque and Granite Post Marker (DCR)

Surprisingly, there is no marker for Hoyt S. Vandenberg (1899-1954), the presumed namesake of the esplanade and Lowell's highest ranking general.

4.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Vegetation management within the park consists primarily of mowing and trimming. DCR staff maintain the lawn and landscaping at the Rourke brothers boat ramp and along the Vandenberg esplanade. The city maintains regatta field (see Recreation Resources, below for more information).

Within downtown Lowell, the National Park Service maintains the grounds around the canal system resources (see Cultural Resources, below). The maintenance of the lawn and landscaping within the Gatekeeper's property falls to the curator or DCR staff, when a curator is not present. DCR staff also maintain the grounds at the Lord pool and the plantings at the Victorian garden. The lawn and landscaping at Tremont Yard and the Janas rink are maintained by Tremont Yard, LLC and North Shore

Rink Management Associates, Inc., respectively (see Infrastructure, below).

Cultural Resources

Buildings and Structures

Michael Rynne Bathhouse. In 1996, the Department of Environmental Management (DEM) issued the City of Lowell a three-year Special Use Permit "to use and occupy the [beach] adjacent to the Rynne [bathhouse] on the Merrimack River for the purpose of providing a safe, clean and accessible swimming area for the general public."

As part of this permit, the city was given one room in the bathhouse, "as designated by the Park Supervisor, for the purpose of a First Aid and storage area." In addition, the DEM agreed, "subject to appropriation and available personnel, to make major repairs to the [bathhouse] such as, roof replacement, exterior painting, heating system replacement, etc." The shared use of the bathhouse has continued, under agreeable terms, for the last 15 years without a Memorandum of Agreement or similar document in place.

Buildings and Structures Associated with the Canal System. In 1991, the four major stakeholders in downtown Lowell's historic properties – the Department of Environmental Management (DEM), Boott Hydropower, Inc. (Boott), the Proprietors of Locks and Canals on the Merrimack River (Proprietors) and the National Park Service (NPS) – signed a five-year Memorandum of Understanding (MOU) for the purpose of "maintaining and operating the Lowell Canal System for the benefit and enjoyment of the general public and for the private production of hydroelectricity and for other private uses of its waters." The agreement divided the critical tasks related to maintaining and operating the canal system, including the associated buildings and structures, among the four major stakeholders with the understanding that each held a slightly different ownership, and general, interest in the various components of the system.

In general, maintenance of the canal walls and bottoms, dams and control apparatuses fell to Boott and the Proprietors. Boott was also responsible for maintaining, and providing access to, the Eldred L. Field Power Station for interpretive tours, as well as managing the water levels and flow rates in the canal system. The cost of utilities for the associated buildings was split between the DEM and Boott, while the DEM and NPS worked together to maintain and secure the buildings and grounds. The DEM and NPS also agreed to meet each year in order to develop building maintenance, destructive vegetation clearing, canal water surface cleanup, and long term capital improvement programs.

Despite evidence that one or more of the stakeholders attempted to renew this MOU after it expired in 1996, the maintenance and operation of the canal system continues today, under somewhat agreeable, if not confusing, terms, in the absence of any legally binding document.

W.A. Mack & Company Building. In 2007, the DCR and New England Electric Railway Historical Society / Seashore Trolley Museum signed a five-year Memorandum of Understanding (MOU), which authorized the group to utilize space on the first and second floors, including the window displays, of the Mack building for the purpose of operating the National Streetcar Museum. As part of this MOU, the group is responsible for:

- Any and all utility services and costs;
- Notifying the DCR's Regional Director of any fees under consideration or charged for using and/or accessing the museum;
- Scheduling and attending an annual in-person meeting with the Regional Director;
- Receiving the approval of the Regional Director prior to making any changes or improvements to the building; and
- Notifying the Regional Director of any injuries, closures, property damage or related incidents associated with the use of the building.

Even though this MOU expired on June 30, 2012, the museum has continued to utilize the Mack building, under agreeable terms, for the last two years.

Objects

Boston & Maine (B&M) Railroad No. 410. The historic steam locomotive is maintained and cleaned, at least twice a year, by the Boston & Maine Railroad Historical Society (B&MRRHS), a non-profit historical and educational organization comprised of volunteers who share a common interest in the history and operations of the B&M

Railroad. There is no Memorandum of Agreement, or similar document, between the B&MRRHS and DCR that guides this management activity.

Recreation Resources

Anne Dean Welcome Regatta Field. In 2007, the DCR and City of Lowell signed a five-year Memorandum of Understanding (MOU), which authorized the city to "…manage, maintain, and schedule events and programs consistent with the recreational missions of both parties at the [field]…." As part of this agreement, the city:

- Retains the funds it generates through permitting fees;
- Schedules an annual meeting with the DCR's Regional Director to discuss the previous year's programs and compliance with the MOU;
- Receives approval from the Regional Director before making any changes or improvements to the property;
- Does not cut, remove or interfere in any manner with any natural vegetation or store equipment or property without approval from the Regional Director; and
- Notifies the Regional Director of any injuries, closures, property damage or related incidents associated with the use of the property.

Despite the fact that this MOU has expired, the management and maintenance of the field, as well as communications between the city and park staff, have seamlessly continued for the last two years.

Rynne Beach. In 1996, the Department of Environmental Management (DEM) issued the City of Lowell a three-year Special Use Permit "to use and occupy the [beach] adjacent to the Rynne [bathhouse] on the Merrimack River for the purpose of providing a safe, clean and accessible swimming area for the general public." As part of this permit, the city agreed, at its own expense, to:

- Assume complete management responsibility of the waterfront area, including daily maintenance of the public restrooms;
- Provide qualified personnel to staff and manage the beach from June 1st through Labor Day of each year;
- Notify the DEM of incidents, such as vandalism, accidents, serious injuries, etc.; and
- Provide the park supervisor with a weekly report that includes a summary of incidents and attendance figures.

The management and maintenance of the beach, as well as communications between the city and park staff, have seamlessly continued for the last 15 years without a Memorandum of Agreement or similar document in place. Today, the beach is generally open from July 1st through mid- to late-August; a schedule that is dependent on the availability of students to fill the lifeguard positions and the timing of the Southeast Asian Water Festival, a popular event that is held on the Vandenberg esplanade each summer (Faticanti 2014).

The lack of a small, motorized boat presents the biggest management challenge for the city (Faticanti 2014). Every year, staff must borrow a boat to place and remove moorings, or swimming area markers, in and from the river. In addition, the city borrows a boat, or more, if available, to guard the non-motorized, dragon boat races that are an integral part of the Southeast Asian Water Festival. Finally, staff are routinely called upon to assist individuals who are swimming outside of the designated area, sometimes up to a mile away.

Raymond J. Lord Memorial Swimming Pool. In 2011, the DCR and Department of Public Health (DPH) signed a Memorandum of Agreement in order facilitate compliance with the State Sanitary Code (105 CMR 435.00, see Appendix F). As part of this agreement, the two agencies meet a minimum of twice per year to discuss pool inspections and compliance issues; share seasonal information regarding the operation of each pool; and jointly inspect each pool at least once per season. The agreement is in effect until terminated by either agency, upon 60 days written notice.

Infrastructure

Property Boundary

Anne Dean Welcome Regatta Field. Under the terms of the license agreement, signed by the Department of Environmental Management (DEM) and Highway Department (MassHighway) in 2001, the DEM must obtain written approval from MassHighway before altering the property and before transferring or assigning the license, in part or in whole. In addition, the DEM is responsible for

maintaining the property, as well as any existing or additional utilities needed to utilize the property. This license is in effect until terminated by MassHighway or the DEM, now DCR.

Buildings and Structures

Rourke Brothers Memorial Boat Ramp. Extensive regulations govern the use of the Office of Fishing and Boating Access (OFBA) sites, such as the Rourke brothers boat ramp (320 CMR 2.00; Appendix F). Use of these sites is restricted to the launching of watercraft and the parking of associated vehicles. No other parking or recreational uses are allowed. Special Use Permits are required for events (e.g., fishing tournaments) at OFBA sites. Permits are issued by the OFBA, following DCR review.

Edmund A. Bellegarde Boathouse. Chapter 238 of the Acts of 2006 authorized the transfer of the boathouse from the DCR to the University of Massachusetts Lowell (UMass). Sections seven through nine of the Act describe the terms and conditions of the transfer, including the requirements for public access and consequences regarding a change in use. The following additional items were also agreed upon, in order to execute and deliver a "care, custody, management and control" agreement between the DCR and UMass:

- Any document transferring the property shall include a reversionary clause, stating that care, custody, management and control reverts back to the DCR if the property ceases to be used as a public boathouse and park land.
- The Division of Capital Asset Management (DCAM), in consultation with the DCR, shall survey and provide a legal description of the property to be transferred.
- UMass shall prepare and submit, at its own expense, an Environmental Notification Form (ENF) regarding a land transfer of Article 97 protected lands.
- The transfer shall not be completed until the Secretary issues a certificate stating that no Environmental Impact Report (EIR) is needed, or that the EIR is adequate until the expiration of the legal challenge period.
- UMass shall comply with all requirements of the National Park Service and shall seek and obtain any required approvals.

The boathouse was officially transferred by the DCAM in 2006 (a signed Transfer Request 1, or TR1, form was located during this planning process); however the care, custody, management and control agreement has yet to be finalized. Several items from the list above, including the property survey and ENF, could not be located during this planning process.

The area including the parking lot to the west of the boathouse and the boathouse itself was estimated to be 1.15 acres, which exceeds the agreed upon land transfer estimate of one-third of an acre. Based on the estimate of 1.15 acres, it is presumed that the parking lot was not included in the land transfer.

Tremont Yard. The 25-year lease signed by Tremont Yard, LLC is a lengthy and detailed document that guides the management and operation of the DCR's property located at 257 Father Morissette Boulevard, excluding the parking area (see Parking, below). Permitted uses, rent, insurance, maintenance and subletting, among other topics, are addressed in the agreement. The DCR's Long-term Permit and Lease Program staff, within the Office of the General Counsel, ensure that the terms of the lease are being met. This lease is scheduled to expire on May 21, 2033, however it may also be extended for seven additional 10-year periods.

On October 31, 2008, Tremont Yard, LLC entered into a 15-year sublease with Jeanne D'Arc Credit Union. The sublease only covers the building that was constructed at 257 Father Morissette Boulevard. The credit union has options to extend the term of the lease, expand the leased premises and to purchase the property from Tremont Yard, LLC. For this sublease, Tremont Yard, LLC is the landlord and responsible for ensuring that the terms of the sublease are being met.

John J. Janas Memorial Skating Rink. The 25-year lease signed by the North Shore Rink Management Associates, Inc. is a lengthy and detailed document that guides the management and operation of the DCR's property located at 382 Douglas Road. Permitted uses, rent, insurance, maintenance and subletting, among other topics, are addressed in the agreement. The DCR's Long-term Permit and Lease Program staff, within the Office of the General Counsel, ensure that the terms of the lease are being met. This lease is scheduled to expire on June 20, 2027.

Parking

National Park Service's Visitor Center Parking Lot. In 1982, the Department of Environmental Management (DEM) and National Park Service (NPS) signed a Memorandum of Understanding (MOU) regarding the use of the parking lot located near the intersection of Broadway and Dutton streets in downtown Lowell. As part of this MOU, the two entities agreed:

- The NPS would be solely responsible for the operation and maintenance of the property, including staffing, daily operation, trash and snow removal, and repairs;
- The DEM would maintain a continuing role in the development of management policy relative to property;
- The obligations assumed by the NPS would not be transferred, assigned or modified without written approval by the DEM;
- The NPS would maintain a sign at the entrance of property, indicating that it may be used by visitors of both state and federal parks; and
- That a reasonable number of official spaces would be reserved for use by state or federal vehicles.

The MOU acknowledged that the DEM was authorized and intended to convey a portion of the property to the NPS and to that end, stated, "This agreement shall remain in full force and effect and shall not be defeated by the execution and delivery of a deed from [the] DEM to [the] NPS in connection therewith."

Tremont Yard. On January 10, 1985 the Trustees of Wannalancit Office and Technology Center Trust (Trustees) signed a 99-year lease with the Department of Environmental Management for the parking area located in the rear of 257 Father Morissette Boulevard. On September 27, 1996, the Trustees assigned the lease to the University of Massachusetts Lowell (UMass), who remains the tenant today. UMass is responsible for maintaining and, when it deems necessary, improving the parking area. Any construction on the property must be approved by the DCR. This lease is set to expire in 2084.

Interpretive Services

The National Park Service provides all of the interpretive programming related to the historic resources in downtown Lowell, due to the lack of DCR interpretive staff assigned to Lowell Heritage State Park and the overlap between the state and federal parks.

Lowell Heritage State Park is a participant in the Park Passport Program; the passport box is located next to the Rynne bathhouse.

Operational Resources

Supplemental Staffing

The supplemental staff at Lowell Heritage State Park are truly invaluable. Without the help of the City of Lowell and National Park Service, many of the DCR's most significant resources would certainly be in a state of disrepair, inaccessible to the public, or safety hazards requiring demolition. Other important partners include the Office of Fishing and Boating Access, University of Massachusetts Lowell, Merrimac River Rowing Association and Merrimack River Watershed Council, all of whom play a role in providing quality, safe access to the Merrimack River. Finally, the many volunteers in downtown Lowell – from the Lowell Canalwaters Cleaners, to the Boston & Maine Railroad Historical Society, to Park Serve Day attendees – help preserve and enhance the park's individual resources, as well as the visitor experience overall.

Public Safety

DCR Rangers issue citations for violations of various forest and park rules. A summary of incident reports recorded in the park during 2013 is provided below.

Table 4.10. Lowell Heritage State Park Incident Reports, January 1 through December 31, 2013

Incident	Number
Vandalism	1
Violation of DCR regulations[a]	1
Total	*2*

a. This violation was related to alcohol consumption on state property and, in turn, a suspected drunk driver. The incident was relayed to the Lowell Police Department, as the individual drove their vehicle onto a city-owned road after leaving the park.

Dairy cows at Great Brook Farm State Park. (DCR)

SECTION 5. GREAT BROOK FARM STATE PARK

5.1. INTRODUCTION

Great Brook Farm State Park is a large property – 929 acres – located in the northern section of the rural community of Carlisle, with a few acres falling over the town border to the north, in Chelmsford. Main access points to the property are located off of Curve Street, North Road and Lowell Street. This is a diverse property with a variety of resources, uses and issues, including an active dairy farm; multiple historic buildings; acres of wetlands, forests and agricultural fields; miles of trails popular with walkers, equestrians and mountain bikers; and home to a cross-country ski concession.

Great Brook Farm is the largest active farm remaining in Carlisle, and is touted as the only active dairy farm within a state park in the country. The farm complex boasts a robotic milking system, the first one to be installed in Massachusetts.

5.2. HISTORY OF PROPERTY

The Concord River Valley area has a long history of human occupation, with a Native American presence that stems back thousands of years. Known archaeological sites within Great Brook Farm State Park confirm pre-contact use of this property.

European settlement of the Carlisle area took place in the mid 17th century, with the establishment of three separate small settlements, one of which, Chelmsford South End, began sometime after 1655 and was located in the area of the present day park (MHC 1980*d*). River Meadow Brook provided serviceable waterpower, and mills and dwellings began appearing along its banks in the 17th century, including the area known as "The City," a small milling community with multiple homes and even a possible garrison (Markey 2002). A fulling mill was established in 1691 by John Barrett. Saw, grist and hoop mills were also located along River Meadow Brook, operated by the Adams and Robbins families through the early 18th century. A blacksmith shop was located in the area, and small scale quarrying also took place on land that is now within the park. A hoop mill continued to operate into the late 19th century.

By the early 18th century, the Spaulding and Adams families settled in the area and established small farms. The first North District schoolhouse was authorized in 1788, and the brick school building, the second one on this site, was constructed by Benjamin Barret in 1828. Small scale agriculture continued into the early to mid 20th century.

In 1939, Farnham Smith purchased eight acres off of North Road and built himself a cabin on a small pond as a summer retreat. Attracted to the area, he began purchasing additional property – the Adams farm in 1943, the home at 886 Lowell St in 1953, and the purchase of the Hart property, including the barn and the schoolhouse shortly thereafter (Miller 1998). He ultimately purchased 29 individual parcels, owning more than 900 acres, eight houses, the former schoolhouse, and five barns (Markey 2002). Smith began dairy farming and some breeding, and in 1948 he hired a farm manager, embarking fully into the breeding of Holsteins. Great Brook Farm became one of the largest dairy farm operations in New England and a highly respected breeder of Holsteins.

In September 1974, Smith sold Great Brook Farm to the Commonwealth of Massachusetts for $4.3 million, for the establishment of a state park. Smith retained the rights to: operate the farm for an additional three years, use and lease the North Farm house for an additional five years, use the log cabin and the East Farm house for an additional eight years, and life tenancy use of the schoolhouse. Smith decided to cease farm operations just one year later, selling off equipment and animals in 1975.

Legislation was passed in 1982 for the establishment of an interpretive farm. The cross-country ski concession has been operating since the 1983-1984 ski season (weather permitting). Applicants were sought to operate the farm in 1986, and Mark and Tamma Duffy have been operating the dairy farm component of the park under lease agreements since 1987. The ice cream stand opened in 1988.

5.3. EXISTING CONDITIONS

Natural Resources

Physical Features

Topography. The topography within Great Brook Farm State Park is composed of lowlands in the south and gently rolling hills in the north. Elevation ranges from 170 to 300 feet above sea level.

Geology. Located within the Nashoba terrane, Great Brook Farm State Park lies primarily within the Nashoba formation. This formation is composed of metamorphosed volcanic rocks and includes schist, gneiss and biotite gneiss as well as an abundance of mica and sillimanite (Skehan 2001). Glacial eskers and erratics can be seen throughout the park.

Soils. The soils at Great Brook Farm State Park include large areas that are well suited to agricultural and pasture use, although there are some issues with droughtiness that limits crop production and pasture usage (Peragallo 2009). The wetlands present on the property are reflected in the high percentage of acres characterized as muck type soils. There are slight to moderate limitations on path and trail development in dry areas, depending on slope, and some limitations on picnic and playground development, based on slope and the stoniness of the soils (Peragallo 2009).

Table 5.1. Soils of Great Brook Farm State Park

Soil Series	% of Park	Drainage Class
Canton fine sandy loam	20.7	Well drained
Freetown muck	14.4	Very poorly drained
Hinckley loamy sand	10.5	Excessively drained
Charlton-Hollis-Rock outcrop complex	7.6	Well drained to somewhat excessively drained
Merrimac fine sandy loam	5.7	Somewhat excessively drained
Swansea muck	5.2	Very poorly drained
Woodbridge fine sandy loam	4.6	Moderately well drained
Scarboro mucky fine sandy loam	4.4	Very poorly drained
Saco mucky silt loam	2.7	Very poorly drained
Freetown muck, ponded	2.3	Very poorly drained
Carver loamy coarse sand	2.3	Excessively drained
Windsor loamy sand	2.2	Excessively drained
Scituate fine sandy loam	2.2	Moderately well drained
Haven silt loam	2.1	Well drained
Hollis-Rock outcrop-Charlton complex	2.1	Somewhat excessively drained to well drained
Deerfield loamy sand	2.0	Moderately well drained
Raypol silt loam	1.7	Poorly drained
Narragansett silt loam	1.7	Well drained
Water	1.2	N/A
Wareham loamy fine sand	1.1	Poorly drained
Raynham silt loam	0.8	Poorly drained
Rock outcrop-Hollis complex	0.6	Somewhat excessively drained
Udorthents	0.5	Variable
Whitman fine sandy loam	0.3	Very poorly drained
Tisbury silt loam	0.2	Moderately well drained

Water Resources

Great Brook Farm State Park is rich in water resources – almost a quarter of the park's total acreage is made up of either ponds or wetlands.

Ponds. Meadow Pond, centrally located in the park, is the largest body of water in Great Brook Farm State Park (see Figure 4). Meadow Pond has an abundant amount of water chestnut (*Trapa natans*) that is impacting the chemistry and habitat of this body of water. Beaver activity, weather, and water releases from nearby cranberry bogs impact the water level, and have led to flooding on nearby trails.

There are two smaller ponds on the property. One is the farm pond located adjacent to the farm complex and the second is located north of North Road, in the eastern portion of the park, near the site of Farnham Smith's cabin retreat (see Figure 4). There are almost 12 acres of water that are encompassed by these three ponds.

Wetlands. The southern portion of the park is dominated by Tophet Swamp, a 76 acre wooded wetland area consisting primarily of mixed trees (see Figure 4), along with two blocks of coniferous wooded swamp. A smaller (28 acre) coniferous wooded swamp can be found in the northern section of the park. Shrub swamps (approximately 33 acres) and deciduous wooded swamps (57 acres) can be found spread throughout the property. All combined, swamp areas cover almost 21% of the park.

Some shallow marsh meadow lands encompassing 10 acres are found north of Meadow Pond, in the area known as "The Meadows". Small pockets of deep marsh can be found scattered nearby, totaling almost nine acres. The largest of these deep marshes is located directly northeast of Meadow Pond.

A small bog area, just over one acre in size, is located within the southern section of Tophet Swamp.

Vernal Pools. There are seven certified vernal pools and 12 potential vernal pools located in the park.

Streams. River Meadow Brook, also locally known as Great Brook, is situated roughly west-east through the park, starting in a cranberry bog west of the park and running just south of Curve Street and North Road until it enters Meadow Pond (see Figure 4). Exiting the north end of Meadow Pond, River Meadow Brook heads northward out of the park into a series of mill ponds in Chelmsford and into the Concord River in Lowell.

Two small, unnamed streams flow into River Meadow Brook from the north, on either side of Lowell Road, while a third stream swings through a small portion of the southern border of the park, ultimately connecting to Pages Brook south of the park.

Groundwater. A small portion of a medium-yield aquifer lies beneath nine acres in the northern part of the park, extending from Meadow Pond north to the park boundary.

There are two drinking water wells located at Great Brook Farm State Park. One well (#3051017-01G) is located just east of the Main Farm house, and serves the farm and the ice cream stand. The second well (#3051017-02G) is located north of the Nature Center Pavilion, in the field just southeast of the North Farm House Barn, along the Litchfield Loop trail, and serves the Nature Center Pavilion. Both are categorized as Transient Non-Community Groundwater Sources by the Department of Environmental Protection.

Flood Zones. The 100-year flood zone covers 84 acres that fall within Great Brook Farm State Park. This zone roughly corresponds to lands adjacent to River Meadow Brook and Meadow Pond, and extends north from Meadow Pond into The Meadows. The 500-year flood zone incorporates 162 acres of land, concentrated in the Tophet Swamp area in the southern half of the park.

Rare Species

A very small component of Great Brook Farm State Park, just 33 acres, has been designated as Priority Habitat under the Massachusetts Endangered Species Act (321 CMR 10.00). Located in the westernmost parcel of the park, the Priority Habitat is located on a non-contiguous piece of land located south of Curve Street and west of Old Morse Road, and extends into nearby municipal conservation land and private lands.

Placeholder for Figure 4.

Two rare species, both reptiles, can be found in this Priority Habitat: Blanding's turtle and eastern box turtle (NHESP 2007*a*; NHESP 2007*c*). These two species are similar in appearance and have similar nesting habitats, and thus are often confused with each other.

Table 5.2. State-listed Species of Great Brook Farm State Park, as identified by the Natural Heritage & Endangered Species Program (NHESP)

Species	Type	MESA[a]
Blanding's turtle	Reptile	T
Eastern box turtle	Reptile	SC

Source: Harper 2013

a. Status of species listed under the Massachusetts Endangered Species Act (MESA): SC = Special Concern and T = Threatened.

Blanding's turtles use a variety of habitats, including vernal pools, marshes, scrub-shrub wetlands and open uplands, during their life cycle, and travel long distances during their active season (NHESP 2007*a*). Eastern box turtles are more of a terrestrial turtle and inhabit a variety of habitat types (NHESP 2007*c*).

In 2010, MassWildlife and The Nature Conservancy (TNC) issued "BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World" (MassWildlife and TNC 2010). This guide identified two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience, and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is "important to conserve the full suite of biodiversity" in Massachusetts (MassWildlife and TNC 2010). At Great Brook Farm State Park, 490 acres (54% of the park) has been designated Core Habitat, a much larger area than the MESA designated Priority Habitat, but no Critical Natural Landscape areas have been designated.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified seven forest sub-types within Great Brook Farm State Park (Table 5.3).

Table 5.3. Forest Sub-types of Great Brook Farm State Park

Forest Sub-type	Acres	% of Park
Eastern white pine - oak	209.3	22.5
Eastern white pine	123.8	13.3
Eastern white pine - hardwoods	83.2	9.0
Mixed oak	76.6	8.2
Oak – hardwoods	33.9	3.6
Eastern white pine - eastern hemlock	8.8	0.9
Red maple - swamp hardwood	3.6	0.4
Total	*539.2*[a]	*57.9*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the park's boundaries since 2003.

More recently (2010-2011), specific areas within the forest were visited by DCR Management Foresters as part of the Massachusetts Continuous Forestry Inventory (CFI). The CFI is a network of permanent, one-fifth-acre plots on state park and forest lands that are routinely monitored for sivicultural purposes, and help to gage forest health. The measurements and observations made within each CFI plot are recorded in a database that dates back to 1960, when the CFI was created. Approximately 10% of the state's CFI plots are inventoried each year, on an on-going basis. As of 2010, there were 1,768 CFI plots statewide (Goodwin 2014).

There are seven CFI plots at Great Brook Farm State Park. These even aged stands range in age from 70 to 100 years and are comprised mostly of white or red pine, red maple, and white, black or scarlet oak.

Some disturbance agents have been noted in these stands, including pasturing (1900 to the present); insects (1981) and wind (1985). Harvesting also occurred in these stands in 1960.

Priority Natural Communities. There are no Priority Natural Communities within the park.

Invasive Species. A number of invasive species have been observed and identified by foresters and visitors to Great Brook Farm State Park. These species include:

- Common buckthorn (*Rhamnus cathartica*), a deciduous small tree or coarse shrub that threatens wetlands, where it can suppress other species, and field edges.

- Garlic mustard (*Alliaria petiolata*), a biennial herb that can spread rapidly, displacing native vegetation and in turn altering habitat. Garlic mustard is very difficult to eradicate.
- Bittersweet, a deciduous woody vine that has the capacity to grow over 60 feet long, girdles trees and smothers other plants. Bittersweet has been observed by the ice cream stand, along the Acorn Trail, and at the small parking area at the intersection of Lowell Street and North Road.
- Purple loosestrife (*Lythrum salicaria*), an herbaceous perennial, can suppress native populations, alter wetland structure and function, and impede water flow. Dense stands can form that are unsuitable for use by wetland habitat animals. Purple loosestrife has been found in wetland areas and along the brook.
- Water chestnut (*Trapa natans*), a fast growing aquatic plant, can crowd out native species and choke waterways. Water chestnut damages habitat and can impede recreational access. This is particularly present at Meadow Pond, and has been one of the contributing factors to the decrease in recreational boating in this pond.
- Multiflora rose (*Rosa multiflora*), is a densely spreading shrub that forms thickets that crowd out native species.
- Japanese knotweed (*Polygonum cuspidatum*), a shrub-like herbaceous plant that forms dense thickets that crowd out native species and reduce wildlife habitat, posing significant threats in riparian areas in particular.
- Catalpa (*Catalpa bignonioides* or *Catalpa speciosa)*, a fast growing tree that can reach a height of 50 feet and crowd out native trees in the process.
- Winged burning bush (*Euonymus alatus*), also known as winged euonymus or burning bush, is a deciduous shrub that forms dense thickets that crowd out native species.
- Japanese barberry (*Berberis thunbergii*), a spiny shrub that forms dense stands that can displace native plants and reduce wildlife habitat and forage. Barberry also harbors deer ticks that have the potential to carry the Lyme disease bacteria, functioning as a nursery of sorts for juvenile ticks (Benson 2011).
- Privet, a rapidly maturing semi-evergreen shrub that forms dense thickets that crowd out native species.

Pests and Disease. White pine weevil (*Pissodes strobe*) has been identified in Great Brook Farm State Park. While tree mortality from this pest is low, damage does impact tree health and reduce wood quality. Leaf feeders have also been identified here as well, although to a much lesser degree than the weevils. Leaf feeders encompass a broad category of insects that are all defoliators, impacting trees and other plants.

Wildlife

Birds. Great Brook Farm State Park is popular with birders, and over 150 wild species have been recorded in or over the park in recent years (see Appendix G). Of these species, 22 are classified as Species in Greatest Need of Conservation (MassWildlife 2006). As part of the farming operation, the farmers also maintain a flock of domesticated chickens.

Mammals. There is little current information on the park's mammals. Nine species confirmed to occur within the park and an additional 34 species that may possibly occur within the park are identified in Appendix G. Of the confirmed species, one of them, the Eastern red bat, is classified as a Species in Greatest Need of Conservation (MassWildlife 2006).

As part of the farming operation, the farmers also maintain a herd of dairy cows for milk production, as well as some goats, sheep, pigs, rabbits and a horse. Some are family pets, while others are kept for visitor enjoyment and farm income.

Reptiles. There is little current information on the park's reptiles. Seven species confirmed to occur within the park and an additional nine species that may possibly occur within the park are identified in Appendix G. Of the confirmed species, two are classified as Species in Greatest Need of Conservation (MassWildlife 2006). These are the Blanding's turtle and the Eastern box turtle.

Amphibians. There is little current information on the park's amphibians. Ten species confirmed to occur within the park and an additional eight species that may possibly occur within the park are identified in Appendix G.

Fish. There is no current information on the park's fish. A survey of River Meadow Brook in 1979 yielded an American eel (*Anguilla rostrata*), a brown bullhead (*Ameiurus nebulosus*), 12 bluegill (*Lepomis macrochirus*), four pumkinseed (*Lepomis gibbosus*), and four largemouth bass (*Micropterus salmoides*) (Wineman 1980).

Cultural Resources

There is a wide range of cultural resources within Great Brook Farm State Park. Some are associated with Farnham Smith's use of the property, while others predate his acquisition of these lands. Many of the cultural resources have been documented on Massachusetts Historical Commission (MHC) inventory forms. The park was evaluated by the MHC in the late 1990s and determined at that time to be eligible for listing in the National Register of Historic Places.

Pre-Contact Archaeological Sites

Four pre-Contact sites have been recorded in the park. One site is a stone tool making workshop that dates to the Middle Archaic Period (7,500-5,000 B.P.). The remaining sites are identified as "find spots" with little more than locational information provided. Despite the low number of sites, the physical characteristics, regional setting, and the known patterns of pre-Contact occupation in the area, all confer a high archaeological potential for this park.

Historic Archaeological Resources

Remnants of the 18th – 19th century mill site operated by the Adams family are located on River Meadow Brook, adjacent to Farnham Smith's cabin. (See MHC inventory form # CAR.902.) The Adams mill site includes a dam, two sluiceways, an impoundment, and the foundation of a mill. The dam and the sluiceways were originally constructed of dry laid stone, which helped to control water and create the impoundment area. The dam, also known as Cabin Pond Dam in agency records (MA02506), has an earthen core and sluiceways with concrete reinforcing. This dam is considered non-jurisdictional, meaning it is not under the regulation or jurisdiction of the DCR Office of Dam Safety and has not been assigned a hazard code. This dam was last inspected in 2007. A gate mechanism was added in the 20th century, probably to manage the water levels in the impoundment area. The mill foundation is located just north of the dam. According to research, this building once functioned as a grist, hoop, and saw mill (Dwyer 1995).

Not far from the Adams mill site, off of the Garrison Loop Trail, is the area locally known as "The City," also known as Chelmsford South End. This area, a collection of cellar holes likely dating from the 18th century, was potentially affiliated with the nearby mill, possibly as an area of mill worker housing. An archaeological survey of the area in 1995 identified five visible cellar holes in this area (Dwyer 1995); only two definite cellar holes and a possible third cellar hole were located during the RMP fieldwork. Archaeological work revealed a low density of artifacts, suggesting the area was not inhabited for a sustained period of time.

One of the cellar holes that is still visible is locally known as the Garrison House site. Although archival research points to a garrison located in the Great Brook area in the 17th century, the archaeological investigation yielded domestic artifacts, and cannot confirm its use as a garrison (Dwyer 1995).

Another cellar hole is located next to three pieces of quarried stone. A third, possible cellar hole is located north of these other two, near the northern intersection of Garrison Loop with the Woodchuck Trail. Lots of leaf and brush debris were noted in the cellar holes during the RMP fieldwork.

Other cellar holes that may or may not be affiliated with the settlement of "The City" can be found within the park. One of these, located across the street from the Litchfield House, consists of a dry laid stone foundation in an I-shape, with a large chimney base. This was also researched and tested during the 1995 archaeological survey of the park, at which time it was determined to have been the site of a mid to late 18th century residential structure (Dwyer 1995). This particular cellar hole is currently filled with brush.

Another cellar hole is located northeast of "The City," alongside the Woodchuck Trail. This one is small and square, with a smaller cellar hole next to it, suggesting an outbuilding. Of note are some stone walls that make some unusual turns in the immediate vicinity of this cellar hole.

The stonework remnants of John Barrett's Mill, located on River Meadow Brook near the

intersection of Lowell Street and North Road, on the west side of Lowell Street, are still somewhat visible. Local historians suggest that this was established in 1691 as one of the first fulling mill sites in the U.S., and later used as a hoop mill until the late 19th century (Lapham 1970). A stone dam that may have been affiliated with this mill site is located near this same intersection, on the east side of Lowell Street, and is known as the Lowell Road dam (MA02508). This dam is considered non-jurisdictional, meaning it is not under the regulation or jurisdiction of the DCR Office of Dam Safety and has not been assigned a hazard code. This dam was last inspected in 2006.

Two historic wells were located in the park during the RMP fieldwork. One of them, located south of North Road, once serviced the Main Farm House. A small well house covered this well until relatively recently, when it was removed for safety reasons and replaced by wooden decking. The other well, which is located southeast of the Litchfield House, is an open well located just off the trail.

Historic Resources

Buildings. In the process of acquiring the acreage for his large farm, Farnham Smith acquired several nearby farms – and their buildings – over the course of about 20 years. Since the establishment of the park, some were able to be put to use for park purposes or through long-term lease agreements. However, several of them no longer function for park purposes, or are residences that in the recent past have housed DCR staff, but with the disbandment of the staff housing program are no longer utilized. The buildings are presented here in three groupings: those that are currently in active use by park staff, long-term leaseholders, or curators; those that are used solely for storage purposes by the park and/or the region; and those that are currently vacant and no longer in active use (see Figure 4).

Buildings in Active Use

North Schoolhouse, located at 984 Lowell Street, is also known as the Park Headquarters building. See MHC Inventory form #CAR.7. Constructed in 1828, this single-story, side gabled, three-by-four bay brick building has a granite block foundation and a slate roof. A single-story rear ell, perpendicular to the main block, has another ell added onto the first one, oriented parallel to the main block. Both are clad in clapboard. The building has two interior brick chimneys; one is located in the main block and the other in the rear ell.

Utilized as a grade school until 1906, the former schoolhouse was adapted in the early 20th century for vegetable storage. Farnham Smith purchased the property in 1955, and renovated the schoolhouse into his farm offices in 1959, which may have been when the side entrance was modified to the present-day central recessed entrance under the elliptical arch. The rear ells, clad in clapboard, were added in 1959 and 1969 respectively.

English ivy is growing on the end walls of the main block, and the brick chimney in the rear ell is experiencing major spalling. The building is in satisfactory condition.

The North Schoolhouse has been in use as the Park Headquarters since establishment of the park.

North Schoolhouse/Park HQ (DCR)

Hart Barn, located at 1018 Lowell Street. This one-and-one-half story, gambrel roofed barn was once a dairy barn, constructed in the first quarter of the 20th century. With a poured concrete foundation, a concrete block first floor, a clapboard second story, and an asphalt shingle roof, this barn also has an attached milk room and metal stave silo. Aluminum framed fixed sash windows and a metal vent in the roof completes the picture.

Recent mortar repairs efforts between the concrete blocks is evident, and it appears that multiple materials were used in the process. This was done in anticipation of a repainting project scheduled for later in 2014. Asbestos abatement of the window glazing was completed in 2014. The development of a plan for the remaining lead and asbestos inside the building is also anticipated. While the southern side of the roof was replaced in the recent past, the northern side has not been in some time, and lichen

growth is evident. While work has slowly been occurring here to address major issues, the building is still in unsatisfactory condition.

The Hart Barn has been in use as the Great Brook Ski Touring Center since the l983-1984 ski season.

Hart Barn (DCR)

The ***Main Farm House***, historically known as the Adams House, is located at 247 North Road. See MHC inventory form #CAR.8. The Main Farm House is a two-story, side-gabled, three-by-two bay, central chimney, Georgian style home with a single-story rear ell. A shed roof provides a covered patio area on the rear façade, between the main block and the ell. The main house has a granite block foundation, and the ell has a concrete block foundation. The entire house is clad in clapboards and has an asphalt shingle roof. Windows are primarily six-over-nine double hung sash, with exterior storms. Architectural details include cornice returns on the gable ends, wide and flat window trim with a small projecting cornice, and top lights above the main entrance. Documentation on the MHC inventory form prepared in 1993 notes interior details including original paneling, wide pine flooring, and exposed gunstock posts in one second floor bedroom, however park staff could not confirm if these features still exist.

The house was constructed in the second half of the 18th century. Local historians differ about the date of construction - Timothy Adams, who purchased the property in 1793, may have constructed a new home on the site or may have remodeled an earlier c1760 home. The main farm complex was acquired by Smith in 1943 and a rear ell was added c1949.

While there is a gutter on the ell, there is no gutter on the main block of the house. This has led to the presence of lichen on the front and rear façades of the house due to splash back, and the doorsill at the main entrance appears to have some moisture damage. Some minor woodpecker damage can be seen on a front corner board. This building is in satisfactory condition.

The Main Farm House is now in use as the residence of the farmers that operate Great Brook Farm under a long-term lease.

Main Farm House (DCR)

Garage/Apartment. Located within the core of the farm complex is a two-story, side gabled structure. This building was built for equipment storage and farm staff housing, and is still utilized for these same purposes. Constructed during Smith's ownership of the property, this concrete block and clapboard building has five vehicle bays on the first floor and a two bedroom apartment on the second floor. Park staff has use of two of these vehicle bays for storage purposes. This building is in satisfactory condition.

Garage/Apartment (DCR)

Tie Stall Barn. Constructed in phases, this long building consists of a single-story gable roofed tie stall barn constructed c1910-1920 on the eastern end; connected to a two-and-one-half-story gambrel roofed barn built in the 1950s; connected to a single-story gable roofed open ended building on the western end. Gabled dormers punctuate the gambrel roofed section, and small single-story additions

punctuate the eastern section, one of which links the barn to a wood stave silo that is no longer in use. The foundation is fieldstone on the eastern end and concrete block on the western end. The building is clad in drop board siding and roofed with asphalt shingles. Vinyl replacement windows dot the structure. Exposed rafter tails provide the only adornment on this building.

Some small sections of siding are in need of repair, due to cracking or pieces missing. There are serious sill and foundation issues in need of attention. The north facing roof has some lichen growth and staining, and may need replacement. The building is in satisfactory condition.

The Tie Stall Barn used to house the dairy herd. A seasonal ice cream stand that is operated by the farmers April through October is now located at the eastern end of the structure. An interior dining and event space was developed by the farmers just behind the pre-existing ice cream stand section, however it was done without prior consultation with the DCR (as stipulated in the farm lease agreement) and without the benefit of a building permit. Authorization of future use of this space for this purpose is still pending, and will not occur until all applicable permits are obtained. The remainder of the barn is currently utilized primarily for storage of hay and sawdust.

Tie Stall Barn (DCR)

Bull Barn. This one-and-one-half-story front gabled building, located just to the east of the Tie Stall Barn, is composed of concrete block on the first floor and clad in drop board above, and has an asphalt shingle roof. Windows are aluminum framed sliding sash, some of which may no longer function. The main entrance is located on the side of the front façade and three more doors are located on the south elevation. A door sized opening is located in the gable end of the upper floor, presumably to access the area for storage. Like the Tie Stall Barn, the only adornment here is exposed rafter tails.

Constructed during Smith's ownership of the property, severe cracking has since occurred in the foundation through the front wall. Due to this issue, the building is in unsatisfactory condition.

This building is currently used for storage. The sign on the building, "Non-Hazardous Industrial Wastewater," reflects the nearby presence of underground piping associated with the tight tank for the Smart Barn (see the Infrastructure section for more information).

Bull Barn (DCR)

The ***Litchfield House***, historically known as the East Farm, is located at 437 North Road. See MHC inventory form #CAR.6. This c1860 one-and-one-half-story front gabled Greek Revival house is composed of a three-by-three bay main block with a one-story rear ell. The ell connects to a side gabled barn and two car garage through a small shed roofed addition, forming an L-shaped plan. The home has a granite block foundation, clapboard sheathing, and an asphalt roof. Architectural details include a deep eave overhang, sidelights flanking the main entrance, and six-over-six double hung sash windows that have been fitted with exterior storms. The New England style banked barn has large at grade openings on both the front and lower rear facades. Lichen is present on the north side of the roof and some can be seen creeping up the walls. The house has two interior brick chimneys, both of which could use some minor repair work. Extensive gardens surround the house. This property was purchased by Farnham Smith in the 1940s and served as the home for his head farmer, Lowell Litchfield.

This home is currently in use as a residence under a long-term lease as a part of the DCR's Historic Curatorship Program. This building is in satisfactory condition. The curators are currently working on the rear wall of the barn, which is in poor condition.

Litchfield House (DCR)

The ***Hounds House***, historically known as the Woods House, is located at 659 North Road. The Hounds House is a two-story, flat roofed modern home, constructed in c1950 of concrete block, with vertical board wood sheathing on the second floor. With metal casement windows and a deep raking eave with exposed rafters, this home reflects the modernism movement that had a large presence in nearby communities. This building is in satisfactory condition. A small one-story, front gabled wood frame horse barn is located to the rear of the home.

This home is currently used as a residential and commercial facility. It has been operating under a long-term lease to Old North Bridge Hounds, a business that kennels hound dogs and organizes local equestrian hunts.

Hounds House (DCR)

Buildings Used for Storage Purposes

Hadley House and Garage. Located at 1003 Lowell Street, this small mid-19th century residential building is a one-and-one-half-story, side gabled, two-by-one bay main block with a full width one-story shed roofed component on the rear. The foundation is largely fieldstone, with some concrete block on the southwest corner. The sheathing is clapboard and the roof is asphalt shingle.

The windows are primarily two-over-two double hung sash, and the main entrance is located on the side of the building, on the south facing façade. A centrally located brick chimney pierces the roofline. A wide fascia board and gable returns are the only adornments on this building.

A lilac bush, along with some bittersweet, can be found in the back yard.

The building has no gutters, the paint is failing, and a hose coming from the basement suggests a water problem.

Most recently, the Hadley House had been in use as staff housing. Vacated about seven years ago, the house is now used for storage by the region, is in non-functioning condition and is on the agency demolition list. As the timing of demolition is unknown, park staff plans on repainting the building in 2014 to make it less of a potentially attractive nuisance.

Hadley House (DCR)

A well maintained, detached two car garage in satisfactory condition is located just south of the Hadley House. Built c 1960, the side gabled garage has a concrete slab foundation, clapboard walls and an asphalt shingle roof. A gutter is located on the front wall, but not the rear wall of the garage.

Park staff currently use this garage for snowmobile storage, and do not plan to demolish the building.

Anderson Barn. Located at 360 Curve Street, this one-and-one-half-story, side gabled 19th century barn has a fieldstone foundation, clapboard walls and an asphalt shingle roof. The primary façade has a pair of adjoining entrances, located slightly off center. One is composed of a set of double doors that swing inward; directly next to it is a small entrance that has an intact sliding door that is affixed to the exterior. Built into a bank, an on grade entrance to the basement level is visible on the west side façade, but not accessible due to vegetative overgrowth. Six-over-six, double-hung sash windows are present on the side and rear walls of the building. This barn has several architectural details not always present in such a utilitarian structure, including: corner boards, a full cornice that wraps the building, an overhanging eave, decorative gable end treatments, and wide and flat trim around the windows that includes a small projecting cornice.

The building is in unsatisfactory condition. Paint is failing on the wall, and some small holes have been addressed by stapling mesh wire over them to prevent access by rodents. Interior evidence suggests some recent insect damage. Lichen is starting to grow on the roof and vegetation is encroaching on the side and rear façades of the building.

This building has electrical service, and is currently utilized for storage by the regional office (including IT equipment and former exhibit materials), as well as the regional Foresters and district Fire Control. It abuts private property and is across the street from another private property that maintains horses on site.

Anderson Barn (DCR)

Vacant Buildings

Duck Coop. Located just to the east of the Main Farm House, the Duck Coop is a small shed roofed outbuilding built into a bank, with the lower level providing access to a low, poorly drained area that used to function as a seasonal pond. The building has a concrete foundation, clapboard walls and an asphalt shingle roof.

Moss and lichen are present on the roof, and the foundation has been compromised by the roots of the directly abutting trees. Due to the foundation damage, this building is in unsatisfactory condition.

Duck Coop (DCR)

Farnham Smith's Cabin. This cross-gabled, L-shaped, single-story cabin was built by Farnham Smith in 1939 as a summer retreat, prior to his establishment of Great Brook Farm. Located adjacent to the Adams Mill site, the cabin provided him with a private spot on a small pond.

Built partially on stone and concrete piers and partially on a fieldstone foundation, the building has a shed roofed front porch and a centrally located rubblestone chimney. Although at first glance it appears to be a log cabin, the building is actually a wood frame building with half round logs that have been applied as exterior sheathing. Since they are not structural, the log ends are mitered at the corners. Exposed rafter tails complete the rustic look. The building was wired for electrical and phone service, and was also outfitted with a security system by Smith (none of these services are currently live).

The cedar shake roofing has deteriorated to the point where there are a several holes in the roof, coupled with minor vegetation growth. At least one interim repair effort involving tar paper occurred, possibly covering an earlier hole. The porch steps are deteriorating as well. The building is in unsatisfactory condition.

In the sale of the property, Farnham Smith negotiated use of the log cabin for an additional eight years. After use reverted to the DCR, the cabin

was periodically rented out for day use, primarily for corporate retreats. It was then briefly utilized as staff housing in the early 1990s. The windows are now boarded over, the door is locked, and the building is posted with "No Trespassing" signs.

Farnham Smith's Cabin (DCR)

Farnham Smith's Cabin Shed. A small, one-by-one bay front gabled shed is located adjacent to Farnham Smith's Cabin. Sheathed in cedar shingles, the shed is built on piers, has a tar paper roof, and is in satisfactory condition. A small open lean-to, probably used for protecting firewood, is located directly in front of this shed. Park staff does not have a key and do not use the space. Materials stored within the shed appear to date to use of the property by the former resident.

Cabin Shed and Lean-to (DCR)

Boat House. A small, one-story, three-by-one bay front gabled building located on the southwest end of Meadow Pond, the Boat House has a full-width front porch and rear addition. Built on a concrete block foundation, the building has drop board siding and an asphalt shingle roof.

The Boat House, unused since the early 1970s, is currently in extremely poor condition and considered to be in a state of critical failure. It has been posted with "No Trespassing" signs and is marked off with snow fencing to discourage people from exploring the site. Chunks of siding are missing, portions of the roof are caving in, and a section of sill appears to no longer exist.

The building is slated for demolition. As per a Memorandum of Agreement with Massachusetts Historical Commission, documentation on an MHC inventory form is underway.

Boat House (DCR)

The ***District 6 Fire Control Office***, historically known as the South House, is located at 841 Lowell Street. This c1950 traditional Cape Cod style former residence is a one-and-one-half story, side gabled, three-by-two bay building. The house has a concrete block foundation, a clapboard exterior, and an asphalt shingle roof. The front slope of the roof was replaced in the recent past with architectural style shingles; the rear slope has standard three-tab style shingles.

Two front gabled dormers punctuate the roof line and a single story breezeway connects the main block to a two car garage. Windows are six-over-six and eight-over-twelve double hung wooden sash. A brick chimney pierces the front slope of the roof, slightly off-center.

The exterior siding has some holes, and other minor deterioration, and the paint job is failing. There may be some foundation sill issues and several window sills are deteriorating. The building no longer has gutters and as one result, the front fascia board is deteriorating. The basement has water issues, as evidenced by the pipe leading out from a basement window.

This building was utilized as the District 6 Fire Control Office and also housed some regional staff until 2010, when those operations relocated to the new, large garage and office built on site to the rear of this building. (See the Infrastructure section for

more information.) At that time, the septic system for this building was retrofitted and re-permitted for use by the new building. This house is in unsatisfactory condition, and is on the agency demolition list.

District 6 Fire Control Office (DCR)

The ***Manseau House***, historically known as the West Farm, is located at 1112 Lowell Street. This three-by-two bay, two-story, central entrance home with a hipped roof, reflects a plan that was popular in the first quarter of the 20thc. A hipped roof entry porch with some scrollwork adorns the façade, and a small single story shed roofed addition has been added to the rear entrance. The home has a fieldstone foundation, late stage aluminum siding, and an asphalt shingle roof. There are no gutters.

Two brick chimneys are present: an exterior one on the south façade and an internal one that pierces the north slope of the roof. Windows are primarily two-over-two double hung sash. Historic photos show a central hipped roof dormer, removed sometime after 1973.

The house is in poor shape. English ivy, growing up the south side and rear walls, appears to have infiltrated the interior of the home. The internal chimney is leaning and the rear entry porch is collapsing.

Most recently, the Manseau House had been in use by regional fire control as storage until about 2008, and prior to that as staff housing. Vacated by the last residents approximately 10 years ago, the house is in non-functioning condition and is on the agency demolition list.

Manseau House (DCR)

A well maintained, detatched, two car garage in excellent condition is located behind the Manseau House. Built c1960, the hipped roof garage has a concrete slab foundation, clapboard walls that have recently been repainted, and an asphalt shingle roof.

The District Fire Control staff currently uses this garage for vehicle and other storage, and there are no plans to demolish this building.

North Farm House and Barn. Located at 107 Old North Road, this well maintained, one-and-one-half-story, cross gabled, five-by-three bay home has a fieldstone foundation, clapboard sheathing and an asphalt shingle roof. The house has two brick chimneys – an exterior one on the south façade and an interior one in the north end of the building. Windows are six-over-six double hung sash. The building is situated on a small rise with nice views of the fields to the south and the barn to the east. Extensively renovated and added onto in 1961, it appears this was originally a Cape Cod style home that had the front gable added to the north half of the front façade.

This home was utilized for staff housing until March, 2014, vacated as part of the discontinuance of the staff housing program. There are no current plans for its future use, but park staff would like the house to be reused in some capacity, especially since it is located on the edge of the park property. Neighbors have already expressed concerns to park staff, and are worried about vandalism.

North Farm House (DCR)

The North Farm House Barn, just east of the house, is a one-and-one-half-story barn with a gambrel roof. Built into a small bank, the foundation is poured concrete, the sheathing is dropboard and the roof is covered with asphalt shingles. The windows appear to be fixed wooden sash and exposed rafter tails provide the only adornment. The barn has also been well maintained.

The lower level of the barn has been used for park storage for many years, while the tenant utilized the upper level of the barn. Park staff has expressed an interest in using the upper level for additional storage, ideally for equipment that cannot stay in the Hart Barn during the winter, but no decisions have been made.

Structures. There are a number of different historic structures located within the park.

Bridges and Culverts

Along the Woodchuck Trail is a small ***bridge*** that is graced on one corner by a short cobblestone pillar with a concrete cap. The pillar appears to have had electrical service to it at some point, possibly to light the bridge. This bridge, constructed of non-historic wooden decking that rests on historic stone and concrete abutments, spans a small stream bed. The abutments appear to have been originally stone, but partially rebuilt through the addition of concrete. A concrete gate is located about 20 feet upstream from the bridge, probably utilized to create a small impoundment and control water flow.

Small bridge on Woodchuck Trail (DCR)

A ***stone arch bridge*** is located on the Pine Point Loop Trail, just north of the Boat House. This at grade crossing consists of a triple arch stone bridge, composed of dressed granite blocks, with low stone curbing for sidewalls, and an earthen pathway. Round holes are visible in the granite curbing, although their original purpose is unclear. While this spans the outlet of Meadow Pond, water seems to be creating problems at either end of the bridge. Debris is visible on the upstream side of the bridge and little headspace is visible through the arched culverts, suggesting that either the water level of the pond has risen over time, or that the openings may be partially blocked and impeding water flow beneath the bridge at the rate needed.

Stone bridge on Pine Point Loop Trail (DCR)

A small stone and earthen ***causeway***, outfitted with a stone culvert, is located just west of the stone bridge. The culvert is composed of rough dry laid fieldstone.

Farm Structures

Pole Barn. This partially enclosed, side gabled barn is actually a post and beam structure with a corrugated metal roof. Where exterior walls exist, they have board and batten siding. Vegetation is

encroaching upon the rear (northern) façade of the building.

Pole Barn (DCR)

Bunk Feeder. The Bunk Feeder, an open air pavilion, provides shade for the farmers' cows and is a space used for feeding. This wood frame building has a corrugated metal roof that appears to have some minor damage, including small spots of corrosion.

Bunk Feeder (DCR)

Both the Pole Barn and the Bunk Feeder were constructed during Smith's ownership of the property, and are currently used for Heifers of breeding age. Both structures are in satisfactory condition.

Metal Stave Silo. This silo, one of two on the property, is located between the Pole Barn and the Bunk Feeder. It appears to be in satisfactory condition, but it is no longer used for silage.

Metal Stave Silo (DCR)

A few additional small farm structures of indeterminate age are located in the core farm area, most notably a chicken coop and a pig shed.

Other Structures

Segments of ***stone walls*** can be seen in many areas throughout the park, both within the woods as well as alongside some of the roadways. These walls, predominantly dry laid loose rubble, vary in condition from failing to being in good condition. These walls show how this land was used and divided over the past three centuries.

A section of ***concrete retaining wall***, poured in stages, is located on the south side of North Road, across the street from the Main Farm House. The function of this retaining wall is not entirely clear. It is almost entirely covered in moss.

A free standing ***stone and brick hearth***, designed for outdoor grilling, is located just south of the Adams Mill remnants, not far from Farnham Smith's Cabin. Designed with two levels for cooking, it has a full chimney to direct smoke away from the cook. The hearth likely dates to Smith's development of this piece of property as his cabin retreat.

Outdoor Stone and Brick Hearth (DCR)

Located outside of Great Brook Farm, proper, is a fire tower, ***Massachusetts State Tower #21***, also known as the Hollis Wilkins Memorial Tower. Situated on a small (.06 acre) parcel at the peak of Robbin Hill, the property at 30 Summit Avenue in Chelmsford was purchased by the Commonwealth for 50 cents in 1918. First used as a site for fire monitoring purposes in 1911, the 60-foot-tall steel tower is the fourth one on the site, dating from 1939. The current cab dates from 1970.

The tower has also served as a host to a number of pieces of telecommunication equipment since 1978, from ham radio antennae to microwave dish antenna and repeaters for state police to commercial users. The following entities currently have equipment on this tower: Nextel, Massachusetts Department of Transportation, Greater Boston Police Council (GBPC), Massachusetts Port Authority, and the Massachusetts State Police.

A structural analysis of the tower undertaken in July, 2009 indicated the tower is in conformance with the requirements of the TIA/EIA-222-F standard (Structural Steel Standard for Steel Antenna Towers and Supporting Structures) for the current and antenna loading. An analysis completed in April, 2013 using the TIA-222-G-2 standard (Structural Standard for Antenna Supporting Structures and Antennas*)*, a more critical standard, found the tower to be overloaded with the existing and proposed antenna load by the GBPC. However, the GBPC chose not to add the proposed antenna systems due to a lack of funding. When and if they obtain the necessary grant funding to proceed with the project, the GBPC will have to reinforce the tower to meet the TIA-222-G-2 standard and their proposed antenna load.

Objects. There are no historic objects within the park.

Landscapes. There are a range of historic landscapes within Great Brook Farm State Park that showcase the history of Carlisle.

The core of ***Great Brook Farm*** and its adjacent fields to the east and northeast collectively form an historic landscape that conveys the agricultural history of the property, and is documented on MHC inventory form #CAR.A. It is through this collection of historic buildings and structures, the farmyard, the adjacent manmade farm pond, and the immediate surrounding fields that visitors can get a sense of what this place is, and see how dairy farming has evolved through the 20th century and into the 21st. The layout of these buildings and structures, as well as the fenced enclosures, provides pathways for visitors and safe spaces for animals and also help visitors understand how the farmyard functions. While the buildings and structures are described separately, the complex as a whole needs to be considered collectively.

Two other historic landscapes, the ***Adams mill site*** and ***"The City,"*** are discussed above, in the Historic Archaeological Resources section. The individual resources within these areas collectively make up larger historic landscapes, and each individual resource within these two sites needs to be considered within the full context of their larger landscape.

Finally, what appears to be a small unmarked family ***cemetery*** can be found off of the Woodchuck Trail, in the part of the park known as "The City." A series of 11 or 12 small stones are lined up, possibly head and foot stones. While there are no inscriptions, and the stones are not formally shaped, their rectilinear layout suggests they were lined up for this purpose, and may have served the mill village community. Additional research is needed.

During the last few decades, stone features and other landscape elements in the park have been the subject of differing research perspectives. Some of the stone features in the park are interpreted as symbolic and having astronomical alignments, or anthropomorphic details, and some have been designated "prayer seats". The public, independent researchers, historians, and archaeologists have all contributed to literature on the interpretation of the stone features within the park. The interpreted origins range from Precolumbian European exploration, Native Americans, and farmers. Because of the differing backgrounds, beliefs and agendas, a consensus on the debate has not been reached.


Cemetery (DCR)

Recreation Resources

Great Brook Farm State Park is primarily accessed via motor vehicle, although some local residents and regional cyclists do visit by bicycle. There are no public transit options to reach this park.

The primary recreational activities at Great Brook Farm State Park revolve around its extensive network of trails. This network, encompassing over 26 miles of trails, provides a variety of trail experiences that help make this park a popular destination. From wooded areas, to the edges of open fields, to rocky areas with some hills, to low lying areas along wetlands, visitors are not apt to get bored with the scenery.

The trails are routinely used by walkers and hikers, often accompanied by a dog, and according to park staff, the occasional goat. Despite signs at trailheads informing users of on-leash restrictions, many dogs are off-leash.

This park is a popular destination for mountain biking, in part because the trail system provides a range of experiences that can accommodate riders of all skill levels; mountain bikers range from beginners to experienced riders, and biking occurs throughout the park. When surveying park users about their use of the park for this RMP, the majority of survey respondents (65%) indicated that they have biked here in the past year. Technically challenging sections are concentrated in the Stone Row and Indian Hill areas. Riders explore the park individually, as well as through organized club rides and events, including an annual event organized by the New England Mountain Bike Association (NEMBA) as a part of the Kona Bicycles MTB Adventure Series. Park staff reports that some mountain bikers ride some of these trails after dark, despite the park officially closing at dusk.

The park's trails are also utilized by individuals and clubs for orienteering activities. The New England Orienteering Club has held events at Great Brook Farm State Park for several years, developing courses that are on- and off-trails. Other trail user groups include the Carlisle Trails Committee, the Cambridge Sports Union, and the local school system, which holds high school cross-country races as well as a local history search for third graders within the park.

The cross-country ski concession is very popular during the winter months, and serves as a major draw of visitors to the park. Over 8 miles of machine groomed loop trails are open, when there is enough snow to ski. The ski trails are restricted for use by skiers during the winter. An active effort made in 2010 to keep hikers off of the ski trails seems to be effective in maintaining the trails in good condition for skiers. The Lantern Loop, lit for nighttime skiing on Tuesday and Thursday evenings, provides visitors with a unique and interesting way to experience the park.

The ice cream stand at the main farm is also a big draw for visitors. Located at the eastern end of the Tie Stall Barn, ice cream is available on a seasonal basis. Approximately 10 picnic tables are located here for sitting and dining and checking out the farm animals. The farmers maintain a number of small farm animals in addition to the dairy cows, including goats, pigs, chickens and rabbits, for viewing in enclosures located adjacent to the Tie Stall Barn.

Equestrian use of the trails is also popular at the park. Complimenting the trail use, a series of cross-country horse jumps are located just off-trail in the section of the park south of North Road, most notably in the open fields to the west of Meadow Pond. These jumps, wooden fencing often flanked by overgrown cedars, are in fair condition. Some visitors complain to park staff (and also evident in the user survey for this RMP) about the frequent presence of horse droppings on the trails.

A canoe launch used to be located at the northern end of Meadow Pond, providing access to this body of water for canoeing and kayaking. This launch was removed in 2009 when a new large bridge was constructed nearby; some park users were unhappy

about this outcome. While there has been some discussion of designing and installing a new canoe launch area nearby, this has not yet happened. The abundance of water chestnut growth in the pond also poses an impediment to canoeing and kayaking. As a result, the use of the pond by boaters has decreased significantly in recent years.

Infrastructure

Property Boundary

Great Brook Farm State Park is located in the northern part of the Town of Carlisle, roughly in the middle of the triangle formed by state routes 4, 225 and 27. Easily accessible by car from interstates 495 and 95/128 and state routes 3 and 2, Great Brook Farm State Park is a popular destination park within the greater metro Boston region.

Buildings and Structures

In addition to the historic buildings and structures discussed in the Cultural Resources section, there are a few more recent ones that have been constructed since establishment of the park, the two most prominent being the Nature Center Pavilion and the Smart Barn (see Figure 4).

The Nature Center Pavilion, constructed in 2002, provides a sheltered area under which interpretive programs can be held and visitors can relax at the six picnic tables. This pavilion also includes an enclosed portion that contains restrooms and an office for the seasonal interpreter.

Nature Center Pavilion (DCR)

Designed to reflect the agricultural history of the park, the cross gabled building features a standing seam metal roof, a bank of clerestory windows in the pavilion to help bring natural light into the sheltered portion, and a gable end detail intended to appear as a haymow.

The Smart Barn, constructed in 2010-2011 and located within the farm complex, is equipped with a DeLaval robotic milking system to support the dairy farm operations. This robotic system is touted as the first one to be installed in Massachusetts. The barn, a cross gabled building with a standing seam metal roof, vertical board siding and a clerestory, evokes the history of the farm and blends nicely with the nearby historic barns.

Smart Barn (DCR)

Also in line with evolving agricultural practices, the silage for the cows is no longer kept in the tall vertical silos, still found on the property. Rather it is stored in a large trench silo, an open trench with large concrete block retaining walls on three sides and a central divider, to facilitate loading and unloading by heavy equipment.

The District 6 Fire Control Office and Garage is located at 841 Lowell Street. It does not have a very visible presence, as it is set back from the road, behind the vacant Cape Cod house, and is not open to the general public. A non-descript, tall, front gabled building with corrugated metal siding and a standing seam metal roof was constructed in 2010 to house vehicles and equipment utilized for regional fire control purposes.

There are several non-historic bridges in the park, facilitating trail connections over wet areas and streams. (For a review of historic bridges, see the Cultural Resources section.) The northernmost bridge, noted on the park's trail map, is located near the intersection of Woodchuck Trail and East Farm Trail and crosses River Meadow Brook. This is a wide bridge, to accommodate park vehicles if needed, constructed of preformed concrete abutments and wooden decking.

Two wooden pedestrian bridges are located over the sluiceways at the Adams mill site, located near Farnham Smith's Cabin.

The largest bridge is located next to the parking area at the Pine Point Trail Loop. It is a wide bridge with a metal truss and wooden decking, sturdy enough to accommodate vehicular traffic. Installed in 2009, this bridge provides a connection to the other end of the loop so that trail users can avoid walking on North Road. As a part of the network of groomed ski trails, this safe connection is also important to skiers.

Non-historic culverts can also be found within the park, in an effort to control water flow. Near the northern intersection of the Woodchuck Trail and Garrison Loop is a concrete culvert, bridged by wooden decking on the trail. This culvert, equipped with a small gate controlled by wood boards to control water flow, has been outfitted with a beaver deceiver. A lot of brush debris has collected around the deceiver and the wetland itself has a lot of vegetation.

A culvert at the intersection of Woodchuck Trail and Garrison Loop. (DCR)

Two other smaller pipe culverts can be found along the Woodchuck Trail.

The last category of non-historic structures is a collection of three rock shelters located in the northern portion of the park, off of the Stone Row trail. These three shelters, one with a functioning chimney, are composed of dry laid fieldstone constructed around an existing glacial outcrop, with makeshift roofing composed of branches.

Rock Shelter (DCR)

Due to local lore suggesting that these may have past and present Native American associations, one of these rock shelters was investigated during the 1995 archaeological survey of the park (Dwyer 1995). After a walk over of the site with local Native American representatives, as well as subsurface testing within one of the shelters, it was determined at that time that these are not affiliated with past or present Native American use of this land.

Park staff indicates that these shelters have been created since the development of the property as the state park. The structures reportedly began as the work of a local park user, a mason that was interested in modern druid culture, and have since been altered, rebuilt, or new ones created by others. According to long time park staff, these have only been in place for approximately the last 25 years.

Roads

Curve Street, Lowell Street and North Road are all town-owned, locally designated scenic roads (see Figure 4). These roads provide access to Great Brook Farm State Park. While these roads are not owned by the park, impacts to any stone walls or trees on DCR land that fall in the right of way of these roads must be first seek the written consent of the Carlisle Planning Board.

Parking

The main parking area for the park, located off of North Road, provides easy access to the Nature Center Pavilion, the farm and the ice cream stand (see Figure 4). This paved lot accommodates over 80 vehicles, and has two spots allocated for handicapped parking. A parking fee of $2.00 is

charged seasonally (April 1st – December 1st) via a pay and display machine located on site. This parking lot contains over 20 signs, 12 of which concern parking and the use of the pay and display machine. Some of these signs are official looking, while others are laminated paper.

Adjacent to this parking lot is a low impact rain garden that the DCR installed in 2010. The garden is planted with native flowers and shrubs, and it catches and filters the water run off from the parking lot and the Nature Center Pavillion.

A paved parking lot is also located at the North School House that now serves as the park headquarters (see Figure 4). This parking area, which primarily serves park staff, is also available for public use. The lot can accommodate approximately seven vehicles and it has one spot that is demarcated for handicapped parking.

A small parking area is located off of North Road at the trail head for Pine Point Loop, adjacent to the former canoe launch location (see Figure 4). This unpaved lot holds four to six vehicles. This location also has a lot of signage and includes four separate signs that address parking and are clustered in one area. None of these signs utilize the actual name of the park.

Signage at the Pine Point Loop parking area. (DCR)

Another small, unpaved lot is located at the intersection of Lowell Street and North Road, and can accommodate parking for approximately four vehicles (see Figure 4). This area is needed for large vehicle turnaround purposes rather than parking, but it is not signed as such.

Parking is also available in the former field directly adjacent to the Hart Barn, and serves the cross-country ski concession (see Figure 4). This unpaved lot can accommodate approximately 120 vehicles. A parking fee of $2.00 is charged seasonally (April 1st – December 1st) via a pay and display machine located on site.

Trails

Great Brook Farm State Park has an extensive and well utilized trail network spread over its 929 acres. This network includes a little over 24 miles of official trails (see Figure 4) and almost two miles worth of additional, unofficial trails.

Of the network of official trails, 0.5 miles are administrative roads, including the entrance to the District 6 Fire Control Office and Garage, as well as the roads within the farm complex. Unpaved forest roads make up 11.5 miles of the network and the remaining 12 miles are trails.

A survey of the trail network within Great Brook Farm State Park was undertaken in 2010. At that time, 19.4 miles were deemed to be in good condition, 4.6 miles were in fair condition, and only 0.3 miles were in poor condition, a fairly low percentage (1.5%) than is typical in other DCR properties, possibly reflecting the presence of the cross-country concession and their use of the trails and the strong volunteer participation in trail construction and maintenance by the mountain biking community. This survey does not reflect the condition of those trails that were subjected to extensive flooding while conducting fieldwork for this RMP. Some of the trails around Meadow Pond in particular were impassable due to flooding, interrupting the trail network in this area.

A series of short boardwalks are placed throughout the trail system, where necessary, for erosion control or wetland and stream crossings. Some of these structures are in good condition, while others are aging.

Great Brook Farm State Park is unique within the DCR system, as it separates trail users during the winter season. During the winter, 8.3 miles of trails in the eastern section of the park are set aside for the exclusive use of cross-country skiers. These trails are groomed to facilitate use by skiers and all other users are encouraged to use the remaining trails that are open to multi-purpose use, most of which are located on the western side of the park. Some trails in the eastern section of the park are closed to all uses during the winter season, if they connect to the groomed trails, but are not groomed for use by skiers. This practice has helped to reduce user

conflicts and maintain a high quality network of groomed trails for use by skiers.

Two trail maps have been developed for Great Brook Farm State Park; one is for summer use, while the other shows the separation of trail uses during the winter. These trail maps are available on the park's webpage, on the DCR's website, as well as at the Hart Barn (during the winter) and in the park headquarters at the North Schoolhouse.

Signs and Kiosks

There is one Road Marker Sign that leads visitors to the state park, located in the center of Carlisle. There is one Main Identification Sign for the state park, located at the intersection of North and Lowell roads. The orientation, material and design of this sign does meet DCR signage standards (DCR n.d.).The sign is surrounded by ornamental plantings that are starting to get tall enough to obscure the bottom of the sign.

There are two informational kiosks located at the park; one is located at the eastern end of Hart Barn parking area, and the other is located within the farm complex.

Informational signage is also located within the Nature Center Pavilion, where a glass enclosed bulletin board is located on one wall, next to a wildlife sighting white board for use by visitors.

Additional interpretive signage is also located within the Smart Barn, informing visitors about the robotic milking system.

A routed wooden sign, now partially broken, marks the site of the Garrison House.

In the user survey undertaken for this RMP, several individuals suggested that better trail signage is needed.

Memorials and Markers

There is one memorial within the park, dedicated to Prospera, a prized cow of Farnham Smith's. Prospera was a champion Holstein heifer, who routinely won prizes from the Holstein-Friesien Association for her level of milk production. She is buried at the entrance to the farm, just off of North Road, and the spot is marked by a stone with a brass plaque that has raised lettering:

PROSPERA
1949 – 1969

5.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Water Resources

Drinking Water. The Transient Non-community Ground Water Sources (TNCs) within the park are tested under contract by WhiteWater Environmental Inc., a Massachusetts certified operator. These systems are operated in accordance with applicable regulations (310 CMR 22; Appendix F).

Massachusetts' regulations require a circular protective area around public water supply wells, including TNCs. The radius of this protective area, known as a Zone I, is based on the well's pumping rate. The DEP requires that activities within Zone I be limited to those directly related to the provision of water. Best Management Practices (BMPs) for protecting Zone I areas include the following (DEP 2001):

- Keep out non-water supply activities.
- Do not establish parking areas.
- Do not store or use lawn chemicals, road salt/deicers, motor oil, gasoline or paints.
- Remove or relocate underground storage tanks, hazardous materials, and septic systems, if possible.
- Use propane or natural gas powered pumps.
- Seal floor drains.
- Properly label, store, and dispose of hazardous substances.
- Restrict access to the well and post water supply protection signs.

These are recommendations, and not requirements.

Vegetation

As part of the long-term lease agreement with the farmers, there are 16 separate fields, totaling 74 acres that are actively managed for agricultural purposes.

Wildlife

A population of beavers has been present in Great Brook Farm State Park for several years, and their dam building and culvert blocking activities effect water levels, impacting the surrounding trail system. The current approach to beaver management includes the installation of beaver deceivers at some of the culverts where there has been a lot of beaver activity, along with beaver trapping by a wildlife contractor through the DCR's Lake and Ponds Program. The wildlife contractor is used at least annually, and makes the final assessment on which approach will be most effective to address the problems on hand.

Great Brook Farm State Park has been included in a statewide Cerceris wasp monitoring project that started in 2010. The Cerecreis wasp is a non-stinging wasp that makes nests in sandy soils and prey on Buprestid beetles, a family of beetles that includes the Emerald Ash Borer (EAB). Monitors examine what kinds of beetles the wasps are bringing back to their nests as one method of potential early detection of EAB. The data is currently very limited, but EAB has not been detected in the nests of the population here.

Cultural Resources

The Litchfield House is under lease with the DCR and is being rehabilitated, occupied and maintained as a single family residence by Darrold and Janet Fritz-Endres through the DCR's Historic Curatorship Program. Through the program, outside partners are selected through an open and competitive proposal process to help the DCR preserve some of its vacant and dilapidated historic properties in exchange for a long-term lease. The current tenants signed a twenty-five year lease in 1996, have rehabilitated the house and grounds, and are in the final stages of restoring the historic barn. The curator's responsibilities for the property include the complete rehabilitation of the house and its systems, management of its reuse (including all utility and insurance costs), and all maintenance responsibilities for the house and surrounding 1.08 acres.

The Hounds House has been under lease to Old North Bridge Hounds since 1994. This lease was established by legislation (Chapter 424, S-1234, 1993), and there have been two subsequent lease clarifications between the Department and the lessees, in 2002 and 2007. As part of the 2007 clarification, the lessee agreed to pay the DCR $550.00 per month and to perform capital repairs on the buildings and grounds at 649 North Road. This lease expired on December 31, 2013; the business owners would like a new lease. While this issue is pending resolution, the lessees are continuing to pay their monthly rental fees to the agency.

Great Brook Farm itself has been leased to Mark and Tammy Duffy since 1987. The original lease, ten years in length, was extended first in 1997, and again in 2007, and next expires on April 30, 2017. The lease was amended in July, 2011 to include language covering the Smart Barn, and establish ownership and maintenance responsibilities, as well as to bring some other language up to date, including insurance provisions. Their lease area consists of 90 acres, including the farm complex, farm buildings several fields and the cranberry bog. As part of the lease agreement, the farmers pay two percent of their gross retail on a quarterly basis to the DCR. Stipulations include the provision of some public access in selected areas of the farm during park hours, and maintaining building interiors and equipment.

Recreation Resources

The Hart Barn has been in use as the Great Brook Ski Touring Center, operating under a series of permit agreements with the same operators since the l983-1984 ski season. The operators groom the designated ski trails and provide lighting on some of the trails during the ski season for nighttime skiing. The current permit for this operation runs through the 2017-2018 ski season.

For the equestrian features within the park, the DCR mows the fields where the equestrian jumps are located; the local equestrian group maintains the jumps.

Infrastructure

Multiple buildings and structures are managed by outside lease holders (see Cultural Resources, above, for more information). Management responsibilities for these resources are stipulated in their lease agreements. Since these resources are predominantly historic, they must also coordinate their efforts in consultation with the DCR's Office of Cultural Resources.

Interpretive Services

A Comprehensive Interpretive Plan was drafted in 2011 for Great Brook Farm State Park by the DCR's Interpretive Services staff. Due to staff workload issues, this plan has not yet been finalized.

The Nature Center Pavilion serves as the home base area for interpretive services. Tours revolve primarily around the farm complex, and currently emphasize the workings of the dairy farm and the technological aspects of the Smart Barn. Tours run on weekends from Memorial Day through Columbus Day.

A Seasonal Interpreter is on site from mid-April through mid-October, providing guided tours of the farm complex, conducting junior ranger and nature programs, guiding school groups, and assisting with the planning and implementation of two major events, Picnic on the Farm, held the first Sunday in June, and Down on the Farm, held the last Sunday of September.

Great Brook Farm State Park is a participant in the Park Passport Program; the passport box is located within the Nature Center Pavilion.

Operational Resources

Supplemental Staffing

Mark and Tamma Duffy operate and staff the agricultural business at the park as part of the terms of their long-term lease agreement. The farm is a key attraction of the park, and the farmers maintain their lease areas so that the public can access much of it.

The park occasionally gets the assistance of a crew of volunteers from the Student Conservation Association (SCA) for specific trail-related projects. In the summer of 2013, the group did work on the Acorn Trail that will be continued in the summer of 2014.

Members of the Merrimack Valley Chapter of the New England Mountain Bike Association (MV-NEMBA) also volunteer at the park, and have been involved with trail construction within the park, as well as the purchase, construction and installation of boardwalks.

Given the wide range of opportunities this park presents to visitors, the many active user groups and the network of local and regional conservation organizations, the potential exists for the reformation of a Friends of Great Brook Farm State Park and their involvement in activities at the park.

Public Safety

DCR Rangers issue citations for violations of various forest and park rules. A summary of incident reports recorded in the state park during 2013 is provided below.

Table 5.4. Great Brook Farm State Park Incident Reports, January 1 through December 31, 2013

Incident	Number
Violation of DCR regulations[a]	3
Suspicious activity	1
Total	*4*

a. These violations were related to after hours use of the park and dogs not under control.

A large eastern white pine tree at Carlisle State Forest. (DCR)

SECTION 6. CARLISLE STATE FOREST

6.1. INTRODUCTION

Carlisle State Forest is the second smallest facility in the Lowell/Great Brook Planning Unit. Covering 25 acres, this property is tucked behind some relatively recent residential development (a subdivision known as Tall Pines), west of Hutchins Road. Access to the property is provided by Forest Park Drive on the south and Barnes Place on the north. Town owned conservation land and property owned by the Carlisle Conservation Foundation, a local land trust, abuts the property to the west.

6.2. HISTORY OF PROPERTY

In November of 1901, prominent landscape architect Warren Manning learned that a collection of about 100 very large eastern white pine were about to be harvested for lumber. Concerned about preserving this collection, he obtained a stay of proceedings and secured an option on the property, and convinced his fellow members of the executive committee of the Massachusetts Forestry Association to raise the funds to purchase the property.

Working in partnership with the Appalachian Mountain Club (AMC), $1,600 was raised through subscriptions by early 1902 to purchase approximately nine acres, with some excess funds collected going towards the AMC, which had agreed to serve as the property owner (Massachusetts Forestry Association, 1902*a* and 1902*b*).

Warren Manning at the Carlisle Pines. (Iowa State University Library Special Collections)

The AMC laid out trails and posted markers, and also selectively thinned some hardwoods on the property in order to showcase the large pines, improve growing conditions, and control gypsy moths (Goodall 1970; Shepard 1913). In 1912, the AMC expanded the reservation through the purchase of approximately 10 additional acres, and increasing

the collection of very large eastern white pine to approximately 150.

In 1934, the AMC sold the Commonwealth the Carlisle Pines and two other AMC reservations in Billerica and Warwick, with the stipulation that if these properties are no longer to be used as state forests, ownership would revert back to the AMC. Following transfer of the property to the Commonwealth, some small red pine plantations, as well as some additional white pine and Norway spruce were planted. The Hurricane of 1938 caused significant damage, knocking down all but 28 of the large eastern white pines, and after the Hurricane of 1954, further pines were lost. By 1980, there were only 14 of the large eastern white pines still standing (Stoddard 1980).

6.3. EXISTING CONDITIONS

Natural Resources

Physical Features

Topography. Carlisle State Forest is located between two ridges, and has relatively level to gently rolling terrain.

Geology. Carlisle State Forest falls within the Nashoba Terrane, formed of plutonic and metamorphic rocks including metamorphosed volcanic rock rich in biotite and hornblende. Surficial glacial deposits are found in the forest (Skehan 2001).

Soils. The soil of Carlisle State Forest consists primarily of Charlton-Hollis-Rock outcrop complex, which is a combination of soils and exposed bedrock encompassing about 50% Charlton soils, 25% Hollis soils, 15% rock outcrop and 10% other soils (Peragallo 2009). Found in upland areas, the Charlton soils can be found on toe slopes, while the Hollis soils are on hilltops and ridges. There are only slight limitations when it comes to potential trail and path development, with moderate limitations in areas where slope exceeds 15%. The Hollis soils are shallow and raise the risk of blown down trees, which could impact the forest. The Deerfield loamy sand, a very deep soil type, can be found on glacial stream terraces and deltas. These soils present moderate limitations to trail and path development due to its sandy composition (Peragallo 2009).

Table 6.1. Soils of Carlisle State Forest

Soil Series	% of Forest	Drainage Class
Charlton-Hollis-Rock outcrop complex	74.0	Well drained to somewhat excessively drained
Deerfield loamy sand	18.9	Moderately well drained
Swansea muck	5.6	Very poorly drained
Whitman fine sandy loam	1.3	Very poorly drained
Scarboro mucky fine sandy loam	0.2	Very poorly drained

Water Resources

Ponds. There are no ponds within the forest.

Wetlands. There are two small wooded swamp areas in Carlisle State Forest (see Figure 5). On the western edge of the property is a 0.4 acre wooded swamp composed of deciduous trees. On the southern edge of the property is a 0.6 acre wooded swamp composed of mixed trees.

Vernal Pools. There are no vernal pools within the forest.

Streams. There are no streams within the forest.

Groundwater. There are no aquifers beneath the forest.

Flood Zones. A very small sliver of the western most corner of the forest, 0.05 acres of property, falls within the 500-year flood zone.

Rare Species

There have been no rare species recorded in the forest.

Vegetation

Forest Types. Carlisle State Forest exists today due to an effort led by Warren Manning to protect an impressive stand of 200+ year old, very large eastern white pine from being logged in 1901. At the time, there were approximately 150 large, mature growth white pine; the hurricanes of both 1938 and 1954 took a serious toll on this stand and by 1980 only 14 remained (Stoddard 1980). DCR Forestry staff recently noted that more have since come down. Known historically (and locally) as the Carlisle Pines, Carlisle State Forest includes a stand of white

Placeholder for Figure 5.

Pine, some hemlock, and a small, centrally located plantation of red pine.

In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified four forest sub-types within Carlisle State Forest (Table 6.2). Some large eastern hemlock that appear to be old was also identified here during the RMP fieldwork, some of which appear to have been impacted by Hemlock Woody Adelgid.

There are no Continuous Forest Inventory (CFI) plots within Carlisle State Forest.

Table 6.2. Forest Sub-types of Carlisle State Forest

Forest Sub-type	Acres	% of Forest
Eastern white pine	10.0	40.0
Mixed oak	7.3	29.2
Eastern white pine – oak	3.0	12.0
Red pine plantation	0.6	2.4
Total	*20.9*[a]	*83.6*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the forest's boundaries since 2003.

Priority Natural Communities. There are no Priority Natural Communities within the forest.

Invasive Species. Common buckthorn (*Rhamnus cathartica*), a deciduous small tree or coarse shrub, threatens wetlands and field edges, where it can suppress other species. It has been observed in the southern portion of this forest in the past. Common buckthorn is often spread by seed dispersal through birds.

Pests and Disease. Hemlock woolly adelgid is present in the Eastern hemlock trees on this site. No other information has been located to date on pests and disease at Carlisle State Forest.

Wildlife

Birds. There is little current information on the forest's birds. Over 175 species that have been identified in some of the other properties in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.1.

Mammals. There is little current information on the forest's mammals. Over 45 species that have been identified in some of the other properties in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.2.

Reptiles. There is little current information on the forest's reptiles. Over 15 species that have been identified in some of the other properties in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.3.

Amphibians. There is little current information on the forest's amphibians. Over 15 species that have been identified in some of the other properties in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.4.

Fish. There is no current information on the forest's fish.

Cultural Resources

Pre-Contact Archaeological Sites

There are no recorded pre-Contact sites in the Carlisle State Forest, and the forest has not been subject to an archaeological survey. The physical characteristics, regional setting, and the known patterns of pre-Contact occupation in the region all confer a high archaeological potential for the forest.

Historic Archaeological Resources

There are no recorded historic archaeological sites in the Carlisle State Forest, and the forest has not been subject to an archaeological survey.

Historic Resources

Buildings. There are no historic buildings within the forest.

Structures. A dry laid stone wall lines much of the eastern boundary of Carlisle State Forest. A segment of another dry laid stone wall is centrally located on the west side of the property, and runs east to west. Constructed of glacial till, these walls are in fair to poor condition.

A stone wall in Carlisle State Forest, with a granite boundary marker in the foreground. (DCR)

Objects. A small granite boundary marker was identified next to the stone wall that lines the eastern boundary, near the Forest Park Drive entrance.

Landscapes. The stand of very old and large eastern white pines that are located in the northwest section of the property inspired the protection of this land, and the creation of the state forest. These natural resources have not only catalyzed the protection of this land, but are the primary draw for visitors to this small parcel and have become a part of its history.

Recreation Resources

Carlisle State Forest is primarily accessed via motor vehicle or on foot by local residents. Individuals who live nearby may walk or ride their bicycle to one of the two trailheads. There are no public transit options to reach this forest.

Recreation resources are limited to a network of 0.7 miles of trails through Carlisle State Forest. These trails are used primarily for hiking, as well as some dog walking, mountain biking, horseback riding, snowshoeing and cross-country skiing.

There is one known geocache located here as of October 2013.

Infrastructure

Property Boundary

Carlisle State Forest is a 25 acre undeveloped property in the northwest section of Carlisle, located west of Curve Street and north of Westford Road /Route 225. Town owned conservation land and property owned by the Carlisle Conservation Foundation, a local land trust, abuts the property to the west. Much of the eastern boundary is marked by a stone wall.

Buildings and Structures

There are no buildings or structures in the forest.

Roads

There are no roads in the forest.

Parking

There is no parking at Carlisle State Forest. At the end of Barnes Place, there is one unpaved parking space; it appears to be located on the abutting Town of Carlisle conservation land. Neighbors do express occasional frustration with the lack of parking in the area.

Trails

There are approximately 0.7 miles of well maintained trails in Carlisle State Forest. This network was mapped and assessed in 2009, and determined to be in good condition.

A trail map has not been created for Carlisle State Forest, and there is no information on the DCR website for the forest or its network of trails.

Signs and Kiosks

There are no Lead-in or Main Identification signs for Carlisle State Forest. The remnants of a wooden sign stanchion are located just off trail at the Forest Park Drive entrance. The only indications that this is state property are some boundary markers, found mostly at the southern edge of the property.

The former entrance sign stanchion. (DCR)

There are no informational kiosks at Carlisle State Forest.

Memorials and Markers

There are no memorials or markers in the forest.

6.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Vegetation

The DCR's forestry staff has periodically undertaken inventory of the remaining large eastern white pines, recording measurements. However, the most recent inventory was completed in 1980 (Stoddard 1980).

Wildlife

The DCR does not actively manage wildlife at Carlisle State Forest.

Cultural Resources

There are no cultural resource management activities that are unique to this state forest.

Recreation Resources

With the exception of keeping the small network of trails clear and usable, there are no other recreational resources in need of active management at this forest.

Infrastructure

With the exception of the small network of trails, there is no other infrastructure at this park to manage.

Interpretive Services

Interpretive service programs are not offered at Carlisle State Forest, nor is any other interpretive information provided.

Operational Resources

DCR Staffing

Carlisle State Forest does not have any full or part-time DCR staff on site.

Supplemental Staffing

The Carlisle Trails Committee has, in the recent past, completed volunteer trail clean ups on the trails at Carlisle State Forest, in conjunction with their work at the abutting town conservation lands.

A fitness trail through a white pine plantation at Warren Manning State Forest. (DCR)

SECTION 7. WARREN H. MANNING STATE FOREST

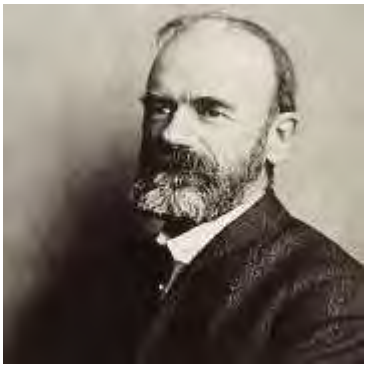
7.1. INTRODUCTION

Warren H. Manning State Forest, named for influential landscape architect Warren H. Manning (1860 – 1938), is a 183-acre property located in the northwest part of Billerica. The forest is located predominantly on the east side of Route 3, and is bisected by Chelmsford Road/Route 129 into two distinctly separate sections: a developed northern section and an undeveloped southern section (see Figure 6).

The forest includes a system of trails throughout the property, utilized mostly by local residents, as well as a picnic area, fitness trail and a small spray deck in the developed, northern section of the forest. The Billerica Recreation Department staffs the spray deck and manages the parking lot and bathhouse.

7.2. HISTORY OF PROPERTY

The area that is now Warren H. Manning State Forest is located in a part of Billerica that was not heavily settled through the 17th, 18th and most of the 19th centuries (MHC 1980*e*). One of the few settlers in this area was Samuel Manning, who built the Manning Manse, located at 56 Chelmsford Road/Route 129, in 1696. The ancestral home of Warren H. Manning, the Manning Manse was empty and in need of preservation when Manning moved to Billerica in 1895. A landscape architect who began working in his family's nursery business in Reading, MA, amassing an extensive horticultural background, Manning then honed his design skills in the Olmsted firm until branching out on his own in 1896. Manning was a founding member of the American Society of Landscape Architects in 1899, and pioneered a system of resource-based planning.



Warren Manning (The Cultural Landscape Foundation)

Placeholder for Figure 6.

After 1900, Manning began to acquire land in close proximity to the Manning Manse. In 1915, Manning moved his practice to Billerica, ultimately operating out of an octagonally-shaped office that was constructed in 1917 on the north side of Chelmsford Road (no longer extant). In 1923, Manning moved his practice to Cambridge when access to Boston and Lowell from Billerica became impossible via public transit.

Manning was very active in Billerica town affairs, and his efforts included promoting the creation of public woodlands in town, with a particular focus on developing a town forest system in Billerica. Manning developed the Billerica Town Forest Plan in the mid-1920s and it was accepted by the town in 1926. In 1934, Manning sold approximately 140 acres of his property surrounding the Manse to the Commonwealth, for the purpose of establishing a state forest, at a rate of $5.00 per acre (Manning n.d.). This property included Manning's former office, which was later removed by the Commonwealth sometime after his death in 1938 (Rockwell 2002). In 1935 and 1939, additional acreage in the area was purchased, increasing the size of the facility. In 1953, even more land was acquired through takings as the Old Middlesex Turnpike was realigned, and the new Middlesex Turnpike, Route 3, cut through a portion of the property. This project left a small portion of the forest on the western side of Route 3, impacting the trail system and making this parcel inaccessible to staff and visitors.

Around 1955, a recreation area was developed in the portion of the property north of Chelmsford Road/Route 129, in what is now known locally as Manning Park. The 1950s improvements included a wading pool, equipment cabin and picnic area.

In 1961, an Act of the Legislature led to the disposition of two parcels of land west of Route 3 to the Town of Billerica for industrial purposes. (See Appendix H for more information.) A lumber yard and self storage business are located here today.

A master plan completed for the forest in the early 1970s proposed an expansion of the picnic area and the installation of a full-sized swimming pool in the northern section of the property, and development of a camping area south of Chelmsford Road; none of these proposals came to fruition.

The Town of Billerica has been managing the recreation area in the northern section of the forest since 1990. A series of Special Use Permits from 1990 through December 2004 formalized this management arrangement. A renewed permit that was to run from 2005 through 2010 was never finalized, due to disagreements between the DCR and the Town over parking revenue. As a result, the Town of Billerica has been managing this area without any formalized agreement or permit in place for almost a decade.

In 2002, the recreation area was updated and the wading pool was replaced by a spray deck. An adult fitness trail is also located on this portion of the property, installed by the Town of Billerica in 2012.

7.3. EXISTING CONDITIONS

Natural Resources

Physical Features

Topography. Warren H. Manning State Forest is fairly level in the southern section, with some low rolling uplands in the northern portions of the forest.

Geology. Warren H. Manning State Forest lies within the Nashoba Terrane, and the bedrock of the area includes gneiss, schists and Andover granite, a pink to buff colored granite that has a granular texture (Skehan 2001). The gneiss and schists are metamorphic rocks that may have originated as volcanic rocks. Some glacial erratics are scattered throughout the property.

Soils. Warren H. Manning State Forest is comprised of a wide range of soil types, from loamy sands in the uplands to muck, reflecting the presence of wetlands. The deep Hinckley loamy sands can be found on glacial outwash plains and terraces, while the Canton fine sandy loam and the Scituate fine sandy loam soils are located on the side slopes and toe slopes of uplands (Peragallo 2009). Slight to moderate limitations on path and trail development exist in the upland areas, the limitations increasing with slope and the sandiness of the soil. Severe limitations are present in the wetter areas where the muck based soils are found. Limitations on playground and picnic area development range from slight to severe, based upon slope and the stoniness of the soils present (Peragallo 2009).

Table 7.1. Soils of Warren H. Manning State Forest

Soil Series	% of Forest	Drainage Class
Hinckley loamy sand	27.4	Excessively drained
Canton fine sandy loam	18.5	Well drained
Scituate fine sandy loam	14.2	Moderately well drained
Saco mucky silt loam	9.8	Very poorly drained
Freetown muck	9.3	Very poorly drained
Montauk fine sandy loam	6.7	Well drained
Windsor loamy sand	6.6	Excessively drained
Deerfield loamy sand	2.6	Moderately well drained
Urban land	2.4	N/A
Ridgebury fine sandy loam	1.8	Poorly drained
Charlton-Hollis-Rock outcrop complex	0.7	Well drained to somewhat excessively drained
Udorthents	0.1	Variable

Water Resources

Ponds. There are no ponds within the forest.

Wetlands. Wooded swamp areas containing deciduous trees can be found throughout the forest, totaling 14 acres; an additional 10 acres of wooded swamp area, centrally located within the forest, contains a mix of trees. Two smaller areas of shrub swamp, one in the center of the forest and one in the northern portion of the forest, have a combined total of just over seven acres in size. A small bog (0.9 acres), locally known as Spruce Pond, is located within the centrally located shrub swamp. See Figure 6.

Vernal Pools. There is one certified vernal pool located in Warren H. Manning State Forest. In addition, there are five potential vernal pools located within this facility.

Streams. Black Brook enters Warren H. Manning State Forest on the northern boundary and heads south, flowing under Route 129/Chelmsford Road and ends in the bog located in the western portion of the forest (see Figure 6).

Flood Zones. On the northern edge of the property, there are two small areas, totaling 0.09 acres of land, that abut wetlands on neighboring properties that fall within the 100-year flood zone. These same areas expand to cover nearly four acres within the 500-year flood zone.

Rare Species

Priority Habitat has been designated on 72 acres of Warren H. Manning State Forest, encompassing roughly two-thirds of the land between Route 3 and Route 129/Chelmsford Road.

The only rare species recorded here, the blue-spotted salamander, is an amphibian that utilizes wetland habitat for reproduction and upland forest habitat for foraging, both of which are present in this part of the forest (Natural Heritage and Endangered Species Program 2007*b*). This species has a MESA status of Species of Special Concern.

In 2010, MassWildlife and The Nature Conservancy (TNC) issued "BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World" (MassWildlife and TNC 2010). This guide identified two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is "important to conserve the full suite of biodiversity" in Massachusetts (MassWildlife and TNC 2010).

In Warren H. Manning State Forest, there are 72 acres of Core Habitat, covering the same area that has been designated Priority Habitat. Critical Natural Landscape has not been identified at Warren H. Manning State Forest.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified four forest sub-types within Warren H. Manning State Forest (Table 7.2).

Table 7.2. Forest Sub-types of Warren H. Manning State Forest

Forest Sub-type	Acres	% of Forest
Mixed oak	74.1	40.5
Eastern white pine - oak	54.5	29.8
Eastern white pine	25.2	13.8
Red maple - swamp hardwood	1.9	1.0
Total	*155.7*[a]	*85.1*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the forest's boundaries since 2003.

Hardwood species – including oak – are uncommon in the town of Billerica. Most of the hardwood stands in town are located on DCR lands.

As part of the Massachusetts Continuous Forestry Inventory (CFI), a specific area within the forest was visited by DCR Management Foresters in 2000. The CFI is a network of permanent, one-fifth-acre plots on state forest lands that are routinely monitored for sivicultural purposes. The measurements and observations made within each CFI plot are recorded in a database that dates back to 1960, when the CFI was created. Approximately 10% of the state's CFI plots are inventoried each year, on an on-going basis. As of 2010, there were 1,768 CFI plots statewide (Goodwin 2014).

There is one CFI plot within Warren H. Manning State Forest. This even-aged, two storied stand is 55 to 60 years old and comprised of primarily of red maple, along with some white pine and swamp hardwoods, including American elm and gray birch.

As part of the CFI process, DCR Management Foresters also look for signs of disturbances that affect the development of vegetation in the vicinity of each CFI plot. One disturbance agent, snow and ice, was recorded here in 1996.

Priority Natural Communities. There are no Priority Natural Communities within the forest.

Invasive Species. A few invasive species have been observed within the forest by DCR staff however none of these species have been identified in the CFI plot. The invasive species observed here include:

- Common buckthorn (*Rhamnus cathartica*), a deciduous small tree or coarse shrub, has been observed by DCR Foresters. Common buckthorn threatens wetlands, where it can suppress other species, and field edges. It is often spread by seed dispersal through birds.
- Multiflora rose (*Rosa multiflora*) has also been observed here. It is a densely spreading shrub that forms thickets that crowd out native species.
- Japanese knotweed (*Fallopia japonica*) is a shrub-like herbaceous plant that forms dense thickets that crowd out native species and reduce wildlife habitat, posing significant threats in riparian areas in particular. This was observed along the edge of Black Brook during RMP fieldwork.

Pests and Disease. White pine weevil (*Pissodes strobe*) has been identified in Warren H. Manning State Forest. While tree mortality from this pest is low, damage does impact tree health and reduce wood quality. To a lesser extent, gypsy moths (*Lymantria dispar*) and Dutch elm disease have also been observed here.

Wildlife

Birds. There is little current information on the forest's birds. Over 175 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.1.

Mammals. There is little current information on the forest's mammals. Over 45 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.2.

Reptiles. There is little current information on the forest's reptiles. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.3.

Amphibians. There is little current information on the forest's amphibians. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.4. Only one of these, the blue-spotted salamander, has been recorded at this forest.

Fish. There is no current information on the forest's fish.

Cultural Resources

Pre-contact Archaeological Sites

There are no recorded pre-Contact sites recorded in the forest, and no archaeological surveys have been conducted. The physical characteristics, regional setting, and the known patterns of pre-Contact occupation in the region all contribute to a high archaeological potential for the forest.

Historic Archaeological Resources

The remnant of a concrete foundation (MHC Inventory Form #BIL-HA-46) from Manning's office complex is located just north of the Warren H. Manning Office Memorial Stone. A concrete curb covered by vegetation, it appears to have been approximately 12 feet square. Some of the ground cover in the area may be remnant plant material from when the office was in use. From c1911 – c1919, Manning built a series of buildings used by his practice, many of which were ultimately interconnected as spokes to a hub. All but two of the buildings were burned down or demolished after 1938.

The foundation of an outbuilding is located adjacent to Spruce Pond, just south of the Manning Manse property. This foundation of poured concrete has been built into a slope and is open on grade on the low sloped side, with a rustic stone retaining wall extending off the rear corner. In the corner formed by the retaining wall there is an overgrown tree that might date to Manning's involvement with the property.

Outbuilding Foundation (DCR)

Historic Resources

Buildings. There are no historic buildings within the forest.

Structures. Stone wall remnants are located in the southern portion of the property, extending north from Old Rangeway Road. These are dry laid, loose stone walls that are in fair to poor condition.

A concrete pad foundation is located just south of Route 129, near the intersection with Rangeway Road. This foundation, roughly 20 feet by 12 feet, is becoming covered in leafy vegetation and moss. A utility pole that once served this structure is located directly adjacent to the pad and still has some severed wires dangling from it. The structure once located on this site housed a forest fire control building.

A concrete pad is located adjacent to the spray deck, and appears to be the foundation of the former bathhouse that was installed in the 1950s as part of the recreational development. The building was removed in the 2002 improvements to the area.

A former bridge abutment was once located at the end of Old Rangeway Road (MHC Inventory From #BIL-HA-44), however that seems to have been removed in a recent culvert replacement project.

Objects. The Warren H. Manning Office Memorial Stone (MHC Inventory Form #BIL.937) is located east of the entrance, adjacent to the picnic area. This memorial stone marks the location of where Warren Manning's office once stood, when his landscape architecture practice operated seasonally out of Billerica from 1915–1923.

Warren H. Manning Office Memorial Stone(DCR)

The memorial stone marking the location of the office, installed sometime between 1938 and 1950, is inscribed as follows:

HERE STOOD THE OFFICE OF
WARREN H. MANNING
LANDSCAPE DESIGNER
A STUDENT AND LOVER OF NATURE
AND MAN. A PIONEER AND LEADER
IN THE FINE ART OF PLANNING THE
WISE USE OF THE LAND FOR THE
PLEASURE AND BENEFIT OF MANKIND.
1860 – 1938

Some lichen growth is present on the memorial stone.

A concrete marker, approximately 8 inches tall and 3 inches square, is located north of the spray deck area. Possibly a former property boundary marker, the letter "C" is inscribed on one side.

Concrete Marker (DCR)

Landscapes. The forest contains a collection of two miles of woods roads that were used in the 19th century for access to woodlots, and in the 20th century as forest roads for recreational purposes and some administrative access. These unpaved roads, approximately eight feet wide in predominantly good to fair condition, vary in terms of level vegetative growth in the road pathway and make up the bulk of the network of trails in use today.

Recreation Resources

Warren H. Manning State Forest is primarily accessed via motor vehicle. Individuals who live nearby may also choose to walk or ride their bicycle to any one of the trailheads, although the area is not particularly pedestrian friendly. The Lowell Regional Transit Authority offers an additional, though likely underutilized, means of accessing the forest. The nearest stop is about a one mile walk to the main entrance.

Recreation at the state forest includes trail-based activities such as hiking and running, dog walking and cross-country skiing. Geocaching also occurs throughout the forest, with participants both on and off trails. As of November 2013, there were three known geocaches at the state forest.

Hunting is currently allowed in Warren H. Manning State Forest. This activity is not allowed near the spray deck area, but it is still not popular with local residents. During the development of this RMP, some concerns were expressed that hunters may be coming too close to abutting properties.

Some bikers and snowmobilers use the forest as well.

The primary recreational feature at Warren H. Manning State Forest is the spray deck area (see Figure 6). A wading pool was constructed here in the 1950s and was in use until it was replaced in 2002 with the new spray deck equipment. The spray deck, which is managed by the Billerica Recreation Department, is operational from May through the end of September. This area is very popular with young families, and on hot days often reaches capacity (Hannon-Rizza 2013).

Complementing the spray deck area is an adjacent picnic area, located between the spray deck and the parking lot. This picnic area includes 18 picnic tables, three of which are accessible, as well as nine grills for use by visitors. Four of these grills are of the metal variety on a low post, while five are concrete bases on the ground. These grills get occasional use by visitors, more so in the off-season than during the summer months. Twice a year, the Billerica Recreation Department offers an outdoor cooking program here that is very popular with families (Hannon-Rizza 2013).

The Billerica Recreation Department has created a "Story Book Trail," a short trail that loops around a portion of the picnic area and includes a series of 10 wooden and plexiglass wayside panels. These panels have laminated pages of a children's book within each of them, so that it is possible to walk the trail and read a story. These panels are periodically updated with a new book so that visitors can read new stories. This trail was recently marked by local

girl scouts with green trail markers affixed to trees via screws.

The Billerica Recreation Department installed an adult fitness trail in 2012. Complete with fitness equipment composed primarily of powder coated metal piping, the fitness trail has five exercise stations with 19 total pieces of equipment and 11 signs providing instruction for safe use.

Fitness Trail (DCR)

The Billerica Recreation Department offers a pre-school program at the park in the summer. The scheduling of this program is coordinated with an adult fitness program that utilizes the fitness trail equipment, providing a unique recreational opportunity for the parents of these pre-schoolers (Hannon-Rizza 2013).

Infrastructure

Property Boundary

Warren H. Manning State Forest is a 183 acre property that is divided into three blocks of land: a developed area located north of Chelmsford Road/Route 129; an undeveloped area south of Chelmsford Road/Route 129 and bordered on the west by Route 3; and 40 acres (22% of the forest), located west of Route 3 and cut off from the remainder of the forest by the highway. This latter piece is inaccessible to DCR staff and visitors.

Billerica State Forest is located just to the south of Warren H. Manning State Forest, and those portions of Warren H. Manning State Forest that lie south of Chelmsford Road/Route 129 are often considered by the public to be a part of Billerica State Forest. Locals refer to the northern section of the forest that contains the spray deck as Manning Park.

A utility easement cuts through the park, as a part of an underground pipeline that is owned and managed by Tennesse Gas. A trail composed of loose stone is located on the northern segment of this corridor. One access stanchion pole was located during fieldwork, located on the north side of Route 129.

Buildings and Structures

There is one contact station, located at the main entrance and parking area. A small front gabled wooden structure with an asphalt roof, this station is portable, in good condition, and does not have electrical service. It is managed by the Billerica Recreation Department.

Contact Station (DCR)

There is one bathhouse at Warren H. Manning State Forest (see Figure 6). Located adjacent to the parking lot, the bathhouse is open when the park is staffed, and is also managed by the Billerica Recreation Department. It is a side gabled, concrete block structure with a metal roof that has plumbing (on town sewer system) and electrical service. It is in good condition.

Bathhouse (DCR)

The Town of Billerica has expressed interest in developing the recreation area further.

Roads

The access road into the parking lot is the only administrative, paved road within Warren H. Manning State Forest.

There are two miles of unpaved forest roads that pre-date the establishment of the forest and continue to be used for hiking and administrative purposes.

Parking

The only parking lot for the forest is at the main entrance, located off the north side of Chelmsford Road/Route 129 (see Figure 6). This paved lot holds 36 vehicles. There are no designated handicapped parking spaces. West of the main entrance on Chelmsford Road/Route 129, there is room for two or three cars to pull over on the north side of the road in front of a trail head.

Trails

There are approximately 3.4 miles of trails at Warren H. Manning State Forest (see Figure 6). All of the trails are located in the eastern portion of the property. Prior to the construction of Route 3 in 1953, some trails went through the northwestern portion of the forest, however the installation of Route 3 effectively cut off this western segment of the property, and any trails that were located here have since grown in.

Of these trails, two miles are comprised of unpaved forest roads, with an additional 1.4 miles of narrow trails that are in good to fair condition.

A trail map has not been created by the DCR for Warren H. Manning State Forest and there is no information on the DCR website for the forest or its network of trails. The Town has developed a map that covers the northern section of the park only. This map is available on the Town's website.

Signs and Kiosks

There are no Lead-in signs for this property.

The forest's Main Identification sign is located at the main entrance to the park on Chelmsford Road/Route 129. While the orientation, material and design of this sign does meet DCR signage standards (DCR n.d.), the information regarding management is not entirely accurate as this only applies to the northern section of the forest.

Main Identification Sign (DCR)

One kiosk, maintained by the Billerica Recreation Department, is located at the northern edge of the parking lot. A small mailbox for map distribution is attached to the kiosk, as is a pet waste bag dispenser.

Informational Kiosk (DCR)

The Billerica Recreation Department has created a "Story Book Trail," a short trail that loops around a portion of the picnic area. Ten panels located alongside the trail include the pages of a popular children's book, so that one reads a story from start to finish while walking along this trail.

Memorials and Markers

There is one memorial in Warren H. Manning State Forest, the Warren H. Manning Office Memorial Stone. For information on this memorial, please refer to the Cultural Resources section.

Other

Residents along the southeast side of Rangeway Road have installed their mailboxes across the street on the forest property, possibly within the road right-of-way.

Illegal Activities

At the southern end of the forest, just off the southernmost trail head off of Rangeway Road, tire dumping has been occurring. This appears to be relatively recent dumping, but may have occurred multiple times.

Dumping Area (DCR)

7.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Vegetation

In the past, the DCR used to allow Home Fuelwood harvests to occur at this state forest. However, since this property has been designated as a Parkland through the Landscape Designation process, this activity is no longer allowed at this facility.

The vegetation in the gas pipeline corridor is managed by Tennessee Gas.

Wildlife

The DCR does not actively manage wildlife at Billerica State Forest; however the hunting of game species is permitted.

Cultural Resources

The DCR's Office of Cultural Resources hired a team of cultural resource management professionals to undertake a survey of cultural resources at Warren Manning State Forest in 2002. The aforementioned MHC Inventory Forms are a result of that effort.

Recreation Resources

The Town of Billerica, through its Recreation Department, has been operating the recreation area in the northern section of the forest since 1990. A series of Special Use Permits formalizing this arrangement were in place from 1990 through December 2004. Attempts were made to get a new permit in place for the 2005 recreation season, but appear to have stalled due to questions regarding the collection and retention of revenue by the Town through the parking fees they collected. The conversation began again in 2006, but appears to have gone nowhere since then. Despite this, the Town continues to operate the area and has since invested in the property with the installation of the fitness equipment. This installation was done in consultation with the DCR Operations staff, however the town typically does not consult with the agency on smaller projects, volunteer requests and programming.

Hunting is currently allowed in Warren Manning State Forest.

Infrastructure

The parking lot, spray deck, bathhouse and "Story Book Trail" are all managed by the Billerica Recreation Department, as part of the Town's management of the northern section of the forest. The Town charges a parking fee of $3.00, and a season pass is available for $35.00. This revenue goes to the Town to help offset their operational costs.

Interpretive Services

There are no formal interpretive service programs provided here by DCR or by the Town of Billerica.

Operational Resources

DCR Staffing

DCR does not maintain a staff presence on site. DCR staff does periodically drive through the property in the off season, when the town does not actively manage the recreation area.

Supplemental Staffing

The Billerica Recreation Department provides seasonal staffing for the northern portion of the forest. There is staff at the facility seven days a week, from 8:30am to 6pm, from May through the end of September. There is one person on duty at a time, and they are responsible for collecting parking fees, maintaining the restrooms and the trash, and doing periodic walk-throughs of the facility (Hannon-Rizza 2013). Billerica Recreation Department staff manages the Town programming at the site.

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A forest road in Billerica State Forest. (DCR)

SECTION 8. BILLERICA STATE FOREST

8.1. INTRODUCTION

Billerica State Forest is a 141-acre undeveloped property located in the northwest part of the town. Utilized primarily by local residents, due to a lack of parking, the network of trails and forest roads provide hikers with an opportunity to access nature in an otherwise dense suburban setting.

8.2. HISTORY OF PROPERTY

Billerica State Forest is located in an area that was not heavily settled through the 17th, 18th and 19th centuries (MHC 1980*e*). Gilson Hill is named for an early settler of Billerica, Samuel Gilson. The name first began appearing on maps in 1853. Maps from the 19th century show this area as being wooded and undeveloped; it was utilized for logging, with wood lots in active use until the turn of the 20th century.

In 1908, Warren H. Manning and John E. Rowell gifted about 25 acres of land that included Gilson Hill to the Appalachian Mountain Club (AMC), who in turn entered into a maintenance agreement with the Billerica Improvement Association (Rockwell 2002; Shepard 1913). Several other landowners soon followed their lead, encouraged by Manning and his efforts to promote and create public woodlands in town, with a particular focus on developing a town forest system in Billerica. Manning developed the Billerica Town Forest Plan in the mid-1920s, and it was accepted by the Town in 1926. He suggested in this plan that Gilson Hill be named Start Forest, in honor of Edwin F. Start, the first Commissioner of the Massachusetts Forest Commission. Manning also suggested names for the trails through this property, many of them for friends and family members, however none of his naming suggestions were ever implemented (Rockwell 2002).

The property was sold by the AMC to the Commonwealth in 1934, along with two other AMC properties (one in Carlisle and one in Warwick), at which time it was renamed Billerica State Forest. In 1953, the Old Middlesex Turnpike was realigned, and the new Middlesex Turnpike (Route 3) cut through a portion of the property, leaving a small portion of the forest on the western side of Route 3, impacting the trail system and leaving this parcel inaccessible.

In the late 1960s and early 1970s, local interest in developing Gilson Hill into a downhill ski facility led to legislation in 1971 authorizing a transfer of this property to the Town of Billerica for this purpose. However, shortly after the town started

planning for the ski area, it was determined that the transfer was not possible due to a stipulation in the original conveyance. The deed stated that if the land were ever discontinued as a state forest it would revert to the AMC. Local pressure on the Commonwealth to develop this for ski purposes followed, but the Department of Natural Resources (DNR), a predecessor to the Department of Conservation and Recreation, staff did not feel this was possible without considerable earth moving, and did not pursue this plan (DNR 1975).

Billerica State Forest was also considered as a potential location for a regional headquarters in 1973-1974, but that plan did not move forward either (Cook 1973; Maisner 1974).

8.3. EXISTING CONDITIONS

Natural Resources

Physical Features

Topography. The primary topographic feature of Billerica State Forest is Gilson Hill (see Figure 7). At 310 feet above sea level, Gilson Hill is the second highest point in Billerica. Large glacial erratics dot the slopes of the hill, and rolling uplands surround the base of the hill.

Geology. Billerica State Forest lies within the Nashoba terrane, and the bedrock of the area includes gneiss, schists and Andover granite, a pink to buff colored granite that has a granular texture (Skehan 2001). The gneiss and schists are metamorphic rocks that may have originated as volcanic rocks. Gilson Hill, like the other low lying hills in Billerica, is a glacial drumlin covered in glacial till (Northern Middlesex Council of Governments 2008).

Soils. Over half of the state forest is covered in Paxton fine sandy loam soils, found on the convex side slopes of glaciated hills. This soil is often found alongside Montauk, Charlton and Woodbridge soils in upland areas, which are also located here. Between the stoniness of these soils and septic tank limitations due to slow percolation rates, land composed of these soils are often woodland (Peragallo 2009). Scituate fine sandy loam, found on the slopes of uplands, is also found here. All of these soils have moderate to high potential productivity for forestry. These soil types generally present slight to moderate limitations with regards to path and trail development, as well as to picnic area and playground development (Peragallo 2009).

Table 8.1. Soils of Billerica State Forest

Soil Series	% of Forest	Drainage Class
Paxton fine sandy loam	46.8	Well drained
Woodbridge fine sandy loam	12.4	Moderately well drained
Charlton fine sandy loam	9.0	Well drained
Charlton-Hollis-Rock outcrop complex	8.8	Well drained to somewhat excessively drained
Montauk fine sandy loam	8.2	Well drained
Scituate fine sandy loam	6.5	Moderately well drained
Hinckley loamy sand	2.8	Excessively drained
Windsor loamy sand	2.8	Excessively drained
Swansea muck	1.4	Very poorly drained
Deerfield loamy sand	0.7	Moderately well drained
Whitman fine sandy loam	0.6	Very poorly drained

Water Resources

Billerica State Forest is largely upland, with little in the way of water resources within this facility.

Ponds. There are no ponds within the forest.

Wetlands. There are three small wetland areas within Billerica State Forest (see Figure 7). The largest one is a 0.8-acre wooded swamp, composed of deciduous trees. There is also a 0.46-acre shallow marsh meadow or fen, and a 0.08-acre shrub swamp.

Vernal Pools. There is one potential vernal pool at Billerica State Forest.

Streams. There are no streams within the forest.

Groundwater. There are no aquifers beneath Billerica State Forest.

Flood Zones. There are no flood zones within the forest.

Placeholder for Figure 7.

Rare Species

Priority Habitat has been designated on 26 acres of Billerica State Forest, encompassing a semi-circular shaped area on the northern boundary of the forest, extending northwest from the intersection of Treble Cove Road and Winning Street.

The only rare species recorded here, the blue-spotted salamander, is an amphibian that utilizes upland forest habitat for foraging (NHESP 2007*b)*. This species has a MESA status of Species of Special Concern.

In 2010, MassWildlife and The Nature Conservancy (TNC) issued "BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World" (MassWildlife and TNC 2010). This guide identified two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is "important to conserve the full suite of biodiversity" in Massachusetts (MassWildlife and TNC 2010).

In Billerica State Forest, there are 26 acres of Core Habitat, the same area that has been designated as Priority Habitat. Critical Natural Landscape has not been identified at Billerica State Forest.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified four forest sub-types within Billerica State Forest (Table 8.2).

Table 8.2. Forest Sub-types of Billerica State Forest

Forest Sub-type	Acres	% of Forest
Mixed oak	124.7	88.4
Eastern white pine – oak	10.2	7.2
Eastern white pine	1.4	1.0
Norway spruce - white spruce	1.3	0.9
Total	*137.6*[a]	*97.5*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the forest's boundaries since 2003.

Hardwood species, including oak and maple, are uncommon in Billerica. Most of the hardwood stands in town can be found within Billerica and Warren H. Manning state forests. The stand of Norway spruce – white spruce is a small plantation stand that may date to Warren Manning's involvement with the property. Images of Norway Spruce appear in his slide collection, and his autobiography notes that some planting was done on the land he owned in Billerica with his staff as part of their training (Manning n.d.). There is a stand of some very large eastern white pine trees along the northern border of the property, adjacent to Winning Street, which is still a town road and may in fact fall within the road right of way.

As part of the Massachusetts Continuous Forestry Inventory (CFI), a specific area within this forest was visited by DCR Management Foresters in 2000. The CFI is a network of permanent, one-fifth-acre plots on state forest lands that are routinely monitored for silvicultural purposes. The measurements and observations made within each CFI plot are recorded in a database that dates back to 1960, when the CFI was created. Approximately 10% of the state's CFI plots are inventoried each year, on an on-going basis. As of 2010, there were 1,768 CFI plots statewide (Goodwin 2014).

There is one CFI plot within Billerica State Forest. The trees in this CFI plot range in age from approximately 75 to 100 years and the stand is comprised mostly of mixed oak with maple and birch associated with this sub-type. This stand has an even-aged, two-storied structure.

As part of the CFI process, DCR Management Foresters also look for signs of disturbances that affect the development of vegetation in the vicinity of each CFI plot. One disturbance agent, likely gypsy moth, was recorded here in 1981.

Priority Natural Communities. There are no Priority Natural Communities within Billerica State Forest.

Invasive Species. A number of invasive species have been observed at Billerica State Forest by DCR Management Foresters. Surprisingly however, none of these invasive species have been identified in the CFI plot. The invasive species observed here include:

- Common buckthorn (*Rhamnus cathartica*), a deciduous small tree or coarse shrub that threatens wetlands and field edges, where it can suppress other species. It is often spread by seed dispersal through birds.
- Garlic mustard (*Alliaria petiolata*), a biennial herb that can spread rapidly, displacing native vegetation and in turn altering habitat. Garlic mustard is very difficult to eradicate.
- Multiflora rose (*Rosa Multiflora*), a densely spreading shrub that forms thickets that crowd out native species.
- Japanese knotweed (*Fallopia japonica*) is a shrub-like herbaceous plant that forms dense thickets that crowd out native species and reduce wildlife habitat, posing significant threats in riparian areas in particular.
- Winged burning bush (*Euonymus alatus*), also known as winged euonymus or burning bush, is a deciduous shrub that forms dense thickets that crowd out native species.
- Japanese barberry (*Berberis thunbergii*), a spiny shrub that forms dense stands that can displace native plants and reduce wildlife habitat and forage. Barberry also harbors deer ticks that have the potential to carry the Lyme disease bacteria, functioning as a nursery of sorts for juvenile ticks (Benson 2011).
- Privet, a rapidly maturing semi-evergreen shrub that forms dense thickets that crowd out native species.

Pests and Disease. Billerica State Forest has experienced issues with gypsy moths, defoliators that commonly feed on oak, which is prevalent here. White pine weevil and bark beetles have also been observed here, although to a lesser extent.

Wildlife

Birds. There is little current information on the forest's birds. Over 175 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.1.

Mammals. There is little current information on the forest's mammals. Over 45 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.2.

Reptiles. There is little current information on the forest's reptiles. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are listed in Appendix G, Table G.3.

Amphibians. There is little current information on the forest's amphibians. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the forest, are identified in Appendix G, Table G.4. Only two of these, the blue-spotted salamander and American toad, have been recorded at this forest.

An American toad observed during fieldwork. (DCR)

Fish. There is no current information on the forest's fish.

Cultural Resources

Pre-contact Archaeological Sites

One pre-Contact site is recorded in the forest, but no data is available on it. There are many sites recorded adjacent to the forest including Woodland (1650 - 450 B.P.) and Late Archaic Period (5000-3000 B.P.) campsites, a village site, and burials. The physical characteristics, regional setting, and the confirmed

nearby pre-Contact occupation of the area, all confer a high archaeological potential for the forest.

Historic Archaeological Resources

Remnants of a 19th century sawmill are reportedly located off of Rangeway Road. This site was recorded in 2002 on a Massachusetts Historical Commission (MHC) Inventory Form (in MHC Area form #BIL.S), but the site could not be located during the fieldwork for this RMP.

Evidence of quarrying activity has been located in the northwestern portion of the forest, along the northern border of Gilson Hill. Waste stone with drill scars are visible. An MHC Inventory Form completed in 2002 (#BIL.S) noted two depressions that were likely the site of the quarrying, but these were not specifically located during the RMP fieldwork.

Historic Resources

Buildings. There are no historic buildings within the forest.

Structures. Remnants of stone walls can be found in Billerica State Forest, along the southwest and northern edges of the forest where the slope is low. These are dry laid walls, constructed using the large glacial till located on site. These remnants are in fair to poor condition, and are starting to fall apart.

Objects. The Rowell Memorial Stone (MHC Inventory Form #BIL.938) is located near the top of Gilson Hill. A glacial erratic that is approximately six feet wide, by 10 feet long, by three feet high, this stone contains the following inscription, in all block letters, on the north side of the boulder:

JOHN EDWIN ROWELL
MEMORIAL

John Rowell, a Billerica resident who was active in conservation, along with Warren Manning donated the land at Gilson Hill to establish the AMC Reservation here in 1908. It is suspected that the memorial inscription was completed shortly after Rowell's death in 1927.

Inscription on Rowell Memorial Stone (DCR)

This same stone was historically called Indian Rock, due to the three large holes on the top of the boulder that are thought to have been evidence of use for grinding, a remnant of pre-contact Native American use of the area.

Grinding holes located on top of the Rowell Memorial Stone. (DCR)

Lichen growth is impacting the resource, and the inscription is becoming difficult to read, resulting in a condition assessment of unsatisfactory.

Landscapes. The core of Billerica State Forest, Gilson Hill, includes a system of nearly one-and-a-half miles of connected wood roads that were used in the 19th century for access to woodlots, and in the 20th century as forest roads for recreational purposes and administrative access. These unpaved roads, approximately 8 to 10 feet wide, vary in terms of level vegetative growth in the road pathway, and are a part of the network of trails in use today. These roads were a part of the appeal of the property to Warren Manning when he set out to protect this land for public enjoyment.

Slide from a lecture Warren Manning gave to the Billerica Improvement Association. Source: Iowa State Library – Warren H. Manning Digital Collection

Recreation Resources

Billerica State Forest is primarily accessed via motor vehicle or on foot by local residents. Individuals who live nearby may walk or ride their bicycle to any one of the trailheads, although the area is not particularly pedestrian friendly. There are no public transit options to reach this forest.

Recreation resources are limited to a network of nearly three miles of trails on the eastern portion of the forest. These trails are used primarily for hiking, as well as some dog walking, mountain biking, snowshoeing and cross-country skiing. The construction of Route 3 in 1953, which cut off a small segment of the northwest portion of the forest, disrupted trail access to this area. This segment of the forest is now inaccessible for use.

Hunting is currently allowed in Billerica State Forest.

There is one known geocache located here as of August 2013.

There are no camping facilities at Billerica State Forest, and back country camping is not allowed here. However, a makeshift lean-to using tree branches and other camping materials (e.g., tarps and other debris) was observed just west of the peak of Gilson Hill. The landscape adjacent to this area also showed evidence of minor fire damage in the past, although it is unclear if this came about through unauthorized camping or a natural cause, such as lightning.

A stone fire ring (not recently used) was also found along one of the forest roads at the top of Gilson Hill, along with evidence of its use as a party spot.

Infrastructure

Property Boundary

Billerica State Forest is a 141-acre undeveloped property located in the northwest part of Billerica, south of Rangeway Road and Winning Street (a town road that is partially gated off from use), lying primarily in between Treble Cove Road and Route 3. A small and inaccessible portion of the forest – 12 acres (8.5%) – is located just west of Route 3 (see Figure 7).

Warren H. Manning State Forest is located just to the north of this property, and the southern portion of that property is often considered by the public to be a part of Billerica State Forest.

Buildings and Structures

There are no buildings and structures within Billerica State Forest.

Roads

There are no paved roads within Billerica State Forest.

There are 1.4 miles of unpaved forest roads that pre-date the establishment of the park and continue to be used for hiking and administrative purposes.

Parking

There are no designated parking areas for Billerica State Forest. There is a place to pull off and park one vehicle in front of the northernmost gate along Treble Cove Road. This lack of access not only discourages use, but also prevents DCR staff and first responders from being able to enter the forest at that gate in the event of an emergency.

Parking also occurs informally at the gated end of Winning Street, which is not a part of the forest, but is a town road.

Trails

There are approximately 2.8 miles of trails at Billerica State Forest, 2.6 miles of which are legal trails. All of the trails are located in the eastern portion of the property. Prior to the construction of Route 3, some trails went through the northwestern

portion of the forest. However the installation of Route 3 effectively cut off this western segment of the property, and the trails that were located here have since been lost to vegetation.

Forest roads make up just about half of the trail system, with almost 1.5 miles of unpaved forest roads that pre-date the establishment of the forest. These historic pathways were mapped and evaluated in 2008, at which time it was determined that approximately 70% were in fair condition, while the remaining 30% were in poor condition.

The remainder of the trail network consists of approximately 1.2 miles of trails, 80% of which were deemed to be in fair condition; the remaining 20% of trails were categorized as poor.

It is worth noting that the percentage of trails rated as poor is higher than normal, and none of the trails at Billerica State Forest were determined to be in good condition. This is likely due, in part, to low visitation rates. Without regular use, vegetative growth impacts both the base and the width of the trail system.

A trail map has not been created for Billerica State Forest, and there is no information on the DCR website for the forest or its network of trails.

Winning Street, which is gated a short way in from Treble Cove Road, continues heading northwest and serves as the functional northern boundary for Billerica State Forest (see Figure 7). This town road is unpaved beyond the gate and is currently not in active use. It is not counted in the total trail mileage as it is not owned by the DCR and not a part of the forest. However, it does serve as a link for several trails from the forest and is used by visitors for recreational purposes.

Signs and Kiosks

There are no Lead-in or Forest Entrance signs for Billerica State Forest.

There are no informational kiosks at Billerica State Forest.

Memorials and Markers

There is one memorial in Billerica State Forest, the Rowell Memorial Stone. For information on this memorial, please refer to the Cultural Resources section.

Other

There are a set of fire hydrants along Treble Cove Road. These hydrants are located within the road right of way, are owned by the town, and maintained by the Billerica Water Department (Conway 2013).

Illegal Activities

Debris has been collecting near the eastern edge of the property, adjacent to Winning Street, reflecting some illegal dumping activity. The top of Gilson Hill also appears to be used as a party spot, with debris and a makeshift fire ring found in the area during fieldwork.

8.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

Natural Resources

Vegetation

Vegetation around fire hydrants is maintained by the Billerica Water Department.

Wildlife

The DCR does not actively manage wildlife at Billerica State Forest; however the hunting of game species is permitted.

Cultural Resources

The DCR's Office of Cultural Resources hired a team of Cultural Resource Management professionals to undertake a survey of cultural resources at Billerica State Forest in 2002, resulting in the completion of the MHC Inventory Form for the Rowell Memorial Stone.

Recreation Resources

There are no unique recreation resource management practices at this property, beyond the trail maintenance practices described under Infrastructure.

Infrastructure

Buildings and Structures

The Town of Billerica owns the fire hydrants located alongside Treble Cove Road, within the road right-of-way; these hydrants are maintained by the Billerica Water Department. There is no Memorandum of Agreement (MOA), or similar document, between the DCR and the town that guides this management activity.

Roads

The DCR's Forest Fire Control District 6 provides forest road maintenance on an annual basis.

Trails

Trail maintenance is performed on a limited basis by DCR staff, and is typically at the request of the DCR's Forest Fire Control District 6 to meet their access needs.

Interpretive Services

Interpretive service programming is not offered at Billerica State Forest, nor is any other interpretive information provided.

Operational Resources

Billerica State Forest does not have any full or part-time DCR staff on site.

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The Concord River, as viewed from Governor Thomas Dudley State Park. (DCR)

SECTION 9. GOVERNOR THOMAS DUDLEY STATE PARK

9.1. INTRODUCTION

Governor Thomas Dudley State Park is the smallest facility in the Lowell/Great Brook Planning Unit, just under 11 acres in size. The park is located off of Dudley Road in Billerica, a locally designated scenic road, providing access to the Concord River (see Figure 8). Access to the property is through an adjacent parcel of Town of Billerica conservation land, as there is no frontage on Dudley Road. Other abutting properties include a parcel owned by the Department of Fish and Game (DFG) and a parcel that is part of the Great Meadows National Wildlife Refuge. This park is approximately one quarter of a mile from the town line with Bedford.

The three properties now owned by the DCR, DFG and Town of Billerica was once a single 21 acre parcel that was split and acquired by these three entities for conservation purposes. A management agreement between these organizations exists, and the Town of Billerica is the primary management and enforcement authority for all three parcels.

This park is located within the Two Brothers Rocks-Dudley Road National Register Historic District, which is located in both Billerica and Bedford. This property was identified in the Massachusetts Scenic Landscape Inventory of 1982.

This section of the Concord River is also within the Sudbury, Assabet and Concord National Wild and Scenic Rivers designation and the Sudbury/Concord River Valley State Important Bird Area, as recognized by the National Audubon Society (National Park Service 2008; National Audubon Society 2008).

9.2. HISTORY OF PROPERTY

Part of a 1637 Massachusetts General Court land grant of 1,000 acres to then Deputy Governor Thomas Dudley, this area was known at the time as Dudley Farm. Sold in 1652 in several parcels, the farm became an early focus of settlement in Billerica (Broomer 2010). The land along this section of Dudley Road became a part of the Stearns family farm holdings in the late 17th century, and stayed in the family until 1850 when Moses Greenwood purchased the property. The western edge of the Greenwood property along the Concord River was known as Greenwood Grove as early as 1891, and likely functioned as a picnic grove. By 1910, the Greenwood family owned 10 cottages on the property, probably providing a source of income in

Placeholder for Figure 8.

the form of summer rentals. The cottage community grew to 17 by 1930, but was back down to 10 by 1939, and by 1950 only six remained (Broomer 2010). No cottages survive.

Parcels of Greenwood Grove began to be subdivided and sold off in the late 1970s. In 1985, 24 acres of the former Greenwood property were sold for the development of a subdivision known as Heatherwood Estates, with 17 individual homesites planned. In January 1988, three adjoining parcels in Billerica were jointly acquired from the developer for open space protection by the Town of Billerica, the Department of Environmental Management (the DCR's predecessor agency), and the Department of Fisheries, Wildlife and Environmental Law Enforcement (the DFG's predecessor), totaling approximately 21 acres. Acquisition of this land occurred in part to contribute to the Massachusetts Bay Circuit Trail land protection efforts. A cooperative management agreement among these three entities details how the entities agreed to manage the land. Lands adjacent to these three properties are also protected as part of the Great Meadows National Wildlife Refuge property, which is owned by the US Fish and Wildlife Service (USFWS).

9.3. EXISTING CONDITIONS

Natural Resources

A portion of the Great Meadows National Wildlife Refuge abuts Governor Thomas Dudley State Park along the park's western border. The Final Comprehensive Conservation Plan for the wildlife refuge identifies a wide range of natural resources within the property (USFWS 2005). It is worth noting that some of the resources identified within the refuge, particularly flora and fauna, may also exist within the state park.

Physical Features

Topography. The topography is rolling uplands, with a high point of approximately 150 feet above sea level roughly in the middle of the property, and decreasing elevations to the eastern side and on the western side, by the Concord River.

Geology. Falling within the Nashoba terrane, the bedrock of the area surrounding Governor Thomas Dudley State Park is largely Andover granite, commonly pink granite with a granular texture. (Skehan 2001).

Soils. Soils for this property are primarily Merrimac fine sandy loam, with some concentrations of Hinckley loamy sand. The Merrimac fine sandy loam is a very deep, somewhat excessively drained soil. The Hinckley loamy sand deposits in the Concord River Valley are three to four feet thick, and are underlain by glacial till (Northern Middlesex Council of Governments 2005). These soil types are formed in glaciofluvial deposits. Both types have primarily slight limitations for path and trail development, with some moderate to severe limitations in areas where the slope is above 15% (Peragallo 2009).

Table 9.1. Soil Types of Governor Thomas Dudley State Park

Soil Type	% of Park	Drainage Class
Merrimac fine sandy loam	66.3	Somewhat excessively drained
Hinckley loamy sand	22.3	Excessively drained
Deerfield loamy sand	9.3	Moderately well drained
Rippowam fine sandy loam	1.5	Poorly drained
Saco mucky silt loam	0.3	Very poorly drained
Windsor loamy sand	0.03	Excessively drained

Water Resources

Ponds. There are no ponds within the park.

Wetlands. There is a small shrub swamp, less than a half acre in size, located in this park.

Vernal Pools. There are no vernal pools within the park.

Streams. Governor Thomas Dudley State Park lies on the eastern shore of the Concord River, a 16 mile long river that drains an area of 27 miles. The Concord River has slow moving characteristics and little change in elevation along its length (USFWS 2005). A portion of the Concord River, including the section that abuts the park, has been designated as a Wild and Scenic River. The Town of Billerica utilizes the Concord River as its sole source of drinking water (Northern Middlesex Council of Governments 2005).

Groundwater. There are no aquifers beneath the park.

Flood Zones. A small half-acre section of the western most edge of the park, alongside the Concord River, falls within the 100-year flood zone.

Rare Species

No part of Governor Thomas Dudley State Park falls within land that has been designated as Priority Habitat. A very large swath of land just south of the park, extending into the western edge of Bedford and encompassing much of the northern half of Concord is currently designated as Priority Habitat.

In 2010, MassWildlife and The Nature Conservancy issued "BioMap 2: Conserving the Biodiversity of Massachusetts in a Changing World" (MassWildlife and TNC 2010). This guide identified two types of areas important for conservation: Core Habitat and Critical Natural Landscape. The first is crucial for the long-term persistence of rare species and other species of conservation concern. The second provides habitat for wide-ranging native wildlife, supports intact ecological processes, maintains connectivity among habitats, enhances ecological resilience, and buffers aquatic Core Habitats to help ensure their long-term integrity. Protection of both areas, which may overlap, is "important to conserve the full suite of biodiversity" in Massachusetts (MassWildlife and TNC 2010). The entire park has been designated Core Habitat, and three-and-a-half of these acres (33%) have also been designated as Critical Natural Landscape.

Despite the lack of Priority Habitat designation within this facility, two rare species have been identified by the Natural Heritage and Endangered Species Program (NHESP) here: Blanding's turtle and river bulrush.

Blanding's turtles are reptiles that use both wetland and upland habitats and travel long distances during their active season (NHESP 2007a). This species has a MESA status of Threatened.

River bulrush, a plant, was formerly protected under MESA but has been delisted, and is now on the NHESP Plant Watch list, which is a non-regulatory tool. It is robust perennial sedge that can be found on river shores and in floodplains.

Vegetation

Forest Types. In 2003, the James W. Sewall Company developed a forest inventory/land cover classification dataset for the state forests and parks. The dataset is primarily based on the interpretation of infrared aerial photography, a process that identified two forest sub-types within Governor Thomas Dudley State Park (Table 9.2).

Table 9.2. Forest Sub-types of Governor Thomas Dudley State Park

Forest Sub-type	Acres	% of Park
Eastern white pine - hardwoods	8.1	73.6
Eastern white pine	1.7	15.5
Total	*9.8*	*89.1*

a. The difference in total acreage is due to the exclusion of wetlands and areas of open water, as well as changes in the park's boundaries since 2003.

The 2008 Billerica Open Space and Recreation Plan Update identified the predominant species in town as red oak and white pine, noting that white pine thrives in this area (Northern Middlesex Council of Governments 2008).

There are no Continuous Forest Inventory (CFI) plots within Governor Thomas Dudley State Park providing additional site specific data for any part of this property.

Priority Natural Communities. There are no Priority Natural Communities within Governor Thomas Dudley State Park.

Invasive Species. No information has been located to date on invasive species within Governor Thomas Dudley State Park.

Pests and Disease. No information has been located to date on pests and disease within Governor Thomas Dudley State Park.

Wildlife

Birds. There is little current information on the park's birds. Over 175 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the park, are listed in Appendix G, Table G.1. The Final Comprehensive Conservation Plan for the wildlife refuge also contains information that may apply here (USFWS 2005).

Mammals. There is little current information on the park's mammals. Over 45 species that have been

identified in some of the other facilities in this planning unit, and may possibly occur within the park, are listed in Appendix G, Table G.2. The Final Comprehensive Conservation Plan for the wildlife refuge also contains information that may apply here (USFWS 2005).

Reptiles. There is little current information on the park's reptiles. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the park, are listed in Appendix G, Table G.3. Only one of these, Blanding's turtle, has been recorded at this park. The Final Comprehensive Conservation Plan for the wildlife refuge also contains information that may apply here (USFWS 2005).

Amphibians. There is little current information on the park's amphibians. Over 15 species that have been identified in some of the other facilities in this planning unit, and may possibly occur within the park, are listed in Appendix G, Table G.4. The Final Comprehensive Conservation Plan for the wildlife refuge also contains information that may apply here (USFWS 2005).

Fish. A small portion of the boundary of this property is at the edge of the Concord River. The Final Comprehensive Conservation Plan for the wildlife refuge identifies 19 different species of fish, including several common varieties of pike, perch and trout (USFWS 2005). The plan also notes an alewife recovery program that was underway while the plan was being written (USFWS 2005). Many of these species may be present in the waters off of Governor Thomas Dudley State Park.

Cultural Resources

Pre-contact Archaeological Sites

Governor Thomas Dudley State Park has not been systematically surveyed and contains no recorded pre-Contact sites. The physical characteristics, regional setting, and the known patterns of pre-Contact occupation in the region all confer a high archaeological potential for the park.

Historic Archaeological Resources

Governor Thomas Dudley State Park has not been systematically surveyed and contains no recorded historic archaeological sites.

Historic Resources

Buildings. There are no historic buildings within the park.

Structures. A small stretch of dry laid stone wall can be found on this property, and more of the historic system of walls can also be seen on adjacent properties. This wall is in fair to poor condition.

Objects. There are no historic objects within the park.

Landscapes. The primary entrance trail into the property is a former cart path that passes through the Town of Billerica conservation land, and has an aging allee of white pine trees. The majority of this allee is on the town owned land, but the western end of it does fall on DCR property. This historic allee may be a remnant from Greenwood Grove.

White Pine Allee (DCR)

Recreation Resources

Governor Thomas Dudley State Park is primarily accessed via motor vehicle. There are no public transit options to reach this park.

Recreation resources within Governor Thomas Dudley State Park consist of a small network of trails for passive walking and hiking use. These trails connect the DCR parcel to the adjacent town, DFG and USFWS lands. There is no boat access to the river.

One picnic table is located alongside the entrance trail, providing a place to rest about halfway between the entrance and the western edge of the property.

There is one known geocache located here as of November 2013.

Infrastructure

Property Boundary

Governor Thomas Dudley State Park is an 11 acre undeveloped property located in the southwest corner of Billerica, very close to the town line with Bedford (see Figure 8). The park is located west of Route 4, and east of the Concord River. A small portion of the western property line abuts the river itself. Directly to the north is property owned by the DFG, and to the east is property owned by the Town of Billerica. These parcels are collectively managed by the town. Much of the western boundary abuts a portion of the Great Meadows Wildlife Refuge, which is managed by the USFWS, and to the south is private property.

No boundary markers were noted during fieldwork, and only one trail marker was located.

Buildings and Structures

There are no buildings or structures at Governor Thomas Dudley State Park.

Roads

There are no roads in Governor Thomas Dudley State Park. The main entrance trail on the property, a former cart path, is wide enough at the entry to be gated, but it quickly narrows.

Parking

There is no parking on the DCR portion of Governor Thomas Dudley State Park. This parcel does not have frontage access on nearby Dudley Road.

One small unpaved parking area is located off of Dudley Road on the adjacent parcel owned by the Town of Billerica. This lot can fit approximately six vehicles.

Trails

There are 0.4 miles of trails in good to fair condition within Governor Thomas Dudley State Park (see Figure 8). With the exception of the main entrance trail, a former cart path, the trails are narrow in nature and do not appear to be extensively utilized. Primary use of these trails is for walking and hiking. These trails connect to a similar system of trails that fall on the DFG land, with some leading further north, into the Great Meadows Wildlife Refuge.

Signs and Kiosks

There is currently no signage at this facility of any kind, and as a result, visitors and local residents are not entirely familiar with the ownership or management of the property. There are no kiosks providing any information. The management agreement between the Town, DCR and DFG stipulated that the three agencies would provide identification and informational signage, as well as a trail map for the property, but it does not appear as if this occurred.

Memorials and Markers

There are no memorials and markers in Governor Thomas Dudley State Park.

9.4. Management Resources and Practices

See Section 2, Management Resources and Practices, for a description of the management resources and practices that apply to the entire Lowell/Great Brook Planning Unit.

The facility is managed by the Billerica Conservation Commission as per the management agreement between the Commonwealth and the Town. This agreement is supposed to be reviewed every five years; however DCR staff indicates that this does not currently occur.

Despite the lack of management responsibilities here, DCR Operations staff does periodically walk through the facility.

Natural Resources

The DCR does not actively manage the natural resources at this park.

Cultural Resources

The DCR does not actively manage the cultural resources at this park.

Recreation Resources

The DCR does not actively manage the recreational resources at this park. As per the management agreement, trails are to be managed by the Town of Billerica.

Hunting is not allowed at Governor Thomas Dudley State Park.

Infrastructure

With the exception of the small network of trails, there is no other infrastructure at this park to manage.

A trail map has not been created for Governor Thomas Dudley State Park, and there is no information on the DCR website for the park or its network of trails.

Interpretive Services

There are no interpretive services provided at Governor Thomas Dudley State Park, either by DCR, DFG or the Town of Billerica.

Operational Resources

DCR Staffing

Governor Thomas Dudley State Park does not have any full or part-time DCR staff on site.

Supplemental Staffing

The facility is managed by the Billerica Conservation Commission as per the management agreement between the Commonwealth and the Town. This management agreement is supposed to be reviewed by all parties every five years.

Public Safety

As per the management agreement between the DCR, DFG and Town of Billerica, the Town is responsible for policing the property and enforcing use restrictions.

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Pawtucket Falls and Gatehouse (Peter E. Lee; CC BY-NC 2.0; cropped from original)

SECTION 10. RECOMMENDATIONS

10.1. INTRODUCTION

The DCR has a broad and dynamic mission that encompasses resource protection, providing public access to recreational opportunities, and active forest management. This multi-faceted mission often results in complex management challenges. These responsibilities are central to the agency's mission and statutory charge.

To help meet this broad mission, the DCR has developed a two-tier system for guiding the management of all state forest and park properties under its care. The two systems, known as Landscape Designations and Land Stewardship Zoning, work in an integrated fashion to accommodate primary ecosystem services while recognizing and providing site-specific resource protection.

The application of Landscape Designations and Land Stewardship Zoning to properties within the Lowell/Great Brook Planning Unit is summarized below. For a more detailed description of Landscape Designations and Land Stewardship Zoning, please see Appendix I.

10.2. LANDSCAPE DESIGNATIONS

Applied statewide at the property level to assess and guide management activities throughout the DCR system, Landscape Designations are based on primary ecosystem services and guide management decisions based upon these services. The designations also communicate the agency's landscape-level management objectives to the public.

As a result of a robust public process called Forest Futures Visioning, the DCR established the following designations for properties under its jurisdiction:

Reserves. Properties designated as reserves provide backcountry recreational experiences and protect the least fragmented forested areas and diverse ecological settings. Successional processes are allowed to progress unimpeded by human disturbance, and are monitored to assess and inform long-term forest stewardship.

Woodlands. Woodlands demonstrate exemplary forest management practices for landowners and the general public, while supporting the range of ecosystem services that sustainably-managed forests

offer, including a diversity of native species and age classes, and compatible recreational opportunities.

Parklands. Areas designated as parklands focus on providing public recreational opportunities while protecting resources of ecological and cultural significance.

Selection criteria and management guidelines for all three landscape designations are described in *Landscape Designations for DCR Parks & Forests: Selection Criteria and Management Guidelines* (DCR 2012*b*).

Applied Landscape Designations

All properties within the Lowell/Great Brook Planning Unit have been designated as Parklands.

10.3. LAND STEWARDSHIP ZONING

Land Stewardship Zoning, and the resource management planning process of which it is a part, addresses the agency's statutory responsibilities in M.G.L. Chapter 21: Section 2F. The legislation requires the DCR to prepare management plans that encompass all reservations, forests and parks; provide for the protection and stewardship of natural, cultural and recreation resources under the agency's management; and ensure consistency between recreation, resource protection and sustainable forest management.

Land Stewardship Zoning Guidelines

The Land Stewardship Zoning Guidelines define three types of zones to ensure resource protection based upon site-specific field data and provide guidance for current and future management based upon resource sensitivities. The inventory and assessment of resources during the preparation of an RMP is factored into land use management and decision-making, and provides guidance for stewardship of these resources. The process results in zoning of areas and specific sites within DCR properties based on their sensitivity to recreational and management activities that are appropriate for each facility as recognized during the RMP process. In this way, the Land Stewardship Zoning system helps to ensure that recreational and management activities do not degrade various resources and values.

The three land stewardship zones provide a general continuum to categorize resources (relative to potential degradation from human activities) from undisturbed sites with highly sensitive resources, through stable/hardy resources, to sites that have been developed and are consistently used for intensive recreation or park administration purposes. The Land Stewardship Zoning system also includes Significant Feature Overlays that may be applied to highlight resource features that have been assessed and documented by professional resource specialists.

Below is a description on the various zones used for Land Stewardship Zoning.

Zone 1

Management Objective. Protection of sensitive resources from management, or other human activities, that may adversely impact the resources.

General Description. This zone encompasses areas with highly sensitive ecological and cultural resources that require additional management approaches and practices to protect and preserve the special features and values identified in the RMP. Zone 1 areas are not suitable for future intensive development.

Examples. Examples identified as being highly sensitive to human activities include rare species habitat or natural communities, areas with concentrations of sensitive aquatic habitats, excessively steep slopes with erodible soils, and archaeological sites or fragile cultural sites, where stewardship of these resources must be the primary consideration when assessing management and recreational activities in these areas.

Zone 2

Management Objective. Provide for a balance between the stewardship of natural and cultural resources and recreational opportunities that can be appropriately sustained.

General Description. This zone encompasses stable yet important natural and cultural resources. Zone 2 is a very important component to the DCR's management responsibilities, because the protected landscape within this zone provides a buffer for sensitive resources, recharge for surface and groundwater, and large areas where existing types of public recreational activities can be managed at sustainable levels.

Examples. Examples include areas of non-intensive use that contain diverse ecosystems, rare species habitat that is compatible with dispersed recreation and sustainable management practices, and cultural resources that are not highly sensitive to human activities.

Zone 3

Management Objective. Provide public access to safe and accessible recreational opportunities, as well as administrative and maintenance facilities that meet the needs of DCR visitors and staff.

General Description. This zone includes altered landscapes in active use and areas suitable for future administrative, maintenance and recreation purposes. The resources in this zone can accommodate concentrated use and require regular maintenance by DCR staff.

Examples. Examples of areas of concentrated use include park headquarters and maintenance areas, parking lots, swimming pools and skating rinks, paved bikeways, swimming beaches, campgrounds, playgrounds and athletic fields, parkways, golf courses, picnic areas and pavilions, and concessions. Examples of future use areas include disturbed sites with no significant ecological or cultural values that are not suitable for restoration, identified through the RMP or in a Master Plan as being suitable for intensive recreation or park administration sites. Note that development would be preceded by detailed site assessments to ensure protection of natural and cultural resources.

Significant Feature Overlays

Management Objective. Provide precise management guidance in order to maintain or preserve recognized resource features, regardless of the zone in which they occur.

General Description. The three land stewardship zones may be supplemented with Significant Feature Overlays that identify formally designated or recognized resources. These resource features have been recognized through research and assessment by professional resource specialists. Information on the significant features is brought into the RMP process via review of previous research projects and associated designations.

Examples. A natural or cultural resource, recognized through professional inventory or research, which cuts across more than one land stewardship zone, or which is located in an area characterized by intensive visitor use. In the latter case, the Significant Feature Overlay is used to highlight the potential conflict between resource stewardship and ongoing visitor use, and provide mitigation strategies. Examples include:

- National Register Historic District.
- Areas subject to public drinking water regulations.
- Priority Habitat for species that are not sensitive to human activities.
- BioMap 2 Core Habitat.
- Designated Areas of Critical Environmental Concern.
- A NHESP Priority Natural Community associated with a summit that is also a popular destination for hikers.
- A barrier beach that provides habitat for rare shorebirds and is subject to CZM barrier beach management guidelines and coastal wetlands regulations, but also supports thousands of visitors during the summer season.
- A significant cultural site such as Plymouth Rock that is subject to ongoing, intensive visitation.
- A natural or cultural resource, recognized through professional inventory or research, which is located in an area characterized by intensive visitor use.

Applied Land Stewardship Zoning

The following Land Stewardship Zoning is recommended for properties in the Lowell/Great Brook Planning Unit. A figure (i.e., Figure 9, 10 and 11) accompanies each property with more than one type of zoning. The remaining properties, which only have one type of zoning, do not have a corresponding figure.

Lowell-Dracut-Tyngsborough State Forest

Zone 1. Spruce Swamp, home to several rare species and a rare Priority Natural Community, is designated a Zone 1 (see Figure 9).

Zone 2. The remainder of the forest is designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. The main parking area for the forest, located at the end of Trotting Park Road, and the former headquarters site are designated a Zone 3 (see Figure 9).

Significant Feature Overlay. There are no significant feature overlays.

Lowell Heritage State Park

Zone 1. No sections of the park have been designated a Zone 1.

Zone 2. No sections of the park have been designated a Zone 2.

Zone 3. The entire park has been designated a Zone 3. While it is historically significant, it is also an integral part of a heavily developed urban landscape.

Significant Feature Overlay. There are no significant feature overlays.

Great Brook Farm State Park

Zone 1. Due to the sensitivity of the area around "The City," it is designated a Zone 1 (see Figure 10).

Zone 2. The remainder of the park is designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. The portion of the park that includes the active farm complex, the Hart Barn, the North Schoolhouse (home of the park headquarters), and the two largest parking areas in the park, are all designated a Zone 3 (see Figure 10).

Significant Feature Overlay. There are no significant feature overlays.

Carlisle State Forest

Zone 1. No sections of the forest have been designated a Zone 1.

Zone 2. The entire forest has been designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. No sections of the forest have been designated a Zone 3.

Significant Feature Overlay. There are no significant feature overlays.

The Land Stewardship Zoning for Carlisle State Forest should be reviewed following the recommendation to update the large tree inventory, in order to determine if there should be a Zone 1 designation or a Significant Feature Overlay to encompass these resources.

Warren H. Manning State Forest

Zone 1. No sections of the forest have been designated a Zone 1.

Zone 2. The remainder of the forest outside of the active recreation area has been designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. The active recreation area, including the parking lot, spray deck and picnic area, has been designated a Zone 3 (see Figure 11).

Significant Feature Overlay. There are no significant feature overlays.

Billerica State Forest

Zone 1. No sections of the forest have been designated a Zone 1.

Zone 2. The entire forest has been designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. No sections of the forest have been designated a Zone 3.

Significant Feature Overlay. There are no significant feature overlays.

Governor Thomas Dudley State Park

Zone 1. No sections of the park have been designated a Zone 1.

Zone 2. The entire park has been designated a Zone 2; it is not particularly sensitive or heavily developed.

Zone 3. No sections of the park have been designated a Zone 3.

Significant Feature Overlay. There are no significant feature overlays.

Placeholder for Figure 9.

Placeholder for Figure 10.

Placeholder for Figure 11.

10.4. MANAGEMENT RECOMMENDATIONS

Management Principle

The resource management planning process for the Lowell/Great Brook Planning Unit resulted in the following management principle:

Protect the natural and cultural resources of the planning unit and provide enhanced recreational and educational opportunities for visitors through the creative use of state resources and partnerships.

Management Goals

The following management goals have been identified to achieve the management principle. These goals are of equal importance, and are not presented in order of priority.

Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.

Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.

Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.

Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.

Recommendations

These management recommendations have been organized first by the planning unit in its entirety, for those that apply to all or most of the properties, and then by individual property. Each set of recommendations is presented by the management goals identified for the planning unit.

Recommendations are also characterized on the basis of priority (i.e., high, medium or low) and resource availability. High priority recommendations are those that address regulatory compliance or public health and safety; prevent immediate damage to, or loss of, resources; or repair or replace damaged equipment or systems critical to operations. They are typically time sensitive. Medium priority recommendations maintain existing resources and visitor experiences. Low priority recommendations enhance resources or visitor experiences; they are not time sensitive.

Resource availability considers both funding and labor. A resource availability of one (1) indicates that funding and/or labor are available to implement the recommendation. A resource availability of two (2) indicates that funding and/or labor are not currently available, but may become so in the near future (i.e., the next five years). A resource availability of three (3) indicates that funding and/or labor are not anticipated in the next five years. Resources to implement these recommendations may, or may not, become available after five years.

Table 10.1. Recommendations for the Lowell/Great Brook Planning Unit[a]

Recommendation	Priority[b]	Resources[c]	Implementation[d]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Complete the certification process for the potential vernal pools within the planning unit.	M	2	P, M, V
Develop a Vegetation Management Plan to address the invasive species observed within the planning unit.	M	2	P, C, F
Undertake a mapping effort to document the stone walls located on these properties and record their condition.	L	3	P, F
Review and apply the Best Management Practices developed by the Office of Cultural Resources for stone wall protection.	M	1	P, M
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Review and update or create, where appropriate, a trail map for each of the properties in the planning unit, and make the maps available through multiple outlets.	H	1	M, X
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
There are no recommendations associated with this goal.	-	-	-
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Fill the Metro West District Ranger position.	H	3	M
Establish webpages on the DCR website for the properties in the planning unit that currently do not have a webpage.	H	1	M, X

a. These recommendations apply to all, or most, properties in the planning unit.
b. Priorities are High (H), Medium (M), or Low (L).
c. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
d. The following codes identify the party or parties responsible for implementing the recommendation: C = Contractor; E = Division of Engineering; F = Bureau of Forest Fire Control and Forestry; L = Office of the General Counsel; M = Division of MassParks; O = Other; P = Bureau of Planning, Design and Resource Protection; U = Universal Access Program; V = Volunteer or partner; and X = Office of External Affairs and Partnerships.

Table 10.2. Recommendations for Lowell-Dracut-Tyngsborough State Forest

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Work with the Natural Heritage & Endangered Species Program to conduct a survey for the blue-spotted salamander.	M	2	P, M, O, V
Investigate the nature and extent of the Coburn mill site.	L	2	P, M
Acquire additional land in the southern part of the forest, if necessary, in order to protect the Coburn mill site.	L	2	P, L
Remove the debris at the former headquarters site that poses a threat to significant resources (i.e., the pump house cellar hole) and public safety (i.e., glass bottles).	H	1	M, V
Undertake further research on the cellar holes that were not located during the fieldwork for this plan.	L	3	P, M
Stabilize the walls and remove the vegetation from the forest's CCC water holes.	M	2	P, M
Address the culverts within the forest that are blocked and/or collapsing.	H	2	P, M, E
Reposition and clean, where applicable, the stone markers within the forest.	L	2	P, M
Remove the graffiti from Sheep Rock and work with the Environmental Police to curb the illegal activities that take place at the site.	H	2	P, M, O
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Work with the Environmental Police to curb the illegal recreation activities (e.g., off-highway vehicle use and paintball games) taking place at the forest.	H	1	M, O
Post signs that clearly indicate the boundary of the forest's "No Hunting Areas."	H	1	M, F, V
Formalize the main parking area at the forest's main entrance on Trotting Park Road in Lowell; consider signing, paving and expanding the area, lining the spaces and designating at least one accessible space.	M	3	P, M, C
Investigate the options for establishing a more suitable parking area on Trotting Park Road in Tyngsborough.	L	1	P, M
Improve the trail signage within the forest, adding trail names and intersection numbers where appropriate.	H	2	M, F, V
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
Investigate the options for removing the illegal dam on Trotting Park Road in Tyngsborough.	M	1	E

Continued on next page.

Table 10.2. Recommendations for Lowell-Dracut-Tyngsborough State Forest (Continued)

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Renew the agreement with the Greater Lowell Indian Cultural Association (GLICA).	H	2	M, L
Work with the Dracut Water Supply District to address and resolve the issues surrounding the current location of their water supply infrastructure.	M	2	M, L
Establish a formal agreement with the Dracut Water Supply District regarding their access to and maintenance of the water supply infrastructure located on Gage Hill.	M	2	M, L
Arrange a meeting between the Dracut Water Supply District and appropriate DCR staff to discuss their need to replace the reservoir at the forest.	H	1	M, L
Work with the Merrimack Valley Chapter of the New England Mountain Bike Association to review and approve, where appropriate, the existing technical features in the forest.	H	1	P, M, L
Develop a formal agreement with the Merrimack Valley Chapter of the New England Mountain Bike Association regarding the review and approval of their trail maintenance, repair and construction projects within the forest.	H	1	P, M, L
Install a new Main Identification and several Road Marker signs at the forest.	M	1	M, O

a. Priorities are High (H), Medium (M), or Low (L).
b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
c. The following codes identify the party or parties responsible for implementing the recommendation: C = Contractor; E = Division of Engineering; F = Bureau of Forest Fire Control and Forestry; L = Office of the General Counsel; M = Division of MassParks; O = Other; P = Bureau of Planning, Design and Resource Protection; U = Universal Access Program; V = Volunteer or partner; and X = Office of External Affairs and Partnerships.

Table 10.3. Recommendations for Lowell Heritage State Park

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Assess the condition of the interior and exterior of the Rynne bathhouse and make repairs, where necessary.	H	2	P, E, M
Work with the National Park Service to repair the cracked end wall of the Pawtucket Gatehouse.	M	2	P, E, M, V
Meet with the National Park Service to develop and implement a preservation plan for the Hamilton Wasteway Gatehouse.	H	1	P, E, M, V
Work with the National Park Service to remove the Boston ivy from the Boott Dam Gatehouse.	M	2	P, E, M, V
Work with Boott Hydropower, Inc. to assess the condition of the Lowell Canal System and make repairs, where necessary.	L	3	P, E, M, V
Work with Boott Hydropower, Inc. to implement the recommendations featured in the DCR's Office of Dam Safety dam inspection reports for the Northern Canal Great Wall, Guard Locks, Swamp Locks and Lower Locks dams.	L	3	P, E, M, V
Repair the steel rail and granite post fences at the Mack plaza and Victorian garden.	H	3	P, E, M, C
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Post fish consumption advisory signs in multiple, locally spoken languages at popular fishing spots along the Merrimack River and Lowell Canal System.	H	1	M, X, V
Ensure that all of the violations noted in the most recent inspection of the Lord pool are addressed in the upcoming modernization project.	H	1	E, C
Install a bike rack at the Lord pool.	M	2	P, M, C, V
Plant additional trees or construct a shade structure(s) in the lawn surrounding the Lord pool.	L	3	P, M, C, V
Work with the Department of Transportation and City of Lowell to improve the parking area at regatta field.	M	2	M, O, C
Assess and repair, where necessary, the condition of the Scott Finneral Memorial Riverwalk.	M	2	P, M, C
Consider adding a formal, off-road connection between the Scott Finneral Memorial Riverwalk and the eastern end of the Vandenberg esplanade.	L	3	P, M
Consider options, such as the DCR's Matching Funds Program, for acquiring a small, motorized boat for public safety purposes at Rynne beach.	M	3	P, M, X
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
Complete an assessment of the Merrimack River retaining wall and make repairs, where needed.	M	2	M, E
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Determine the owner of the Hadley House and establish an agreement that guides the management and use of the building.	H	1	P, M, L
Meet with the University of Massachusetts Lowell to develop and implement a preservation plan for the eastern section of the wall in the Tremont Yard parking area.	M	2	P, M, L
Meet with Tremont Yard, LLC to discuss ways in which the preserved, below grade water power features within the Jeanne D'Arc Credit Union can be promoted.	L	2	M, L
Install DCR signs at the parking areas along the Vandenberg esplanade, next to the Lord pool and on Broadway Street.	H	2	M, O
Install gates at the parking areas next to the Lord pool and on Broadway Street.	H	3	M, C
Install a new Main Identification Sign at Francis Gate Park.	M	2	M, O

Continued on next page.

Table 10.3. Recommendations for Lowell Heritage State Park (Continued)

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Establish an agreement with Lowell General Hospital regarding the placement and maintenance of their three-sided directional sign.	M	2	M, L
Replace the bronze plaque for the brick vault.	L	3	P, M
Confirm that the namesake of the Vandenberg esplanade is Hoyt S. Vandenberg and update DCR signage to reflect the full and proper name of the esplanade, where needed.	L	3	P, L, O
Renew the agreements with the City of Lowell related to their management of the regatta field and Rynne beach, as well as their use of the Rynne bathhouse.	H	1	M, L
Renew the agreement with the stakeholders in the Lowell Canal System.	H	1	M, L
Renew the agreement with the New England Electric Railway Historical Society / Seashore Trolley Museum.	H	1	M, L
Establish an agreement with the Boston & Maine Railroad Historical Society regarding their maintenance of the B&M 410.	H	2	M, L
Finalize the transfer of the Bellegarde boathouse, obtaining a copy of the items listed in Section 4.4. and executing the care, custody, management and control agreement.	H	1	L
Work with the National Park Service to establish signage at the visitor center lot that indicates the parking area is open to state park visitors.	M	2	M, V

a. Priorities are High (H), Medium (M), or Low (L).
b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
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Table 10.4. Recommendations for Great Brook Farm State Park

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1 Preserve natural and cultural resources through appropriate stewardship strategies.			
Work with the DCR Lakes and Ponds program to assess the water chestnut growth in Meadow Pond and make a plan for eradication.	M	1	P, O, M
Undertake a hydrological study to gain a complete understanding of water flow through the park, assessment of existing culvert capacity and impacts to trails, and make recommendations for improvements.	H	3	P, C
Revisit the draft Comprehensive Interpretive Plan; revise and update as necessary and finalize.	H	1	M
Develop interpretive programs, opportunities, and products as identified in the Comprehensive Interpretive Plan, working to expand interpretive offerings beyond the smart barn tours.	H	2	M
Clear the debris currently built up around the beaver deceivers to maintain water flow and keep them operational.	H	1	M, C
Make sure park and regional staff are aware of local scenic road designations and local review requirements.	L	1	P, M
Remove leaf and brush debris from all cellar holes and routinely monitor these sites for other disturbances.	M	2	M
Routinely monitor the Adam's Mill dam site for stability and potential disturbances.	M	2	M
Routinely monitor "The City," particularly the Garrison House site, for stability and potential disturbances.	H	1	M, P
Remove the broken sign at the Garrison House site.	H	1	M
North Schoolhouse: Carefully remove the English ivy from the walls, with guidance from DCR's Office of Cultural Resources.	H	2	M, P
North Schoolhouse: Assess the condition of the chimney, and identify and address the moisture issue that is causing the spalling.	M	2	P, E
Main Farm Area: Request a reevaluation of the Main Farm Area for National Register eligibility by the Massachusetts Historical Commission, and complete a nomination if still deemed eligible.	L	3	P
Hart Barn: Replace the roofing shingles on the north side of the barn.	M	2	E, C
Hart Barn: Assess the effectiveness and stability of the recent mortar repairs.	M	2	E
Main Farm House: Install an appropriate gutter, with guidance from DCR's Office of Cultural Resources.	H	2	P, V, C
Main Farm House: Clean the lichen growth that has appeared on the walls of the house.	M	2	V
Main Farm House: Complete minor repairs to the siding and the front door sill, with guidance from DCR's Office of Cultural Resources.	H	2	P, V, C
Tie Stall Barn: Undertake selective siding repair, with guidance from DCR's Office of Cultural Resources.	M	3	P, V, C
Tie Stall Barn: Replace the roofing shingles on the north side of the barn.	M	2	E, V, C
Tie Stall Barn: Assess the stability of the foundation in areas where it has visibly been compromised, and repair as necessary, with guidance from DCR's Office of Cultural Resources.	H	1	P, E, V, C
Pole Barn: Carefully remove vegetation from the rear façade.	L	3	V
Duck Coop: Assess the stability of the foundation.	L	3	E
Duck Coop: Work with the farmer to determine if any new uses are possible for this building.	L	2	P, E, V, M
Silos: Assess structural stability of each and explore possible interpretive opportunities with farmer, park, and interpretive staff.	M	2	E, M, V

Continued on next page.

Table 10.4. Recommendations for Great Brook Farm State Park (Continued)

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1 Preserve natural and cultural resources through appropriate stewardship strategies.			
Silos: Assess structural stability of each and explore possible interpretive opportunities with farmer, park, and interpretive staff.	M	2	E, M, V
Litchfield House: Complete repairs to the barn.	H	2	V, P
Litchfield House: Clean the lichen growth that has appeared on the walls of the house.	M	2	V
Litchfield House: Identify the cause of the lichen growth on the roof and address.	M	2	V, P
Litchfield House: Assess the chimneys to determine if any repairs are necessary.	M	3	V, P
Cemetery: Apply the BMP developed by the office of Cultural Resources.	L	1	M, P
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Working with the Lakes and Ponds program, determine if a new canoe launch should be designed and installed to reopen Meadow Pond for recreational boating.	M	1	M, O
Develop a trails plan, assessing existing density and incorporating critical information developed through the hydrological study to better address areas that have trail washout problems.	H	2	P
Work with the local equestrian community to formalize the maintenance of the horse jumps, and prune the vegetation growth around them.	M	1	M, X, V
Securely cover the open well located southeast of the Litchfield House.	H	1	M
Reassess all boardwalk crossings to identify older ones in need of replacement, including those on the Acorn Trail.	H	1	M
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
Routinely monitor the area around the rock shelters for possible illicit activities.	M	1	M
Former Regional HQ site: remove former sign holder and pavement to let the site return to a natural state.	H	2	M, E
Tie Stall Barn: Address the outstanding permit issues for the event space and renew discussions about future use.	H	2	V, E, M
Farnham Smith's Cabin: Undertake a structural assessment and reuse feasibility study to determine if reuse is possible and develop some potential options.	H	2	P, E, M
Cabin Shed: Access and clean out the interior of the shed, so that it does not become a potential nuisance.	H	1	M
Boat House: Complete and submit MHC Inventory form.	H	1	P
Boat House: Undertake demolition.	H	2	E, C
South House/District 6 Fire Control: Assess for any reuse possibilities by the park and/or the region, such as accommodating the storage needs currently being met by the Hadley House and the Anderson Barn.	H	2	F, M, P
Hadley House: Investigate alternative uses of the property and possibly making it available to be moved. If not possible, identify a funding source for demolition before it becomes an attractive nuisance.	H	2	P, M, E
West Farm/Manseau House: Assess for inclusion in the Historic Curatorship Program. If not a good candidate, identify a funding source for demolition, before it becomes an attractive nuisance.	H	2	P, M, E

Continued on next page.

Table 10.4. Recommendations for Great Brook Farm State Park (Continued)

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
North Farm House and Barn: Make sure the buildings are secure, and routinely monitor to ensure they aren't damaged or broken into.	H	1	M
North Farm House and Barn: Work with current long term leaseholders of other facilities within the park to identify any potential complementary reuses for this property, and explore putting out a Request for Proposals.	H	1	P, X, M
Anderson Barn: Explore any potential interest in, and options for, permitting use of the barn by others, and relocate current storage closer to the Park HQ.	H	2	P, M
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Conduct annual meetings with lease holders and annual property inspections of leased property as specified in lease agreements and permits.	H	1	M, L
Twice a year, hold a joint meeting of park staff and all leaseholders, to maintain the lines of communication among all parties and make sure that everyone is aware of activities, events, or other projects that have the potential to impact each other.	M	1	M, X
Encourage and support the re-establishment of a Friends of Great Brook Farm State Park.	L	1	M, X
Pine Point Loop Parking Area: Streamline the signage as to not visually overwhelm visitors, but still inform them.	M	1	M, X
Main Parking Area: Streamline the signage as to not visually overwhelm visitors, but still inform them.	M	1	M, X
Litchfield House: Identify joint interpretive and public programming opportunities with the Curators that enhance interpretive activities while promoting DCR's Historic Curatorship Program.	L	1	P, M, V, X
Woods House: Update and renew the expired lease agreement for the Woods House with the old North Bridge Hounds.	H	1	L

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Table 10.5. Recommendations for Carlisle State Forest

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Update the inventory of the large eastern white pine trees, last done in 1980.	H	1	F
After completion of tree inventory update, revisit the Land Stewardship Zoning to determine if any changes are applicable.	H	1	P, F
Establish a Continuous Forest Inventory (CFI) plot within the forest.	L	2	F
Develop an interpretive program around the natural and cultural history of the Carlisle Pines.	L	1	M, P
Monitor and assess red pine stands within the forest; manage if necessary for public safety or ecological need.	M	1	F
Monitor for invasive pests, especially hemlock wooly adelgid. Propose biological or chemical controls if warranted on the specimen trees.	H	1	F
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Develop and install an informational kiosk that includes interpretive information, for installation within the interior of the property.	M	2	M
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
There are no recommendations associated with this goal.	-	-	-
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Clear the vegetation from around the former DEM sign stanchion, and hang a new DCR entrance sign from the existing sign stanchion.	H	1	M
Continue to partner with the Carlisle Trails Committee for assistance with trail work.	M	1	M, P, X,

a. Priorities are High (H), Medium (M), or Low (L).
b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
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Table 10.6. Recommendations for Warren H. Manning State Forest

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Undertake further research on the outbuilding foundation located near Spruce Pond to determine if it has any connection to Warren Manning.	L	2	P
Clean up the dumping debris located off of Rangeway Road, and continue to monitor the area for illegal dumping.	H	2	M
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Establish designated handicapped accessible parking spaces in the parking lot, total number to be determined in consultation with DCR's Universal Access Program.	H	1	E, U
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
Assess the accessibility and potential uses of the portion of the state forest west of Route 3, and evaluate options to better utilize this space and/or establishing connections to other nearby open space.	L	2	P, M, V, X
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Work with the Town of Billerica to get a Special Use Permit in place, to formalize their operation of the recreational area.	H	1	L, M
Hold bi-annual meetings with the Town of Billerica Recreation Department to discuss programs, events, and maintenance and operation of the recreational area.	H	1	M, X
Provide DCR information on the informational kiosk.	H	1	X

a. Priorities are High (H), Medium (M), or Low (L).
b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
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Table 10.7. Recommendations for Billerica State Forest

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Carefully clean the lichen from the Rowell Memorial Stone.	L	1	P, M
Document the network of historic forest roads on a MHC inventory form.	L	2	P
Clean up illegal camping debris located near the top of Gilson Hill.	M	1	M
Dismantle the fire ring located at the top of Gilson Hill, to discourage use.	H	1	M
Clean up the dumping debris located adjacent to Winning Street, and continue to monitor the area for illegal dumping.	H	2	M
Develop interpretive materials to tell the story of this land and the establishment of the forest – it is an interesting piece of Billerica history.	L	2	M
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
Establish a system of routine trail maintenance to address the high percentage of trails in poor condition, possibly partnering with other organizations such as the Student Conservation Association or other local organizations for assistance with specific projects.	M	3	M, P
Evaluate potential locations and establish a small formal parking area (possibly adjacent to an existing gate) to facilitate safe access to the forest.	M	3	M, E, C
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
Assess the accessibility and potential uses of the portion of the state forest west of Route 3, and evaluate options to better utilize this space and/or establishing connections to other nearby open space.	L	2	P, M, V, X
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Monitor the area for future illegal camping activities, engaging local residents and police for additional assistance.	M	1	M
Install a DCR entrance sign for the forest.	H	1	M

a. Priorities are High (H), Medium (M), or Low (L).
b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
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Table 10.8. Recommendations for Governor Thomas Dudley State Park

Recommendation	Priority[a]	Resources[b]	Implementation[c]
Goal 1. Preserve natural and cultural resources through appropriate stewardship strategies.			
Conduct further research on the historic drive and allee of trees to determine if it is a remnant of Greenwood Grove.	L	2	P
Develop interpretive materials to tell the story of this property and the connection to Governor Dudley.	M	2	M
Goal 2. Offer diverse recreational opportunities and facilities to ensure visitor safety and access.			
In coordination with abutting property owners, establish a system of routine trail maintenance for the park, possibly partnering with other organizations such as the Student Conservation Association for assistance with specific projects.	M	3	M, X, V
Goal 3. Address underutilized buildings and structures to improve visitor experiences and DCR operational responsibilities.			
There are no recommendations associated with this goal.	-	-	-
Goal 4. Improve engagement with partners, stakeholders, visitors and volunteers.			
Hold an annual meeting with the MA Department of Fish & Game and the Town of Billerica Conservation Commission to discuss any issues, plans or projects.	H	1	M
With the MA Department of Fish & Game and the Town of Billerica Conservation Commission, conduct the stipulated 5 year review of the Management Agreement.	H	1	M, L
Establish and maintain an active relationship with the Sudbury, Assabet and Concord Wild & Scenic River Stewardship Council.	M	2	M
Establish and maintain active communication with US Fish & Wildlife about the resources in this general area and potential collaborative efforts.	M	2	M, P
Working with the Town of Billerica and the MA Department of Fish & Game, identify an appropriate location for an entrance sign that recognizes the partners.	H	2	M

a. Priorities are High (H), Medium (M), or Low (L).
b. Availability of resources for implementing recommendations: 1 = funding and/or labor is currently available; 2 = funding and/or labor is currently unavailable, but may become so in the near future; and 3 = funding and/or labor is currently unavailable, but may become so in more than five years.
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Form No. 10-300 (Rev. 10-74)

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UNITED STATES DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

NATIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

FOR NPS USE ONLY
RECEIVED MHC OFFICE COPY
DATE ENTERED

SEE INSTRUCTIONS IN *HOW TO COMPLETE NATIONAL REGISTER FORMS*
TYPE ALL ENTRIES -- COMPLETE APPLICABLE SECTIONS

1 NAME

HISTORIC
Locks and Canals Historic District

AND/OR COMMON
same

2 LOCATION

STREET & NUMBER
multiple

CITY, TOWN
Lowell — VICINITY OF

_NOT FOR PUBLICATION

CONGRESSIONAL DISTRICT
5

STATE
Massachusetts

CODE
025

COUNTY
Middlesex

CODE
017

3 CLASSIFICATION

CATEGORY	OWNERSHIP	STATUS	PRESENT USE	
X DISTRICT	_PUBLIC	X OCCUPIED	_AGRICULTURE	_MUSEUM
_BUILDING(S)	_PRIVATE	_UNOCCUPIED	X COMMERCIAL	X PARK
_STRUCTURE	X BOTH	X WORK IN PROGRESS	_EDUCATIONAL	_PRIVATE RESIDENCE
_SITE	**PUBLIC ACQUISITION**	**ACCESSIBLE**	_ENTERTAINMENT	_RELIGIOUS
_OBJECT	X IN PROCESS	_YES: RESTRICTED	_GOVERNMENT	_SCIENTIFIC
	_BEING CONSIDERED	X YES: UNRESTRICTED	X INDUSTRIAL	_TRANSPORTATION
		_NO	_MILITARY	_OTHER:

4 OWNER OF PROPERTY

NAME
multiple ownership

STREET & NUMBER

CITY, TOWN
Lowell — VICINITY OF

STATE
Massachusetts

5 LOCATION OF LEGAL DESCRIPTION

COURTHOUSE, REGISTRY OF DEEDS, ETC.
Northern Middlesex District Registry of Deeds

STREET & NUMBER
Goreham Street

CITY, TOWN
Lowell

STATE
Massachusetts

6 REPRESENTATION IN EXISTING SURVEYS

TITLE
Inventory of the Historic Assets of the Commonwealth/ HAER

DATE
1976

_FEDERAL X STATE _COUNTY _LOCAL

DEPOSITORY FOR SURVEY RECORDS
Massachusetts Historical Commission/ Library of Congress

CITY, TOWN
Boston/ Washington D.C.

STATE
Massachusetts

DESCRIPTION

CONDITION		CHECK ONE	CHECK ONE
__EXCELLENT	__DETERIORATED	__UNALTERED	X ORIGINAL SITE
X GOOD	__RUINS	X ALTERED	__MOVED DATE_____
__FAIR	__UNEXPOSED		

DESCRIBE THE PRESENT AND ORIGINAL (IF KNOWN) PHYSICAL APPEARANCE

'he Locks and Canals Historic District encompasses all of the canals in Lowell, (built)etween 1793 and 1848), their associated locks, and the mills that were powered by the :anals. There are about five miles of canals, and the associated mill yards increase the :creage of the nominated district to approximately 100 acres. The canals are all contiguous :hough they meander throughout the city. The mill buildings and yards are all associated :irectly with a canal, and three boarding houses, not contiguous to the canals but built y mill owners for their workers, are also included in the district.

'he Pawtucket Canal, the first canal to be built in Lowell, leaves the Merrimack River a ew hundred yards upstream from the Pawtucket Dam. The site of the guard locks, about ,000 feet from the head of the canal, has been in continuous use since the canal was pened to navigation in 1796, and the present structures and facilities include the Francis ate, a lock house and a sluice gate house. The Francis Gate (#2) also known locally as rancis' Folly, is a proticullis flood gate, built in 1848-1850. The lock house (#1), uilt in 1881 over the upstream gate of the locking chamber, replaced an earlier 1852 tructure. It is a wooden frame building with round arched windows and a slate hipped oof. The sluice gate house (#3) built in 1870, is a brick Romanesque structure with ound arched windows and a slate ridge roof, containing machinery for five gates. Ma- onry work around the Guard Locks includes the lower part of the dam (1832), the upper dam ortion (1848), the walls of the upstream island and lock chamber (1801) and downstream ock chamber (1877) and the downstream wall of the power canal chamber, built in 1867 nd 1900.

ne Northern Canal (#7), the last canal to be built, was constructed in 1846-48. It was uilt as a feeder canal to supplement the Pawtucket Canal and to raise the water level t the lower end of the canal system. Its construction provided for almost perfect con- rol of the water level in the canal system and greatly increased its complexity by re- ersing flows and transforming some canals from power to feeder uses.

ne Great River Wall surmounted by the Northern Canal Walk (#8) was created by the con- truction of the Northern Canal. The Great Wall is a 2,200 foot section of the canal all that separates the Northern Canal from the river. The Northern Canal Gatehouse, ne blacksmith shop and the Gate Keeper's Cottage are all located at the head of the orthern Canal. The Gatehouse (#4), constructed in 1847, is a one-story brick Roman- sque Revival structure with round arched windows and a slate ridge roof; the interior con- ains ten guard sluice gates and the Francis turbine. Opposite the building is a nav- gation lock. The Locks and Canals Blacksmith Shop (#5) is a simple wood shed built next the river, and is used to repair the lock machinery after spring flooding. Next to the ate House is the Gate Keeper's Cottage (#6), a one and one-half story Victorian wood ame cottage built c. 1850 to serve as living quarters for the gate keeper.

e Suffolk Millyard (#9) adjacent to the Northern Canal, covers approximately five acres. e of the earliest corporations, the yard was built in 1831, but the major courtyard was built in 1863. The buildings are primarily Romanesque Revival although much of the rly Federal styling remains. Structures of particular interest are the Counting House d an 1831 boarding house converted for industrial use. The Suffolk Manufacturing Com- ny Boarding Houses (#3) across French Street from the Suffolk Yard, were constructed 1845. Five units at the northern end of this fine example of workers' row housing re removed in the 1960's to allow construction of the French Street extension, a part of e Northern Canal Urban Renewal Project, but the remaining block has been re-habed.

continued

[8] SIGNIFICANCE

PERIOD

—PREHISTORIC
—1400-1499
—1500-1599
—1600-1699
X 1700-1799
X 1800-1899
—1900-

AREAS OF SIGNIFICANCE -- CHECK AND JUSTIFY BELOW

—ARCHEOLOGY-PREHISTORIC
—ARCHEOLOGY-HISTORIC
—AGRICULTURE
—ARCHITECTURE
—ART
X COMMERCE
—COMMUNICATIONS
—COMMUNITY PLANNING
—CONSERVATION
—ECONOMICS
—EDUCATION
X ENGINEERING
—EXPLORATION/SETTLEMENT
X INDUSTRY
—INVENTION
—LANDSCAPE ARCHITECTURE
—LAW
—LITERATURE
—MILITARY
—MUSIC
—PHILOSOPHY
—POLITICS/GOVERNMENT
—RELIGION
—SCIENCE
—SCULPTURE
—SOCIAL/HUMANITARIAN
—THEATER
X TRANSPORTATION
—OTHER (SPECIFY)

SPECIFIC DATES 1790–1870 BUILDER/ARCHITECT

STATEMENT OF SIGNIFICANCE

The Locks and Canals Historic District in Lowell is significant for its contributions to the development of Lowell as the first great industrial city in the United States. The industrial revolution in North America was first initiated on a large scale in Lowell, and our industrial economy and present levels of technology are a reflection of Lowell's manufacturing experiments.

In 1792 Governor John Hancock signed a charter incorporating the Proprietors of the Locks and Canals on the Merrimack River. The charter gave to this group of Newburyport merchants riparian rights on the Merrimack River from the Massachusetts border to the Atlantic Ocean, and more specifically, the right to build locks and a canal to circumvent the Pawtucket Falls. This canal, opened in 1796, formed an island between itself and the Merrimack River, where the City of Lowell later developed. The canal was used to transport lumber, foodstuffs and people around the Pawtucket Falls on their journey from New Hampshire to Newburyport. In 1803 the Middlesex Canal opened, funnelling off to Boston the traffic which had been going to Newburyport, and caused the Pawtucket Canal to fail financially.

In 1822 the Merrimack Manufacturing Company, founded by Patrick Tracy Jackson and Nathan Appleton, bought up the holdings of the Proprietors and all of the land between the Merrimack River and the Pawtucket Canal. Both Jackson and Appleton had been partners of Francis Cabot Lowell in his successful mill at Waltham, Massachusetts where, for the first time, cotton was processed into cloth within a single building. At the Waltham mill Francis Lowell had developed the system of boarding houses and strict social regulation, which brought New England farm girls into the mills and had such an impact on the early days of the American industrial revolution. Expansion of the mill at Waltham was not possible because the Charles River was too slow moving to provide sufficient power, so after Lowell's death in 1816, his partners, searching for a new site, chose the area that is now the city of Lowell.

In 1825 the Merrimack Manufacturing Company had widened the Pawtucket Canal and constructed the Merrimack Canal. They built the first large mill (no longer extant) to be established in Lowell between the Merrimack River and Merrimack Canal and paved the way for future mill development. The first mill used only a fraction of the available water power, so the Merrimack Company, determined to keep out of the development business, sold its water power rights and unused land back to the Proprietors of the Locks and Canals, who were reorganized to develop the area by selling land and water power, building additional canals and supplying textile machinery to the mills. The Locks and Canals Company built the Hamilton Canal in 1826, the Lowell Canal in 1828, the Western Canal in 1831-32, the Eastern Canal in 1835, and finally the Northern Canal in 1847. Each of the new canals supplied power to new mill companies, built on the best sites to obtain power. The first priority in the development of the town was to bring water power to these mills; corporate housing, private businesses, and homes were built only where they did not interfere with the

continued

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CONTINUATION SHEET ITEM NUMBER 7 PAGE 1

#7:

The Tremont Gatehouse (#10), a one-story ridge roof Romanesque Revival building, five bays wide, was constructed in 1855 as a component of the Northern Canal Project. Its purpose was to direct the flow of water from the Northern Canal through the upper level of the Western Canal to the Lawrence Yard, should the flow from the Suffolk and Tremont tailraces prove insufficient. The Tremont Yard (#11), next to the Western Canal, incorporates a site of about five acres and was the location of the Tremont Corporation, formed in 1830. The structures were razed in the 1930's and only fragments of the buildings remain.

The Lawrence Yard (#12), bounded by the Western Canal and the Merrimack River, covers approximately nine acres and contains structures ranging in date from 1826 to 1909. The weaving and spinning mills are principally Federal in style, four to six stories in height with Romanesque Revival additions and ornamentation. The Counting House is a particularly notable two-story High Victorian Gothic structure distinguished by the polychromatic banding of its slate roof. The Lawrence Canal, about 500 feet long, was constructed in 1831 and runs westerly from the Western Canal to provide water power for the Lawrence Yards.

Completed in 1848, the Moody Street Feeder (#13) was also built as part of the Northern Canal project, to increase the supply of water flowing into the Merrimack and Eastern Canals via the Boott Penstock. The Feeder extends from the Western Canal to the Merrimack Canal and consists of three brick vaulted tunnels. The Merrimack Canal Gate House (#14), built over the Moody Street Feeder and completed in 1848, is a Romanesque Revival building, two bays wide and six bays long. The building is distinguished by its fine dentiled cornice. The Gate House contains three service gates, each manually operated with counterweighted rock and pinion equipment over the waterway. The gate operating equipment is original to the feeder construction except for the counterweight system which was added in 1853. The building is already listed in the National Register as part of the City Hall Historic District.

The Eastern Canal (#22) runs northerly from the Pawtucket Canal just above the lower locks and, bending 90°, runs parallel to the Merrimack River but flows in the opposite direction. The Canal is 1,913 feet long and provided power to the Prescott, Massachusetts and Boott Mills. The Boott Mills (#15), bounded by the Merrimack River and the Eastern Canal, were founded in 1839. The cores of the majority of the buildings date from this period, but the yard was extensively rebuilt in the 1860's. The Romanesque Revival style of this completely intact millyard is enhanced by a graceful octagonal cupola and bell tower. The site comprises about six acres and is completely enclosed by buildings which form two interior courtyards.

The Massachusetts Mills Boarding House (#18), constructed in the 1840's by the Massachusetts Mills, is a three and one-half story Greek Revival building. The first floor has been altered for commercial use. The Boott Mills Boarding House (#17), across French Street from the Massachusetts Mills Boarding House, was also constructed in the 1840's. In the 1890's a Queen Anne facade was applied to the Bridge Street elevation and a wing was attached at the southwest corner, facing French Street.

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#7:
The Pawtucket Canal, both upper (#31) and lower (#23) portions, was originally constructed between 1792-96 with four sets of locks, for use as a navigation canal around the Pawtucket Falls on the Merrimack River. Falling into disuse after the opening of the Middlesex Canal in 1805, it was extensively rebuilt between 1821-25 to provide both transportation and water power to the Lowell mills. The canal is 9,188 feet long and is the backbone of the locks and canals system. The Lower Locks (#19) on the Lower Pawtucket Canal were originally built in 1822, and rebuilt in 1841. The locks consist of a dam and two navigation locks, covered by a frame structure. The Merrimack Canal (#27) was built in 1822-23 to provide water power to the Merrimack Manufacturing Co., Lowell's first mill yard, no longer extant. It runs in a northerly direction 2,586 feet from the Pawtucket Canal at the Swamp Locks and eventually discharges into the Merrimack River. It includes a dam and a connector to the Eastern Canal, the Boott Penstock. The Bigelow Yard (#20), originally founded in 1828, is located between the Merrimack and Lower Pawtucket Canals. The only extant structures include a four-story Romanesque Revival structure from the 1870's and three other buildings from the 1890's. The Lowell Canal, now covered, was built in 1828 to supply water to this yard. It is 500 feet long, has a drop of thirteen feet, and runs between the Merrimack and Lower Pawtucket Canals.

The Hamilton Canal (#25), 1,771 feet long, runs parallel to the Pawtucket Canal from the Swamp Locks and discharges into the Pawtucket Canal by raceways through the Hamilton and Appleton Yards. It was constructed in 1826 to power the aforementioned mills, and has a fall of 13 feet. The Hamilton Yard (#21) was the site of Lowell's second oldest manufacturing company, the Hamilton Mills, incorporated in 1825. The structure now standing along the Pawtucket Canal is early Greek Revival distinguished by triangular granite pediments over the windows, and granite lintels on square brackets. The fifth and sixth floors and the other structures in the yard are Romanesque Revival dating from the rebuilding of the 1860's and 70's. The Appleton Mills (#24) east of the Hamilton Yard, were founded in 1828. The structures on the island between the Hamilton and Pawtucket Canals nearly all date from the c. 1905 rebuilding; the structures on the south side of Jackson Street were built in 1873 and are Romanesque Revival. The Swamp Locks (#26) similar to the Lower Locks, were built in 1822-23 and rebuilt in 1839-41.

The Lowell Machine Shop (#28), razed in the 1930's, stood in the island formed by the Lowell, Merrimack and Pawtucket Canals. The only remaining portions of the shop are on Dutton Street; a mill, constructed c. 1890 and c. 1910, and a reinforced concrete plant built in 1911 now cover the site of the Machine Shop boarding houses. The Proprietors of the Locks and Canals Yard, containing one and one-half and two-story buildings now used as offices and shops, are frame Italianate structures built in the 1850's to serve as the administrative headquarters for the canal system.

The Western Canal (#30), a mile long, originally ran northwesterly from the Pawtucket Canal to provide water power to the Tremont, Suffolk and Lawrence Mills. The construction of the Northern Canal changed its direction so that it now flows south from the Northern Canal to the Swamp Locks, but continues to flow north from the Tremont Gate House to power

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#7:
the Tremont, Suffolk and Lawrence Mills.

The Pawtucket Dam (#32), built between 1826-1830 at the Pawtucket Falls, created a "mill pond" on the Merrimack River eighteen miles long. The dam has been continually modified throughout the nineteenth century.

#8:
routing of water power and the production of textiles. The population of Lowell mushroomed during this period, from 200 people in 1822 to over 33,000 in 1850.

The engineering involved in the construction of the canals was extremely complex, and each new canal was built in an attempt to solve the problem of keeping all the mills supplied with a sufficient supply of power. The construction of the Northern Canal, the most complex of all because it reversed the flow of the Western Canal, finally increased the average flow of water to each mill sufficiently to solve the distribution problem. The hydro-engineering breakthroughs of the canal engineers, including James Francis and George Whistler, received international acclaim and recognition, and their techniques were used world-wide. The sociological pattern of corporate paternalism in Lowell, manifested by the mill-owned boarding houses and strictly run social functions, also received international recognition and served as a model for Utopian industrial communities in the United States and Europe.

Unfortunately, Lowell's position as a leader in the field of science and as an ideal industrial society was lost in the last quarter of the nineteenth century. The latter nineteenth century mill owners were more concerned about making a profit than in their workers' welfare and the waves of immigrants who poured into Lowell completed the destruction of the boarding house system; speculative tenement flats became the norm. In this century, when many of the major textile companies left the north to move south to cheaper power and labor sources, Lowell was left with huge empty mill buildings, a large canal system and a high level of unemployment. The entire city has been affected by this economic depression and most of the commercial, industrial and residential buildings in the district have deteriorated.

Prospects for Lowell are now looking brighter. The State of Massachusetts, through the Department of Environmental Management, is in the process of acquiring all of the locks and canals and turning them into a state heritage park. The Federal government is considering the creation of an urban cultural park in Lowell, and Federal funds, through the Department of Housing and Urban Development and funds appropriated especially for Lowell are being expended to upgrade housing and to rehab existing mill buildings. New uses are being sought for the abundant mill space in the district, both in order to save the buildings and to provide jobs.

9 MAJOR BIBLIOGRAPHICAL REFERENCES

Historic American Engineering Record Survey Inventory; Spec Struc:Hydra (81.2), 1975
Coolidge, John, Mill and Mansion, Russell & Russell, New York 1967
Malone, Patrick, The Power Canals of Lowell, Massachusetts, Human Services Corporation Lowell, 1973

10 GEOGRAPHICAL DATA

ACREAGE OF NOMINATED PROPERTY approximately 100 acres

UTM REFERENCES

	ZONE	EASTING	NORTHING
A	19	310,960	4,724,900
B	19	311,290	4,723,840
C	19	309,360	4,722,680
D	19	308,540	4,724,610

VERBAL BOUNDARY DESCRIPTION

see district sketch map

LIST ALL STATES AND COUNTIES FOR PROPERTIES OVERLAPPING STATE OR COUNTY BOUNDARIES

STATE	CODE	COUNTY	CODE
STATE	CODE	COUNTY	CODE

11 FORM PREPARED BY

NAME / TITLE

Christine Boulding, Preservation Planner, and Joe Orfant

ORGANIZATION — DATE

Massachusetts Historical Commission — March 1976

STREET & NUMBER — TELEPHONE

294 Washington Street — 617-727-8470

CITY OR TOWN — STATE

Boston — Massachusetts 02108

12 STATE HISTORIC PRESERVATION OFFICER CERTIFICATION

THE EVALUATED SIGNIFICANCE OF THIS PROPERTY WITHIN THE STATE IS:

NATIONAL X STATE X LOCAL ____

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service.

STATE HISTORIC PRESERVATION OFFICER SIGNATURE Elizabeth Reed Amadon

TITLE Executive Director, Massachusetts Historical Commission DATE 3/30/76

FOR NPS USE ONLY

I HEREBY CERTIFY THAT THIS PROPERTY IS INCLUDED IN THE NATIONAL REGISTER

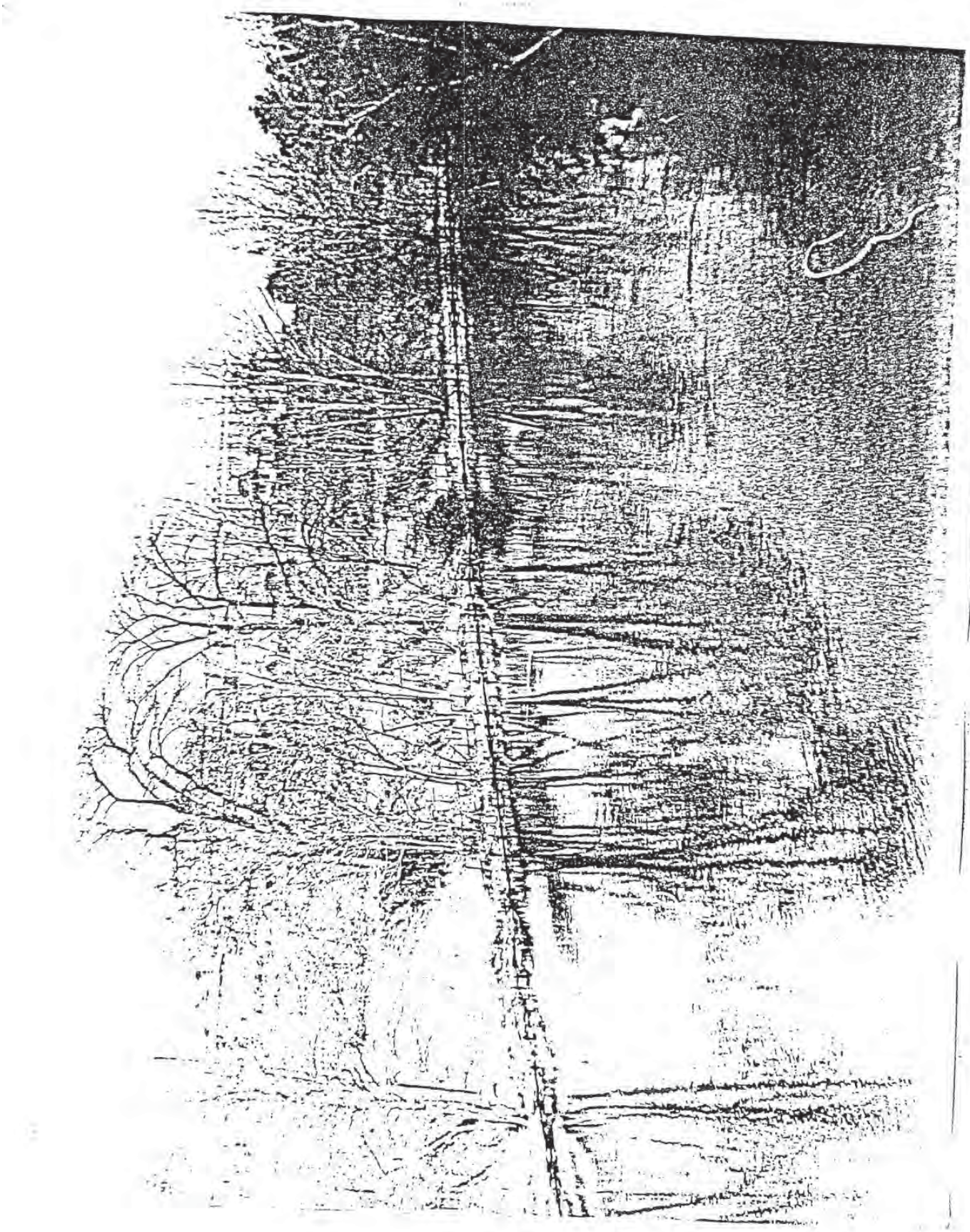
DATE

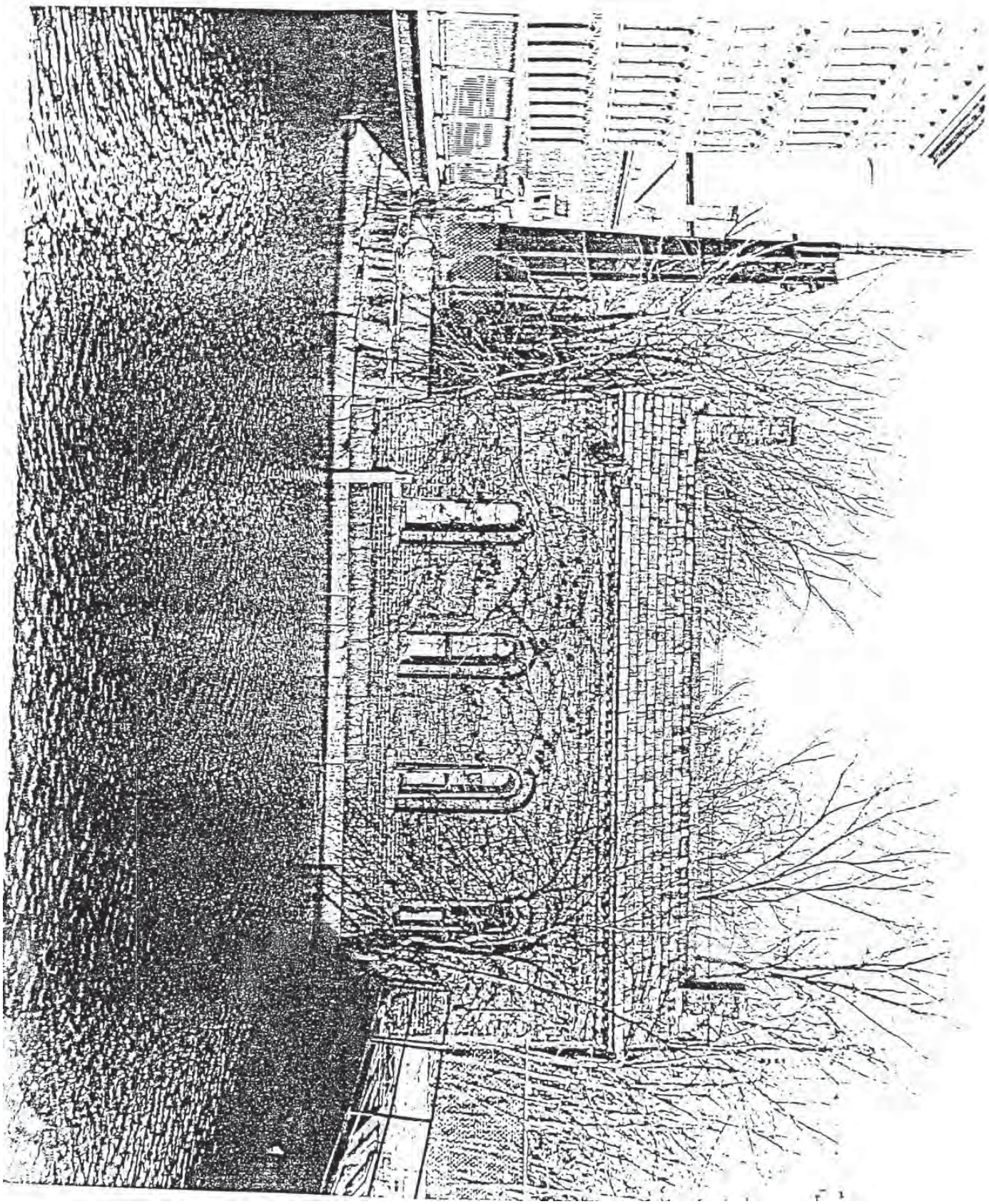
DIRECTOR, OFFICE OF ARCHEOLOGY AND HISTORIC PRESERVATION

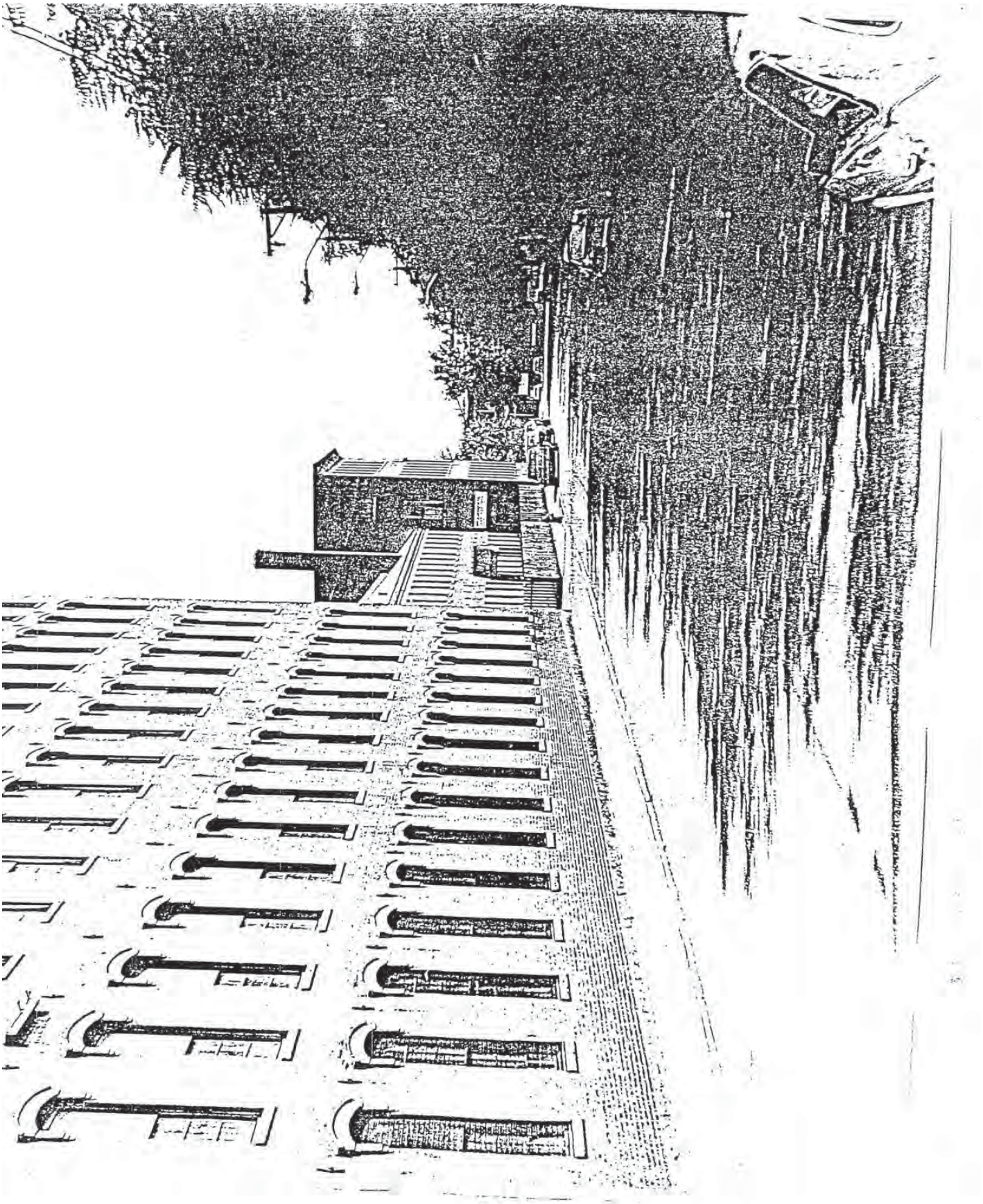
ATTEST: DATE

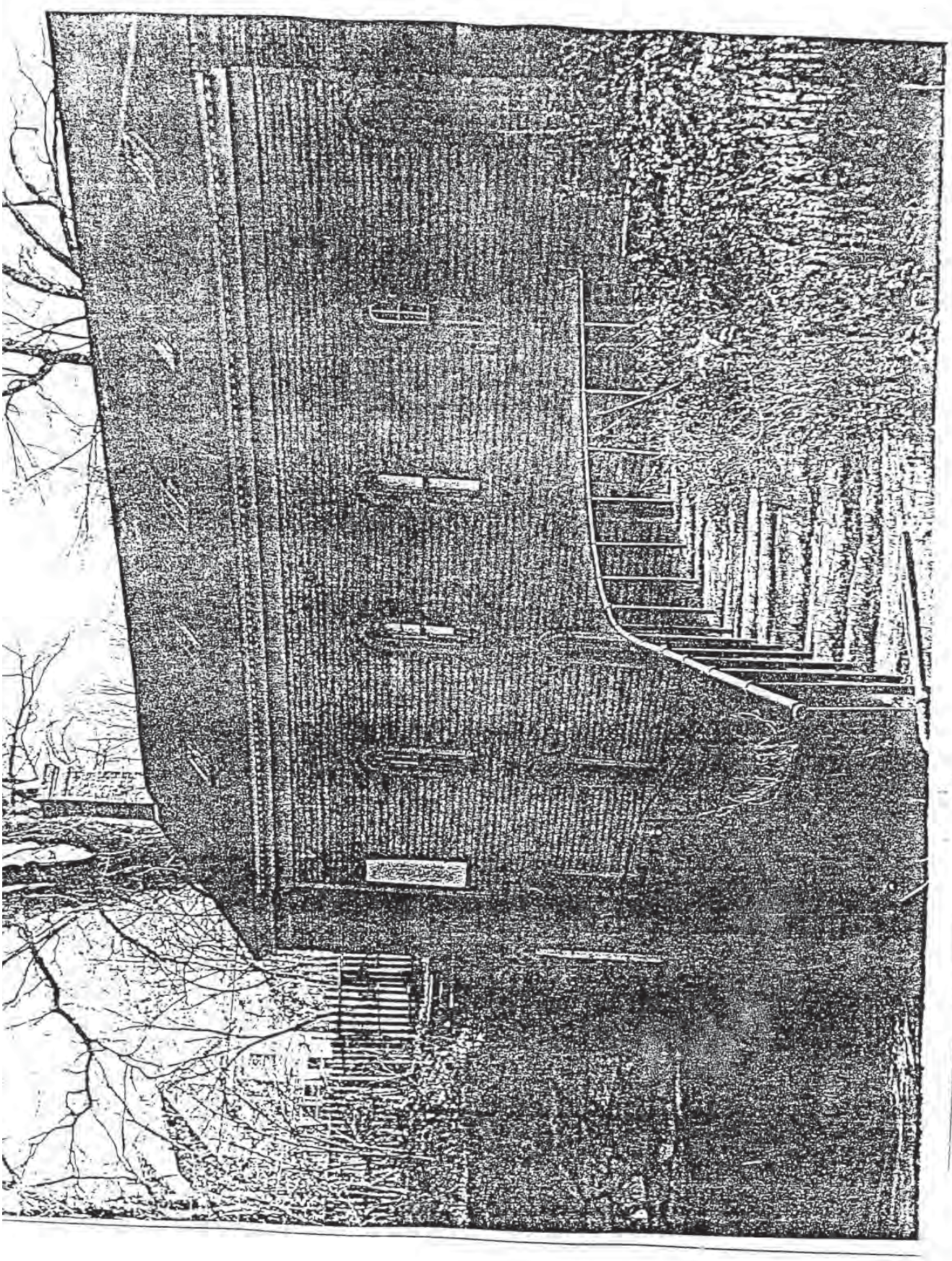
KEEPER OF THE NATIONAL REGISTER

GPO 892-453









ocks and Canals Historic District, Lowell, MA
e Orfant, 1975
ty Development Authority, Lowell, MA
oking northeasterly from the O'Donnell Bridge
at the Northern Canal and the Canal Walk
oto #1

cks and Canals Historic District, Lowell, MA
e Orfant, 1975
A, 50 Arcand Drive, Lowell
oking southwest at the Swamp Locks Dam and
Sluicway, in the Background is the 1890
plant of the Lowell Machine Shop
oto #2

and Canals Historic District, Lowell, MA
fant, 1975
O Arcand Drive, Lowell
g north from French Street Extension to
Tremont Gatehouse and the Suffolk Yard
he left
3

and Canals Historic District, Lowell, MA
fant, 1975
O Arcand Drive, Lowell
g north on Suffolk Street to the Suffolk
on the left, the Lawren ce County House
he background, and the Tremont Yard on
right

#4

Locks and Canals Historic District, Lowe
Joe Orfant, 1975
CDA, 50 Arcand Drive, Lowell
looking south at the sluiceways gatehouse
the Francis Gate site
photo #5

Locks and Canals Historic District, Lowe
Joe Orfant, 1975
CDA, 50 Arcand Drive, Lowell
looking northwest from Broadway at the
Western Canal
photo #6

10-300a
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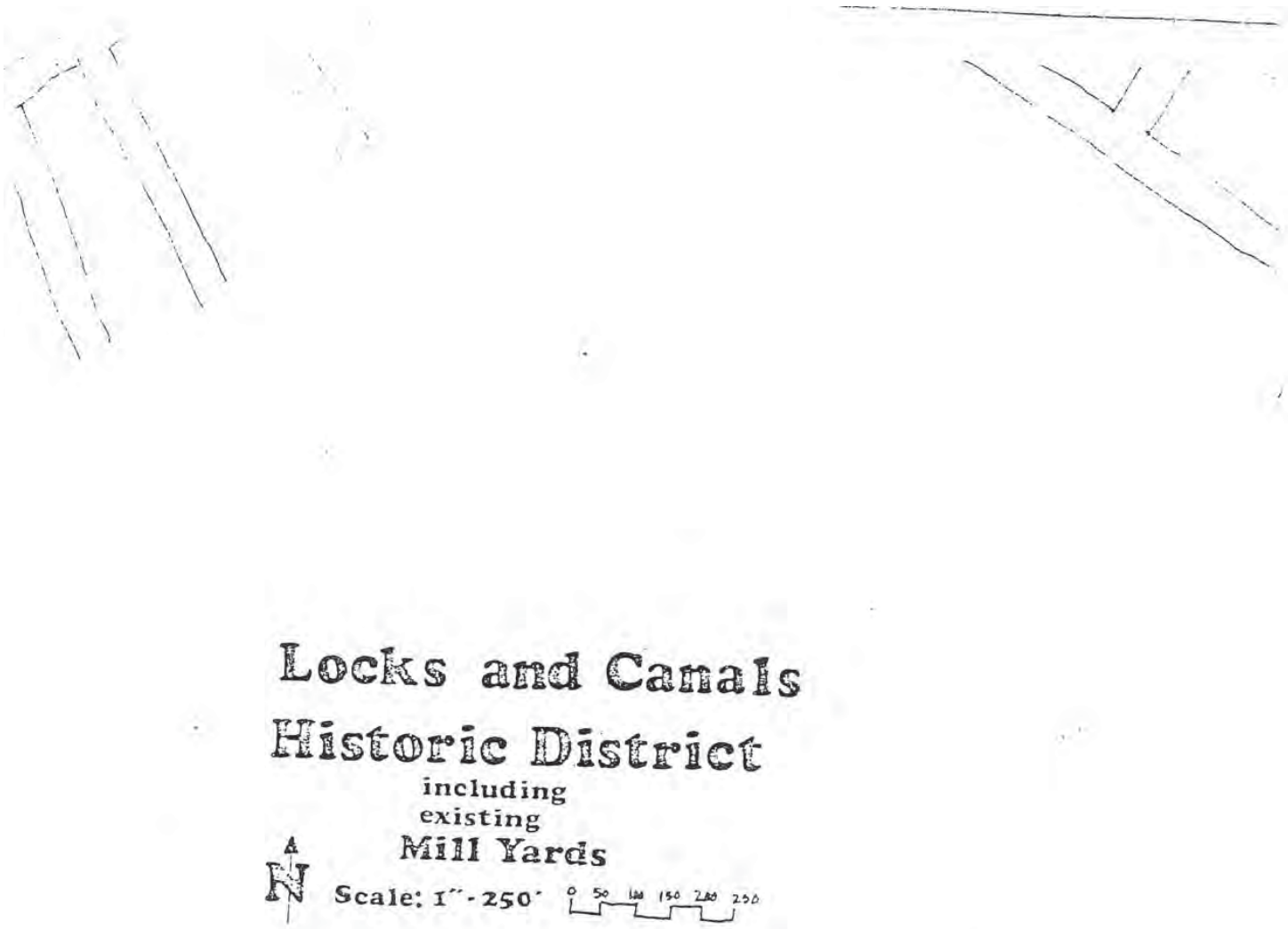
CONTINUATION SHEET ITEM NUMBER PAGE 1

Key to sketch Map

Number	Property name
1 - 1144	P Lock House - Francis St
2 - 1145	P Francis Gate and House - Francis St
3 - 1146	P Sluice gate house - Francis St
4	Northern Canal Gatehouse
5 - 1147	Locks and Canals Blacksmith Shop Locks and Canals
6 - 1148	P Gate Keeper's Cottage - Jackson St
7 - 1149	S Northern Canal - Northern Canal
8 - 1150	S Northern Canal Walk and Great River Wall - Northern Canal
9	Suffolk Millyard
10	Tremont Gatehouse
11 - 1151	Tremont Yard - Hall St
12	Lawrence Yard
13 - 1152	S Moody Street Feeder Moody St
14 - 1153	B Moody Street Feeder Gatehouse Patten St
15	Boott Mills
16	Massachusetts Mills
17 - 1154	P Boott Mills Boarding House Prince St
18	Massachusetts Mills Boarding House
19 - 1155	S Lower Locks, ~~Pawtucket Canal~~ Lower Pawtucket Canal
20 - 1156	B Bigelow Yard - Market St
21	Hamilton Yard
22 - 1157	S Eastern Canal Eastern Canal
23 - 1158	S Lower Pawtucket Canal Lower Pawtucket Canal
24	Appleton Mills
25 - 1159	B Hamilton Canal Hamilton Canal
26 - 1160	S Swamp Locks - Lower Pawtucket Canal
27 - 1161	S Merrimack Canal - Merrimack Canal
28 - 1162	B Lowell Machine Shop - DUTTON St
29 - 1163	B Proprietors of Locks and Canals Yard - Broadway
30 - 1164	S Western Canal - Western Canal
31 - 1165	S Upper Pawtucket Canal - Upper Pawtucket Canal
32 - 1166	S Pawtucket Dam - Pawtucket Canal
33	Suffolk Manufacturing Company Boarding Houses


Locks and Canals
Historic District
including
existing
Mill Yards
N
Scale: 1" - 250'
0 50 100 150 200 250
ACRE

Pitcaithley
McManamon
Clapper

32-NAR(PC)

Memorandum

To: Assistant Manager, Cultural Resources Management Division, Washington (560)

From: Regional Director, North Atlantic Region

Subject: National Register Data for Lowell National Historical Park

Enclosed are continuation sheets for the five properties which will eventually come under federal ownership. All of the structures are already listed on the National Register, but because they are included as parts of large historic districts, the existing forms contain little specific information. This amplification of sections seven and eight will provide a greater understanding of those sites for all who are involved in the management and compliance processes. Please forward them on to the National Register at your earliest convenience.

(SGD.) RICHARD L. STANTON

Richard L. Stanton

cc: LOWE, Supt.
Mass. SHPO

project file

DPitcaithley:id 7/31/80

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Locks and Canals
CONTINUATION SHEET Historic District ITEM NUMBER 7 PAGE 1

Merrimack Gate House

Situated over the eastern terminus of the Moody Street Feeder, this rectangular one-and-one-half-story brick gate house was built in 1848[1]. The Merrimack Gate House extends approximately 60' along Dutton Street and the Merrimack Canal. Its southern facade faces Merrimack Street. The waters of the Moody Street Feeder flow through the three granite arches on which this structure rests. Its exterior walls are red brick laid in Flemish bond. The pitched roof is covered in slate shingles. Chimneys are situated at the ridge near the north and south end walls.

Stylistically, the Merrimack Gate House is a hybrid of the Italianate and Romanesque Revival styles. Its windows are inset and round arched. The cornice features brick dentils. The date '1848' appears incised on its eastern foundation and in raised brick on the gable of its southern facade.

There are three gates for the Moody Street Feeder housed within the Merrimack Gate House. The gates are original with the exception of the woodbox counterweights which were added in 1853[2].

Structurally, the Merrimack Gate House is in good condition. Exterior and interior alterations date, with a few exceptions, from the early 1970s[3]. A doorway has replaced a window on the Merrimack Street facade. Other alterations include the addition of interior platforms, stairs, restrooms and a heating system. At some point in the late nineteenth or early-twentieth century the two original stoves disappeared and a vent was added to the center of the roof.

[1]Shepley, Bulfinch, Richardson and Abbott, Lowell National Historical Park and Preservation District Cultural Resources Inventory, 1979, n.p.

[2]Merrimack Valley Textile Museum and H.A.E.R., The Lower Merrimack River Valley, An Inventory of Historic Engineering and Industrial Sites. p. 80, 1976.

[3]Roberts, Shelley K., Historic Structures Report-Merrimack Gate House, 1979 p.36.

Francis Gate Complex

The structures located at the head of the Pawtucket Canal, presently referred to as the Francis Gate Complex, include a Guard Dam Gate House, Guard Locks Lock House, and the Great Gate. An island, formed in 1822[1], is situated between the canal and boat lock. The Guard Dam Gate House and Great Gate stand atop the dam. The Guard Locks Lock House which shelters the headgates is upstream of the dam at a lower level.

The Guard Dam Gate House, built in 1870[2], contains the controls to the sluice gates. The upstream side of the Guard Dam Gate House shelters five sluice gates, some of which retain their original lifting machinery. Although most of the openings in the brick portion of the building have been bricked in, much of the original fabric is intact and is in good condition.

The present guard dam may contain elements of the earlier dam (1832) which served the same purpose on this site. [3] This rectangular structure is built of wood frame and is two stories tall. The rest of the building is brick and a single story in height. Both portions display round headed openings and a plain freize and dentils at the cornice. A brownstone plaque set into the east end of the Gate House near the gable is inscribed:

Guard Dam built A.D. 1832
Raised A.D. 1848
Sluice Gates reconstructed A.D. 1970

This Italianate/Romanesque structure culminates in chimneys situated at either end of the ridge roof. The slope of the roof features five small square skylights.

The Pawtucket Canal Guard Locks Lock House was built in 1881. This Lock House structure stands over the upstream pair of gates for the navigational lock. [4] The single-story Lock House is constructed of wood and is of an "I" shaped plan. It has a granite foundation and exterior walls faced with painted clapboards approximately four inches wide. The hipped roof is covered with slate shingles. A hybrid of the Italianate and Romanesque Revival in style, the exterior walls of the Lock House are pierced by narrow round-arched openings.

The chain and windlass equipment which assists in opening the navigational lock date from 1881. [5] The head lock gates are badly deteriorated. The Guard Locks Lock House has been severely vandalized in recent years, threatening the structural integrity of the southern end of the building. That end was built with long horizontal slots through the walls to accommodate the ends of the gate-lever beams. These beams have been broken and burned away.

The navigation lock below the Lock House extends beneath the Francis Gate, ending at a downstream pair of gates which appear to be in good condition. [6]

The Great or Francis Gate was built 1848-50 for the purpose of flood control. This portcullis gate is sheltered by a rectangular wood frame structure. The Great Gate consists of 26 timbers, each 27' long and 17" wide, assembled in two separate sections held together by vertical iron rods. The wooden gate is suspended over the boat lock by an iron strap. [7] Both the Great Gate and its shelter are in good condition.

1 Robbins, John, Historic Structure Report, Architectural Data, Pawtucket Canal Guard Gates, Locks and Great Gate and Northern Canal Guard Gates and Lock (NPS: February, 1980), pg. 54.

2 Shepley, Bulfinch, Richardson and Abbott, Lowell National Historical Park and Preservation District Cultural Resource Inventory, Lowell Canal System, (1979)

3 Ibid.

4 Ibid.

5 Ibid.

6 Ibid.

7 Ibid., pg. 16

Tremont Gate House/Tremont Yard

1. The Tremont Gate House is located at the point where the northern and western canals meet. It was built in 1855 to replace a temporary installation that had performed the same function since 1847[1]. The gate house shelters sluice gates which control the flow of water into the lower level of the Western Canal which in turn feeds the Lawrence Canal.

   This diminutive one-story building is of a rectangular plan. It rests on a granite ashlar foundation. The gate house's exterior walls are constructed of red brick laid in common bond. The pitched roof is covered with slate shingles. Chimneys are at the ridge near the east and west ends. Access to the guard house's interior is gained via the narrow round-arched doorway on the western facad

   Stylistically, the Tremont Gate House is a hybrid of the Italianate and Romanesque Revival styles. Its windows are inset and round arched. The cornice features brick dentils.

   Structurally, the Tremont Gate House is in good condition. The northern facade's wide round-arched doorways are boarded over. The slate shingles of the roof's southern slope are in need of replacement.

2. Tremont Yard is the site of the Tremont Mill complex which existed from 1831 until its demolition during the 1930s[2]. The western boundary of this rectangular parcel is Suffolk Street. To the east is Tremont Street. The southern boundary is adjacent to the Tremont Gate House and railroad tracks.

   Foundations of buildings which pre- and post-date the 1862[3] reconstruction of the Tremont Mill complex are still evident as are traces of three tail races which date from the late 1860s[4], the remains of a cloth shute, and the locations of hydrants from the mills' fire-fighting system.

   The Tremont Yard is presently framed on the east, north and west by the exterior walls of Mills No. 1, 9, 4 and 3 which have been reduced to a height of 5 to 6'.

   Mill No. 2 at the south end of the yard is also in ruins. Beneath the floor of Mill No. 2 are four Morgan-Smith 46" turbines for electric power which date from 1919-1924[5].

[1]Peter M. Molloy, editor. The Lower Merrimack River Valley. An Inventory of Historic Engineering and Industrial Sites sponsored by Merrimack Valley Textile Museum, North Andover, Mass. and Historic American Engineering Record. National Park Service, Washington, D. C. 1976. p. 76.

[2] Shepley, Bulfinch, Richardson and Abbott, Lowell National Historical Park and Preservation District, Cultural Resource Inventory, prepared for Division of Cultural Resources, North Atlantic Regional Office, National Park Service. see volume entitled "Industrial: Merrimack Manufacturing Company Site through Whipple's Mills and Wamesit Canal. Research Report: Suffolk Manufacturing Co." pp. 2 and 28.

[3]ibid. p. 14

[4]ibid. p. 24

[5]ibid. p. 28.

Wannalancit Textile Company (Suffolk Manufacturing Company)

Mill buildings formerly owned by the Suffolk Manufacturing Company occupy a large squa parcel within Lowell's northwestern industrial district. The Suffolk site is bounded by Hall Street to the north, Suffolk Street to the east, the Northern Canal to the south and Cabot Street to the west.

With the exception of the William J. Graham Company building (Suffolk Machine Shop) the eastern half of the Suffolk complex is owned by the Wannalancit Textile Company. This company leases the first floor of Mills No. 8 and 6 to the Lowell Museum.

To the west of Wannalancit property are Suffolk buildings which are presently controll by Stoney Brook Properties and Tewksbury Wood Products Company. These buildings include Mill No. 10 and its annex, Boiler House No. 2, and Building No. 12.

The Wannalancit buildings are grouped around a large rectangular open yard which is parallel to Suffolk Street. Entrance and egress to the Suffolk Yard is provided by a passage defined by the southern wall of the Counting House and Mill No. 8's northern wall. Mill No. 8 and Mill No. 6 frame the southeastern corner of the yard. Mill No. is parallel to the Northern Canal. The central portion of Mill No. 6's northern wall is abutted by Mill No. 5. Running from Mill No. 6 to Hall Street, Mill No. 5 forms the yard's western boundary. The former Suffolk Machine Shop and the Repair Shop portion of the Counting House enclose the yard's northeastern corner.

The mills surrounding the Suffolk Yard display a uniformity of plan, materials, and height. These rectangular red brick buildings rise to a height of five stories. Mill roofs are either flat or slightly pitched. Most of the Suffolk building stock dates from 1862-1900[4]. The two-story Counting House, however, was built prior to 1850[2]. Its flat, simply detailed facades show the influence of the Federal Style. The majority of Suffolk buildings exhibit a surface plasticity characteristic of the

Italianate style. Projecting from factory facades are brick segmental lintels and corbelled cornices. Particularly picturesque are the octagonal stair towers situated at the southeastern and northeastern corners of Mill No. 5. The towers' facades are ornamented with the curved forms of narrow round-arched openings and oculus windows inserted in recessed eliptical panels. Below the cornice of the eastern facade of Mill No. 5's central pavillion are three granite pl[illegible] Placed at regular intervals, these plaques proclaim in raised lettering, "[illegible]31.... Suffolk Mills... Rebuilt 1862."

The Suffolk Complex has served as a manufacturing facility for almost one hundred and fifty years. The good condition of Suffolk Manufacturing Company buildings' exterior and interior fabric is probably attributable to the periodic maintenance which accompanies continuous occupancy.

[1]Shepley, Bulfinch, Richardson, and Abbott. Lowell National Historical Park and Preservation District Cultural Resource Inventory prepared for Division of Cultural Resources, North Atlantic Regional Office, National Park Service. See volume entitled Industrial: Merrimack Manufacturing Company through Whipples Mills and Wameset Canal." Suffolk Mfg. Co. 1979 Research Report" pp. 14-29.

[2]Cornelia E. Wyma and Paul C. Cloyd, Historic Structures Report Wannalancit Textile Company, Lowell National Historical Park 1979. n.p. See Existing Conditions chapter-raises questions about traditional 1831 dates for the Counting House.

Dutton Street Parking Lot

The Dutton Street Parking Lot is a roughly trapezoidal parcel situated to the southeast of the Market and Dutton Streets intersection. The northern boundary of this asphalt-paved parking facility is in line with the southern wall of two brick additions which project from Bigelow Lowell Building #1. Its eastern and southern boundaries are demarcated by a chain link fence which separates the lot from Pandel Bradford and Pellon Corporation property. The eastern boundary is parallel to the Merrimack Canal. A ten-foot-wide strip of Locks and Canals land is situated between the Dutton Street Parking Lot and the Merrimack Canal

Entrance and egress to the lot is provided via a road which leads from Dutton Street into the southwestern portion of this site. To the immediate north of this entrance is a portion of the Lowell Machine Shop offices' western wall.

This parking lot site and adjacent areas were covered by Lowell Machine Shop and Lowell Manufacturing Company buildings, Canal Components, and railroad tracks. The lot was paved with asphalt sometime after the 1930s[1]. Accompanying this description are maps which show the locations of these earlier structures and features.

[1]Shepley, Bulfinch, Richardson and Abbott, Lowell National Historical Park and Preservation District Cultural Resource Inventory. Industrial: Lowell Machine Shop Site through Massic Falls Industrial Site. Lowell Machine Shop Research Report pg. 6.

Form No. 10-300a
(Rev. 10-74)

UNITED STATES DEPARTMENT OF THE INTERIOR
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NATIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

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CONTINUATION SHEET Locks and Canals Historic District ITEM NUMBER 8 PAGE 1

Merrimack Gate House

The Merrimack Gatehouse is a significant element of the district because it possesses a high degree of structural integrity. The exterior of the structure as well as the interior with its three original gates has changed only slightly since the mid-nineteenth century.

Despite its rather diminutive scale, the Merrimack Gate House occupies a commanding position in the downtown streetscape. The effects of its canal-side site is maximized through considerable length compared to width and its crisp detailing (including locally unusual use of Flemish bond brickwork).

Francis Gate Complex

The Francis Gate Complex is a key component of the Lowell Power Canal System. Since the mid-nineteenth century it has functioned as a power, navigation and flood control facility on the Pawtucket Canal. It is significant that a high percentage of its original structural and mechanical fabric dating from 1848-1881 is still extant.[1]

The Francis Gate Complex has important historical associations with James B. Francis. Francis was chief engineer and agent of the Proprietors of the Locks and Canals from 1834-1885. He designed the Francis Gate Complex's most famous feature, the Francis or Great Gate. Initially dubbed Francis' Folly upon its completion in 1850, the Great Gate saved the heart of the city from the great floods of 1852 and 1936[2].

Francis gained international recognition for his improvement of water turbine design and the publication of Lowell Hydraulic Experiments (1855)[3]. He might well be called "the Father of American Hydraulic Engineering."

The Francis Gate Complex was the last major hydraulic engineering project completed in Lowell during the Ante-bellum era.

[1] Merrimack Valley Textile Museum and Historic American Engineering Record. The Lower Merrimack River Valley, an Inventory of Historic Engineering and Industrial Sites. p. 1976.

[2] Shepley, Bulfinch, Richardson and Abbott. Lowell National Historical Park and Preservation District Cultural Resources Inventory. prepared for Division of Cultural Resources North Atlantic Regional Office, National Park Service. Industrial Lowell Canal System Volume . n.p. Pawtucket Canal North of Broadway.

[3] Arthur L. Eno, Jr. ed. Cotton was King, a History of Lowell, Massachusetts. p. 219 New Hampshire Publishing Company 1976.

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Tremont Gate House/Tremont Yard

1. The Tremont Gate House, built in 1855[1], is significant as a Lowell Power Canal System component which retains most of its mid-nineteenth century structural and mechanical fabric. The sluice gates' original manually operated rack and pinion equipment is sheltered within the gate house[1].

   Despite its diminutive scale, the Tremont Gate House occupies a commanding position on the southern perimeter of Lowell's northwestern industrial district. Its ivy-covered red brick southern wall, pierced by narrow round-arched openings, picturesquely presides over the Western Canal's northern terminus.

2. Construction of the Tremont Mill buildings was begun in 1832[3]. During the 1860s, however, this complex was dismantled and the Tremont Mills were rebuilt[4]. The final phase of building on the Tremont site occurred in the 1890s[5]. The Tremont Millyard was demolished between 1929 and 1933[6]. The significance of this site is its potential for yielding significant information. It could be developed as an interpreted industrial archeological site.

   The razed Tremont Yard is a perfect foil for the largely intact Suffolk Yard as its original configuration was essentially the mirror image of the adjacent Suffolk Complex. The Tremont site affords the opportunity to view features of a hydropower system (e.g. turbines and tail races) which were originally located underground. A similarly disposed and equipped hydropower system exists beneath the Suffolk millyard.

[1]Peter M. Molloy, editor. The Lower Merrimack River Valley, an Inventory of Historic Engineering and Industrial Sites. sponsored by the Merrimack Valley Textile Museum and Historic American Engineering Record. 1976. p. 77.

[2]ibid. p. 77

[3]Shepley, Bulfinch, Richardson and Abbott. Lowell National Historical Park and Preservation District Cultural Resources Inventory. prepared for Division of Cultural Resources North Atlantic Regional Office, National Park Service. see volume-Industrial Merrimack Manufacturing Co. Site through Whipple Mill and Wamesit Canal. Research Report: Suffolk Manufacturing Co. p. 5.

[4]ibid. p. 16.

[5]ibid. p. 27.

[6]ibid. p. 28.

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CONTINUATION SHEET Locks and Canals Historic District ITEM NUMBER 8 PAGE 3

Wannalancit Textile Co. (Suffolk Mfg. Co.)

From 1831 until 1926[1] the buildings currently occupied by the Wannalancit Textile Company were known as the Suffolk Mills. The Suffolk Manufacturing Company was incorporated in 1831[2]. Mill building construction began in the spring of 1832[3]. During the 1860s[4] the Suffolk and Tremont Yards were the scene of an ambitious rebuild campaign. The modernized mills merged in 1872[5]. Sold to the Nashua Manufacturing Company in 1926, the Suffolk Complex survived the 1930s essentially intact[6]. Edward A. Lartner, Jr., owner and president of the Wannalancit Mills has controlled most of the Suffolk Millyard since 1950[7].

The Suffolk Complex is an important survivor of the initial phase of the American Industrial Revolution. It is the only Lowell mill still engaged in the manufacturing of textiles. Virtually every stage of the Suffolk Millyard's development is presently represented by buildings dating from 1831-1915[8]. The Suffolk Mills have significant historical associations with prominent nineteenth-century Boston and Lowell business leaders. Its founders included "Proper Bostonians" such as Amos and Abbott Lawrence, Samuel and William Appleton, Henry Cabot and George W. Lyman.[9] Local patent medicine tycoon James C. Ayer directed the Suffolk and Tremont's merger in 1872[10].

[1] Shepley, Bulfinch, Richardson and Abbott. Lowell National Historical Park and Preservation District Cultural Resource Inventory. prepared for Division of Cultural Resources, North Atlantic Regional Office, National Park Service. see volume entitled Industrial: Merrimack Manufacturing Company Site through Whipples Mills and Wamesit Canal. Suffolk Mfg. Co. Research Report pgs. 2-28.

[2] ibid. pg. 2.

[3] ibid. pg. 2.

[4] ibid. pg. 14-25.

[5] ibid. pg. 25

[6] ibid. pp. 28-31

[7] ibid. p. 29

[8] ibid. pp. 2, 28.

[9] ibid. p.2.

[10] ibid. p. 25.

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The Dutton Street Parking Lot

The Dutton Street Parking Lot has a high potential for yielding subsurface archeologic remains. From the 1820s until the 1930s[1], Lowell Machine Shop and Lowell Manufacturin Company buildings covered portions of this site. Presumably the foundations of machine shops, storehouses, and offices exist below ground. An understanding of 19th and early 20th century onsite activities would be fostered by the recovery of mechanical apparatus, tools and other artifact deposits associated with social and industrial activities.

This asphalt-paved parcel overlies, as well, components of the Lowell Power Canal System. No longer visible are the Lowell Canal, three penstocks and a rectangular "basin." The Lowell Canal, laid out in 1828[2], is covered for its entire 500' length. It was filled in during the 1930s[3]. Three penstocks lie beneath the central and southern portion of this lot.

Immediately to the southeast of the junction of the Merrimack and Lowell Canals was a rectangular body of water labeled "basin" on an 1828 Lowell Manufacturing Company plan[4]. A raceway lead from the basin to a sawmill. The sawmill was situated to the east of the present lot. The basin is of particular interest because it was aligned with a semicircular basin to the west of Dutton Street which was apparently designed for purely decorative purposes[5]. All of these canal features are significant remnants of the important Lowell industrial power system which was one of the most elaborate and sophisticated ever developed. In addition to being the physical remains of this historically important sytem, their configuration and characteristics probably contain important information about the construction, modification and maintenance of the canal system.

[1] Shepley, Bulfinch, Richardson and Abbott. Lowell National Historical Park and Preservation District Cultural Resource Inventory. Inventory Forms and Research Reports. Industrial: Lowell Machine Shop site through Massic Falls Industrial site. Lowell Machine Shop research report pp. 1-8. Lowell Manufacturing Co. research report pp. 1-19.

[2] ibid, Industrial: Lowell Canal Systeml Lowell Canal System Research Report. p. 6.

[3] ibid, p. 7.

[4] ibid. Industrial: Lowell Machine Shop site through Massic Falls Industrial site. Lowell Manufacturing Company Research Report Fig. 2.

[5] ibid. Lowell Machine Shop Research Report Figure 3A.

Lowell Hydroelectric Project (FERC Project No. 2790)
Relicensing Pre-Application Document Information Questionnaire

Boott Hydropower, LLC (Boott), a subsidiary of Enel Green Power North America, Inc. (Enel), is the Licensee and operator of the Lowell Hydroelectric Project (FERC No. 2790) (Project), with principal Project facilities located along the Merrimack River in Middlesex County, Massachusetts and a reservoir extending upstream to Hillsborough County, New Hampshire (see attached map). Boott, with assistance from HDR, Inc. (HDR), is beginning the Federal Energy Regulatory Commission (FERC) relicensing process for the existing Project. Accordingly, Boott is preparing a Pre-Application Document (PAD) that will provide FERC and other entities with existing, relevant, and reasonably available information pertaining to the Project that will be used to prepare documents related to analyzing the relicensing application to be prepared by Boott. To prepare the PAD, Boott will use information in its possession and information obtained from additional sources. This PAD Information Questionnaire will be used by Boott to help identify sources of existing, relevant, and reasonably available information that are not currently in Boott's possession.

1. Information about person completing the questionnaire:

Name & Title	Robert Kubit, Environmental Engineer
Organization	MA Department of Environmental Protection Central Regional Office
Address	8 New Bond St, Worcester MA 01606
Phone	508 767 2854
Email Address	robert.kubit@state.ma.us

2. Do you or your organization know of existing, relevant and reasonably available information that describes the existing Project's environment (e.g., information regarding the Merrimack River in or close to the Lowell Hydroelectric Project)?

✓ Yes (*If yes, please complete 2a through 2c)* __ No (*If no, go to 3*)

a. If yes, please circle the specific resource area(s) that the information relates to:

- Geology and soils
- Water resources
- Fish and aquatic resources
- Wildlife and botanical resources
- Wetlands, riparian, and littoral habitat
- Rare, threatened & endangered species
- Recreation and land use
- Aesthetic resources
- Cultural resources
- Socio-economic resources
- Tribal resources
- Other resource information

b. Please briefly describe the information referenced above or list available documents *(additional information may be provided on pages 3 or 4 of this questionnaire).*

c. Where can Boott obtain this information? Please include contact information if there is a specific representative that you wish to designate for potential follow-up contact by Boott's or HDR's representative *(additional information may be provided on pages 3 or 4 of this questionnaire).*

3. Do you or your organization plan to participate in the Lowell Hydroelectric Project relicensing proceeding?

✓ Yes __ No

If you answered yes to Question 3, please provide contact information for your organization's representative(s) that can be used for future communications regarding this relicensing:

Primary Representative Contact Information

Name	Robert Kubit
Address	MA Dept. Environmental Protection Central Regional Office 8 New Bond St Worcester MA 01606
Phone	508 767 2854
Email Address	robert.kubit@state.ma.us

Additional Representative Contact Information (Optional)

Name	
Address	
Phone	
Email Address	

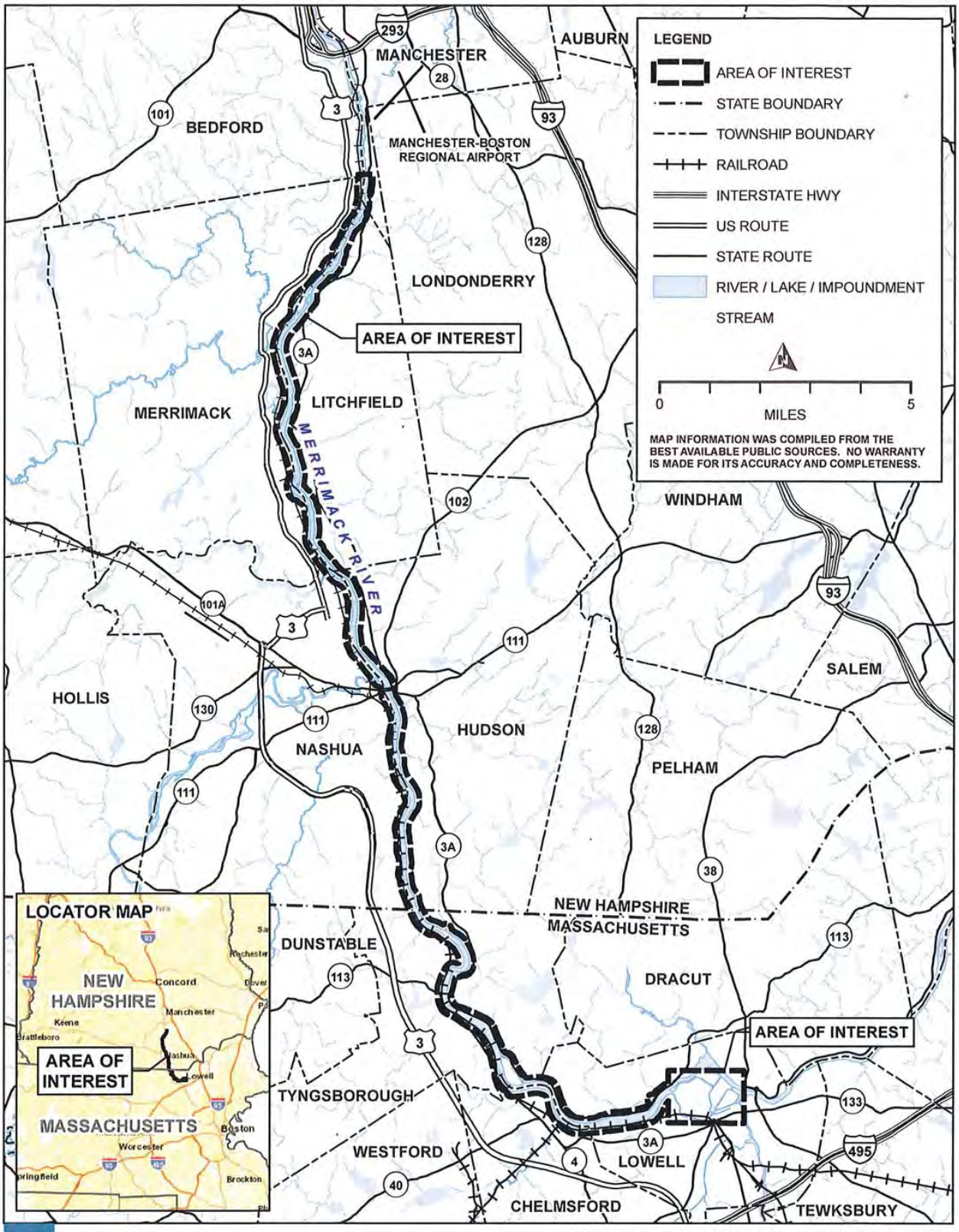
Additional Information (additional space provided on the following page):

Comments and/or questions may be sent via email to:

Jim Gibson, HDR, at Jim.Gibson@hdrinc.com or
Rob Quiggle, HDR, at Robert.Quiggle@hdrinc.com

If you have any questions about the Project, or the upcoming FERC licensing processes, please contact Mr. Kevin Webb, Enel Relicensing Manager for the Lowell Hydroelectric Project, at (978) 681-1900 ext. 809 or Kevin.Webb@enel.com; Jim Gibson at (315) 414-2202; or Rob Quiggle at (315) 414-2216.

Please return this questionnaire in the enclosed, self-addressed, stamped envelope within 21 days of receipt to allow for any follow-up contact that may be necessary by a representative from Boott or HDR. Not responding within 21 days indicates that you are not aware of any existing, relevant, and reasonably available information that describes the existing Project environment or known potential impacts of the Project.



LOWELL HYDROELECTRIC PROJECT
FERC NO. 2790
BOOTT HYDRO, LLC.

Scida, Rebecca

From: MacVane, Kelly
Sent: Friday, April 06, 2018 11:45 AM
To: Scida, Rebecca
Cc: Gibson, Jim; Quiggle, Robert
Subject: FW: Request for Integrated Report or Assessment Report
Attachments: 20180406114453026.pdf

Hi Becky-

Can you please add this response to the log? Also please PDF the email and attach to the PAD response.

Thanks,
Kelly

Kelly MacVane
D 207-239-3828 **M** 207-775-4495

hdrinc.com/follow-us

From: Gibson, Jim
Sent: Friday, April 6, 2018 11:41 AM
To: MacVane, Kelly <Kelly.MacVane@hdrinc.com>
Cc: Quiggle, Robert <Robert.Quiggle@hdrinc.com>
Subject: FW: Request for Integrated Report or Assessment Report

Note the links at the bottom of the email

Jim Gibson, MPA, MSES
Vice President

HDR
1304 Buckley Road, Suite 202
Syracuse, NY 13212
D 315.414.2202 **M** 315.415.2729
jim.gibson@hdrinc.com

hdrinc.com/follow-us

From: Kubit, Robert (DEP) [mailto:robert.kubit@state.ma.us]
Sent: Friday, April 6, 2018 11:39 AM
To: Gibson, Jim <Jim.Gibson@hdrinc.com>; Quiggle, Robert <Robert.Quiggle@hdrinc.com>
Subject: FW: Request for Integrated Report or Assessment Report

Gentlemen,

The attachment and information below provides the information you need from the MA Department of Environmental Protection.

Thanks.

Bob

Robert Kubit, P.E.
MassDEP
Division of Watershed Management
8 New Bond Street
Worcester MA 01606
Telephone: (508) 767-2854
Email: robert.kubit@state.ma.us
Fax: (508) 791-4131

From: Kennedy, Laurie (DEP)
Sent: Thursday, April 05, 2018 2:31 PM
To: Kubit, Robert (DEP)
Subject: RE: Request for Integrated Report or Assessment Report

Hi Bob,
Here is the link to the Merrimack River water quality assessment reports:
https://www.mass.gov/lists/water-quality-assessment-reports-merrimack-through-weymouth-weir-watersheds

Here is the link to the Interactive Mapping of the Integrated List of Waters
http://www.mass.gov/eea/agencies/massdep/water/watersheds/integrated-list-of-waters.html

Here is the link to the 2014 Integrated List of Waters
http://www.mass.gov/eea/docs/dep/water/resources/07v5/14list2.pdf

Link to MassDEP 1994-2014 Water Quality Monitoring Stations and to the data
https://docs.digital.mass.gov/dataset/massgis-data-massdep-1994-2014-water-quality-monitoring-stations
https://www.mass.gov/guides/water-quality-monitoring-program-data

Hope this helps!
Laurie

From: Kubit, Robert (DEP)
Sent: Thursday, April 05, 2018 12:30 PM
To: Kennedy, Laurie (DEP)
Subject: Request for Integrated Report or Assessment Report

Hi Laurie,

If you could provide public links to the Integrated/Assessment Reports for the Merrimack River Watershed, I will be able to fulfill a public record request.

Thank you.

Bob

Robert Kubit, P.E.
MassDEP
Division of Watershed Management
8 New Bond Street
Worcester MA 01606

Telephone: (508) 767-2854
Email: robert.kubit@state.ma.us
Fax: (508) 791-4131

IPaC **U.S. Fish & Wildlife Service**

IPaC resource list

This report is an automatically generated list of species and other resources such as critical habitat (collectively referred to as *trust resources*) under the U.S. Fish and Wildlife Service's (USFWS) jurisdiction that are known or expected to be on or near the project area referenced below. The list may also include trust resources that occur outside of the project area, but that could potentially be directly or indirectly affected by activities in the project area. However, determining the likelihood and extent of effects a project may have on trust resources typically requires gathering additional site-specific (e.g., vegetation/species surveys) and project-specific (e.g., magnitude and timing of proposed activities) information.

Below is a summary of the project information you provided and contact information for the USFWS office(s) with jurisdiction in the defined project area. Please read the introduction to each section that follows (Endangered Species, Migratory Birds, USFWS Facilities, and NWI Wetlands) for additional information applicable to the trust resources addressed in that section.

Location

Massachusetts and New Hampshire

Local office

New England Ecological Services Field Office

(603) 223-2541
(603) 223-0104

70 Commercial Street, Suite 300
Concord, NH 03301-5094

http://www.fws.gov/newengland

Endangered species

This resource list is for informational purposes only and does not constitute an analysis of project level impacts.

The primary information used to generate this list is the known or expected range of each species. Additional areas of influence (AOI) for species are also considered. An AOI includes areas outside of the species range if the species could be indirectly affected by activities in that area (e.g., placing a dam upstream of a fish population, even if that fish does not occur at the dam site, may indirectly impact the species by reducing or eliminating water flow downstream). Because species can move, and site conditions can change, the species on this list are not guaranteed to be found on or near the project area. To fully determine any potential effects to species, additional site-specific and project-specific information is often required.

Section 7 of the Endangered Species Act **requires** Federal agencies to "request of the Secretary information whether any species which is listed or proposed to be listed may be present in the area of such proposed action" for any project that is conducted, permitted, funded, or licensed by any Federal agency. A letter from the local office and a species list which fulfills this requirement can **only** be obtained by requesting an official species list from either the Regulatory Review section in IPaC (see directions below) or from the local field office directly.

For project evaluations that require USFWS concurrence/review, please return to the IPaC website and request an official species list by doing the following:

1. Draw the project location and click CONTINUE.
2. Click DEFINE PROJECT.
3. Log in (if directed to do so).
4. Provide a name and description for your project.
5. Click REQUEST SPECIES LIST.

Listed species[1] are managed by the Ecological Services Program of the U.S. Fish and Wildlife Service.

1. Species listed under the Endangered Species Act are threatened or endangered; IPaC also shows species that are candidates, or proposed, for listing. See the listing status page for more information.

The following species are potentially affected by activities in this location:

Mammals

NAME	STATUS
Northern Long-eared Bat Myotis septentrionalis No critical habitat has been designated for this species. https://ecos.fws.gov/ecp/species/9045	Threatened

Critical habitats

Potential effects to critical habitat(s) in this location must be analyzed along with the endangered species themselves.

THERE ARE NO CRITICAL HABITATS AT THIS LOCATION.

Migratory birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.

Additional information can be found using the following links:

- Birds of Conservation Concern http://www.fws.gov/birds/management/managed-species/birds-of-conservation-concern.php
- Measures for avoiding and minimizing impacts to birds http://www.fws.gov/birds/management/project-assessment-tools-and-guidance/conservation-measures.php
- Nationwide conservation measures for birds http://www.fws.gov/migratorybirds/pdf/management/nationwidestandardconservationmeasures.pdf

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see maps of where birders and the general public have sighted birds in and around your project area, visit E-bird tools such as the E-bird data mapping tool (search for the name of a bird on your list to see specific locations where that bird has been reported to occur within your project area over a certain timeframe) and the E-bird Explore Data Tool (perform a query to see a list of all birds sighted in your county or region and within a certain timeframe). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME

BREEDING SEASON (IF A BREEDING SEASON IS INDICATED FOR A BIRD ON YOUR LIST, THE BIRD MAY BREED IN YOUR PROJECT AREA SOMETIME WITHIN THE TIMEFRAME SPECIFIED, WHICH IS A VERY LIBERAL ESTIMATE OF THE DATES INSIDE WHICH THE BIRD BREEDS ACROSS ITS ENTIRE RANGE. "BREEDS ELSEWHERE" INDICATES THAT THE BIRD DOES NOT LIKELY BREED IN YOUR PROJECT AREA.)

American Oystercatcher Haematopus palliatus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/8935	Breeds Apr 15 to Aug 31
Bald Eagle Haliaeetus leucocephalus This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Oct 15 to Aug 31
Black Skimmer Rynchops niger This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/5234	Breeds May 20 to Sep 15
Black-billed Cuckoo Coccyzus erythropthalmus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9399	Breeds May 15 to Oct 10
Bobolink Dolichonyx oryzivorus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 20 to Jul 31
Buff-breasted Sandpiper Calidris subruficollis This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9488	Breeds elsewhere

Cerulean Warbler Dendroica cerulea — Breeds Apr 29 to Jul 20
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/2974

Clapper Rail Rallus crepitans — Breeds Apr 10 to Oct 31
This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA

Eastern Whip-poor-will Antrostomus vociferus — Breeds May 1 to Aug 20
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Evening Grosbeak Coccothraustes vespertinus — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Golden Eagle Aquila chrysaetos — Breeds elsewhere
This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities.
https://ecos.fws.gov/ecp/species/1680

Golden-winged Warbler Vermivora chrysoptera — Breeds May 1 to Jul 20
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/8745

Hudsonian Godwit Limosa haemastica — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Kentucky Warbler Oporornis formosus — Breeds Apr 20 to Aug 20
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

King Rail Rallus elegans — Breeds May 1 to Sep 5
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/8936

Least Tern Sterna antillarum — Breeds Apr 20 to Sep 10
This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA

Lesser Yellowlegs Tringa flavipes — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/9679

Long-eared Owl asio otus — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.
https://ecos.fws.gov/ecp/species/3631

Nelson's Sparrow Ammodramus nelsoni — Breeds May 15 to Sep 5
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Prairie Warbler Dendroica discolor — Breeds May 1 to Jul 31
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Prothonotary Warbler Protonotaria citrea — Breeds Apr 1 to Jul 31
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Purple Sandpiper Calidris maritima — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Red-headed Woodpecker Melanerpes erythrocephalus — Breeds May 10 to Sep 10
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Red-throated Loon Gavia stellata — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Rusty Blackbird Euphagus carolinus — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Seaside Sparrow Ammodramus maritimus — Breeds May 10 to Aug 20
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Semipalmated Sandpiper Calidris pusilla — Breeds elsewhere
This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.

Short-billed Dowitcher Limnodromus griseus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9480	Breeds elsewhere
Snowy Owl Bubo scandiacus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds elsewhere
Whimbrel Numenius phaeopus This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9483	Breeds elsewhere
Willet Tringa semipalmata This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds Apr 20 to Aug 5
Wood Thrush Hylocichla mustelina This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 10 to Aug 31

Probability of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds.

Probability of Presence (■)

Each green bar represents the bird's relative probability of presence in your project's counties during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.

3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

To see a bar's probability of presence score, simply hover your mouse cursor over the bar.

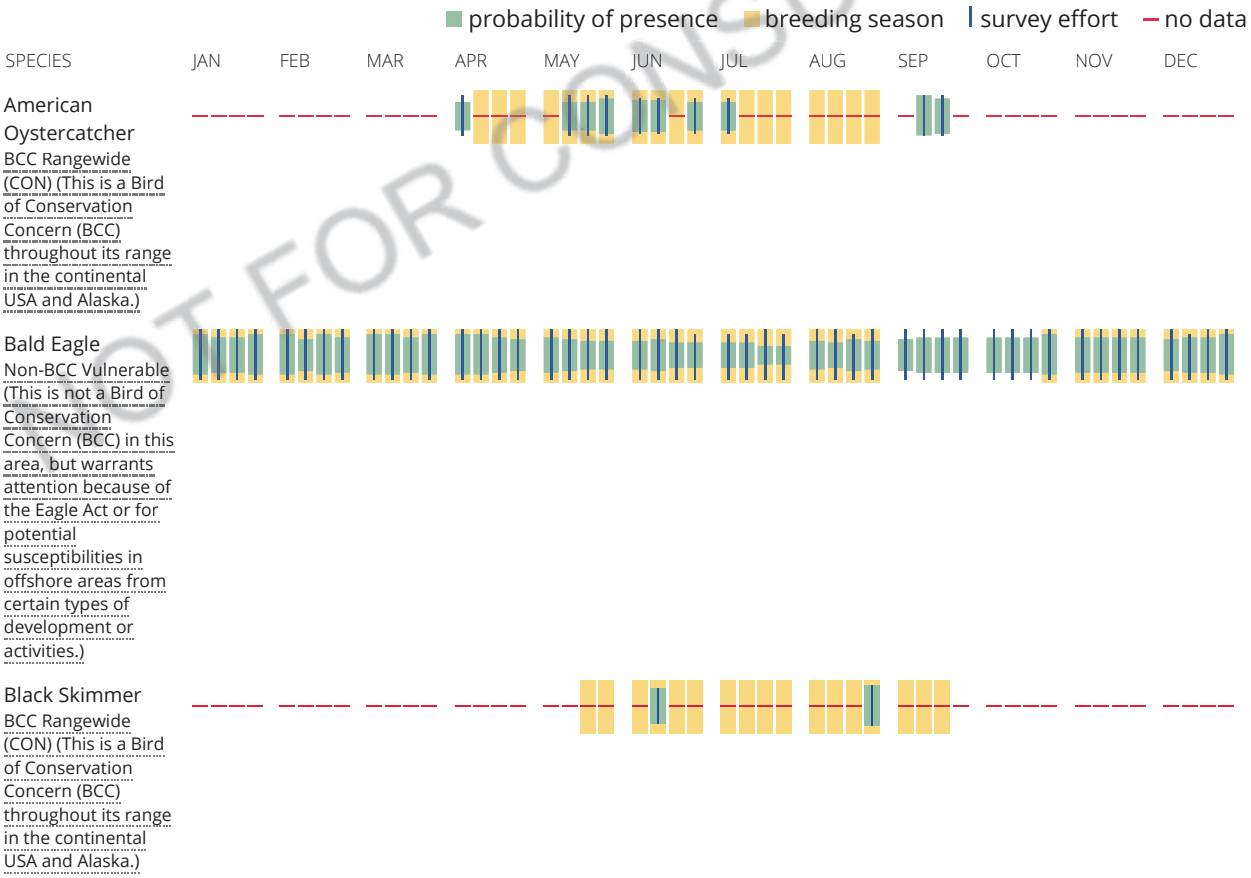
Breeding Season ( )
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

Survey Effort (|)
Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the counties of your project area. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

To see a bar's survey effort range, simply hover your mouse cursor over the bar.

No Data (–)
A week is marked as having no data if there were no survey events for that week.

Survey Timeframe
Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information.



Black-billed Cuckoo
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Bobolink
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

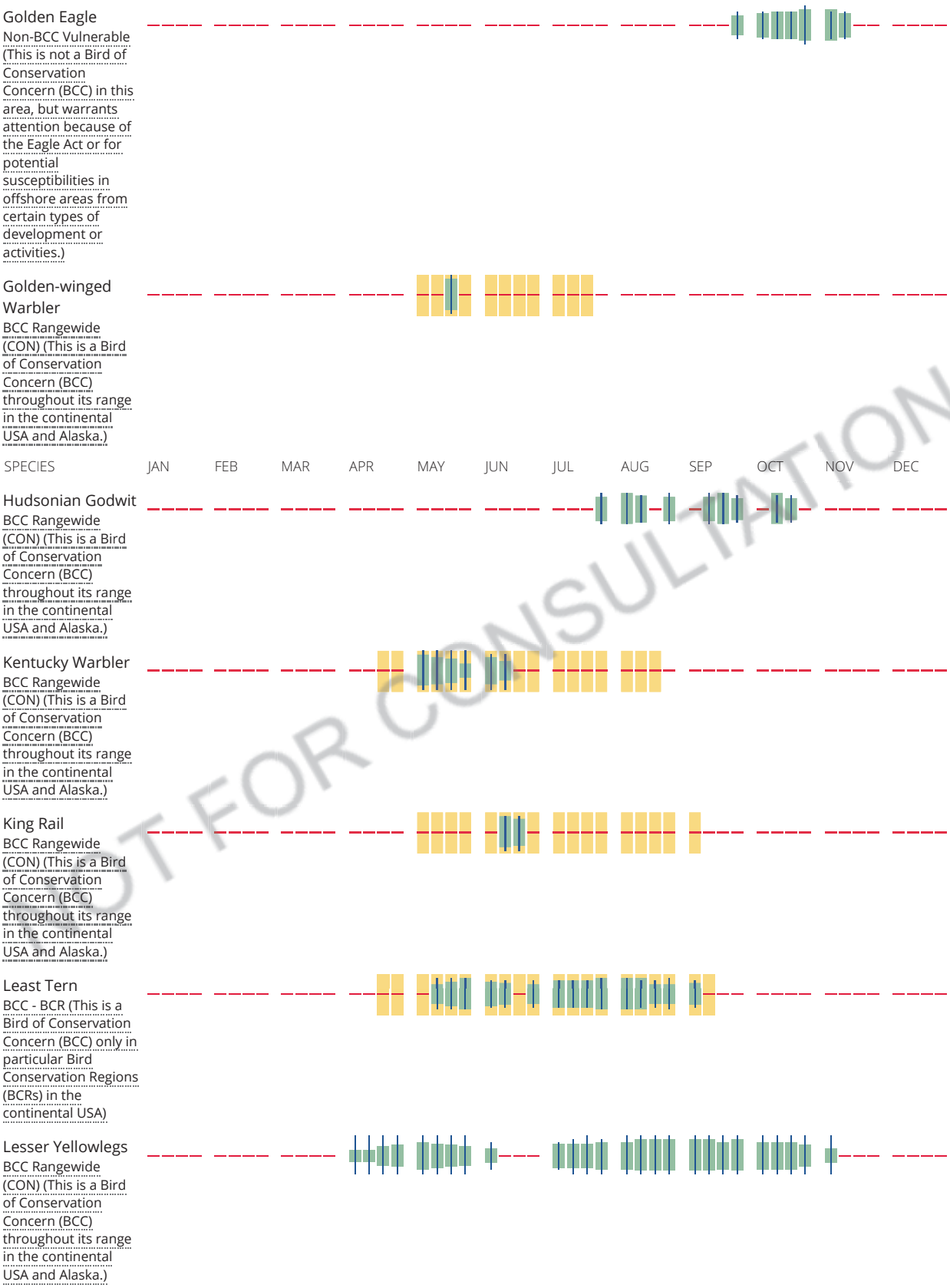
Buff-breasted Sandpiper
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Cerulean Warbler
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Clapper Rail
BCC - BCR (This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA)

Eastern Whip-poor-will
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Evening Grosbeak
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)



Rusty Blackbird
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Seaside Sparrow
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Semipalmated Sandpiper
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Short-billed Dowitcher
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Snowy Owl
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Whimbrel
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Willet
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Wood Thrush
BCC Rangewide (CON) (This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.)

Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures and/or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

What does IPaC use to generate the migratory birds potentially occurring in my specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the counties which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the E-bird Explore Data Tool.

What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?

The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets .

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

How do I know if a bird is breeding, wintering, migrating or present year-round in my project area?

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may refer to the following resources: The The Cornell Lab of Ornithology All About Birds Bird Guide, or (if you are unsuccessful in locating the bird of interest there), the Cornell Lab of Ornithology Neotropical Birds guide. If a bird entry on your migratory bird species list indicates a breeding season, it is probable that the bird breeds in your project's counties at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

What are the levels of concern for migratory birds?

Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

Details about birds that are potentially affected by offshore projects

For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

What if I have eagles on my list?

If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the BGEPA should such impacts occur.

Facilities

National Wildlife Refuge lands

Any activity proposed on lands managed by the National Wildlife Refuge system must undergo a 'Compatibility Determination' conducted by the Refuge. Please contact the individual Refuges to discuss any questions or concerns.

THERE ARE NO REFUGE LANDS AT THIS LOCATION.

Fish hatcheries

This location overlaps the following National Fish Hatcheries. Please contact them for further guidance.

HATCHERY	ACRES

Merrimack River Atlantic Salmon Smolt Release Site 8.42 acres

(603) 595-0891
(603) 595-0892

MAILING ADDRESS
151 Broad Street
Nashua, NH 03063-3213

PHYSICAL ADDRESS
Charles Bancroft Highway
Litchfield, NH 03052

https://www.fws.gov/offices/Directory/OfficeDetail.cfm?OrgCode=53261

Wetlands in the National Wetlands Inventory

Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

For more information please contact the Regulatory Program of the local U.S. Army Corps of Engineers District.

WETLAND INFORMATION IS NOT AVAILABLE AT THIS TIME
This can happen when the National Wetlands Inventory (NWI) map service is unavailable, or for very large projects that intersect many wetland areas. Try again, or visit the NWI map to view wetlands at this location.

Data limitations

The Service's objective of mapping wetlands and deepwater habitats is to produce reconnaissance level information on the location, type and size of these resources. The maps are prepared from the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. A margin of error is inherent in the use of imagery; thus, detailed on-the-ground inspection of any particular site may result in revision of the wetland boundaries or classification established through image analysis.

The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data and the amount of ground truth verification work conducted. Metadata should be consulted to determine the date of the source imagery used and any mapping problems.

Wetlands or other mapped features may have changed since the date of the imagery or field work. There may be occasional differences in polygon boundaries or classifications between the information depicted on the map and the actual conditions on site.

Data exclusions

Certain wetland habitats are excluded from the National mapping program because of the limitations of aerial imagery as the primary data source used to detect wetlands. These habitats include seagrasses or submerged aquatic vegetation that are found in the intertidal and subtidal zones of estuaries and nearshore coastal waters.

Some deepwater reef communities (coral or tuberficid worm reefs) have also been excluded from the inventory. These habitats, because of their depth, go undetected by aerial imagery.

Data precautions

Federal, state, and local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, in either the design or products of this inventory, to define the limits of proprietary jurisdiction of any Federal, state, or local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advice of appropriate federal, state, or local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities.

Memo

NH Natural Heritage Bureau
NHB Datacheck Results Letter

To: Kelly MacVane, HDR Engineering, Inc.
970 Baxter Boulevard
Portland, ME 04103

From: Amy Lamb, NH Natural Heritage Bureau
Date: 4/16/2018 (valid for one year from this date)
Re: Review by NH Natural Heritage Bureau
NHB File ID: NHB18-1178 Town: Bedford, Merrimack, Litchfield, Nashua, Hudson Location: Merrimack River from Lowell, MA to Bedford, NH

Description: On behalf of Boott Hydropower, LLC (Boott), HDR, Inc. (HDR) is gathering information in support of the Pre-Application Document (PAD) for the upcoming Federal Energy Regulatory Commission (FERC) relicensing of the Lowell Hydroelectric Project (FERC No. 2790) (Project). In support of this process, HDR is requesting information regarding the following within the Project area:
- State-listed threatened or endangered species;
- Species proposed for listing as threatened or endangered, or species of concern;
- Designated or proposed critical habitat; and
- Candidate species.

The Lowell Hydroelectric Project is located on the Merrimack River in in Middlesex County, Massachusetts, and an impoundment extending upstream to Hillsborough County, New Hampshire.

cc: Kim Tuttle

As requested, I have searched our database for records of rare species and exemplary natural communities, with the following results.

Comments: This site is within an area flagged for possible impacts on the state-listed *Alasmidonta varicosa* (brook floater) in the Merrimack River

Invertebrate Species	**State[1]**	**Federal**	**Notes**
Brook Floater (*Alasmidonta varicosa*)	E	--	Contact the NH Fish & Game Dept (see below).

Natural Community	**State[1]**	**Federal**	**Notes**
Hemlock forest*	--	--	Threats include logging, introduction of invasive species, and direct destruction due to development.
High-gradient rocky riverbank system	--	--	Threats are primarily changes to the hydrology of the river, land conversion and fragmentation, introduction of invasive species, and increased input of nutrients and pollutants.

Department of Natural and Cultural Resources
Division of Forests and Lands
(603) 271-2214 fax: 271-6488

DNCR/NHB
172 Pembroke Rd.
Concord, NH 03301

Memo

NH Natural Heritage Bureau
NHB Datacheck Results Letter

Plant species	State[1]	Federal	Notes
arrow-head rattlebox (*Crotalaria sagittalis*)*	E	--	
bird-foot violet (*Viola pedata var. pedata*)	T	--	This species occurs in sandplains, disturbed openings, dry forests, and thin woods. Threats would include direct destruction of the plants or major alterations in their habitat.
clasping milkweed (*Asclepias amplexicaulis*)*	T	--	This species grows in sandplains and disturbed openings, and is sensitive to disturbances that eliminate its habitat.
dry land sedge (*Carex siccata*)*	E	--	Threats to this species are mainly loss of habitat.
long-spined sandbur (*Cenchrus longispinus*)*	E	--	This species grows in sandplains and disturbed openings, and is sensitive to disturbances that eliminate its habitat.
red-footed spikesedge (*Eleocharis erythropoda*)*	E	--	This wetland species, which occurs in bogs/fens/seeps, and marshes, would be threatened by changes to local hydrology, including increased nutrient input from stormwater runoff, and sedimentation from nearby disturbance.
river birch (*Betula nigra*)	T	--	The population could be deleteriously affected by any project activities that alter the hydrology of its habitat, by increased sedimentation, and by increased nutrients/pollutants in stormwater runoff.
unpretentious yellow-seeded false pimpernel (*Lindernia dubia var. anagallidea*)*	E	--	The pond shore habitat that supports this species can only withstand a limited amount of human disturbance. Trampling, removal, and burying of vegetation are all destructive and can also result in the introduction of non-native invasive species. Dams that reduce natural fluctuations in water level threaten the long-term survival of this habitat, e.g., by allowing woody shrubs and other more competitive vegetation to become established. Another threat is the contamination of water quality by road and agricultural runoff.
wild lupine (*Lupinus perennis ssp. perennis*)	T	--	This wildflower grows in extremely dry, sandy openings and is easily identified in the field (see any wildflower guide) between early May and August. It is tolerant of surrounding disturbance and depends upon periodic mowing (or, historically, wildfire) to eliminate trees that would otherwise shade it out. It does not transplant well due to a tap root that can be more than three feet long.
Wright's spikesedge (*Eleocharis diandra*)	E	--	Primarily vulnerable to changes to the hydrology of its wetland habitat, especially alterations that change water levels. It may also be susceptible to increased pollutants and nutrients carried in stormwater runoff.

Vertebrate species	State[1]	Federal	Notes

Department of Natural and Cultural Resources
Division of Forests and Lands
(603) 271-2214 fax: 271-6488

DNCR/NHB
172 Pembroke Rd.
Concord, NH 03301

American Eel (*Anguilla rostrata*)	SC	--	Contact the NH Fish & Game Dept (see below).
Bald Eagle (*Haliaeetus leucocephalus*)	SC	--	Contact the NH Fish & Game Dept (see below).
Banded Sunfish (*Enneacanthus obesus*)	SC	--	Contact the NH Fish & Game Dept (see below).
Blanding's Turtle (*Emydoidea blandingii*)	E	--	Contact the NH Fish & Game Dept (see below).
Eastern Hognose Snake (*Heterodon platirhinos*)	E	--	Contact the NH Fish & Game Dept (see below).
Eastern Meadowlark (*Sturnella magna*)	T	--	Contact the NH Fish & Game Dept (see below).
Grasshopper Sparrow (*Ammodramus savannarum*)	T	--	Contact the NH Fish & Game Dept (see below).
New England Cottontail (*Sylvilagus transitionalis*)	E	--	Contact the NH Fish & Game Dept (see below).
Northern Black Racer (*Coluber constrictor constrictor*)	T	--	Contact the NH Fish & Game Dept (see below).
Northern Leopard Frog (*Lithobates pipiens*)	SC	--	Contact the NH Fish & Game Dept (see below).
Peregrine Falcon (*Falco peregrinus anatum*)	T	--	Contact the NH Fish & Game Dept (see below).
Redfin Pickerel (*Esox americanus americanus*)	SC	--	Contact the NH Fish & Game Dept (see below).
Sea Lamprey (*Petromyzon marinus*)	SC	--	Contact the NH Fish & Game Dept (see below).
Smooth Green Snake (*Opheodrys vernalis*)	SC	--	Contact the NH Fish & Game Dept (see below).
Sora (*Porzana carolina*)	SC	--	Contact the NH Fish & Game Dept (see below).
Spotted Turtle (*Clemmys guttata*)	T	--	Contact the NH Fish & Game Dept (see below).
Vesper Sparrow (*Pooecetes gramineus*)	SC	--	Contact the NH Fish & Game Dept (see below).
Wood Turtle (*Glyptemys insculpta*)	SC	--	Contact the NH Fish & Game Dept (see below).

[1]Codes: "E" = Endangered, "T" = Threatened, “SC” = Special Concern, "--" = an exemplary natural community, or a rare species tracked by NH Natural Heritage that has not yet been added to the official state list. An asterisk (*) indicates that the most recent report for that occurrence was more than 20 years ago.

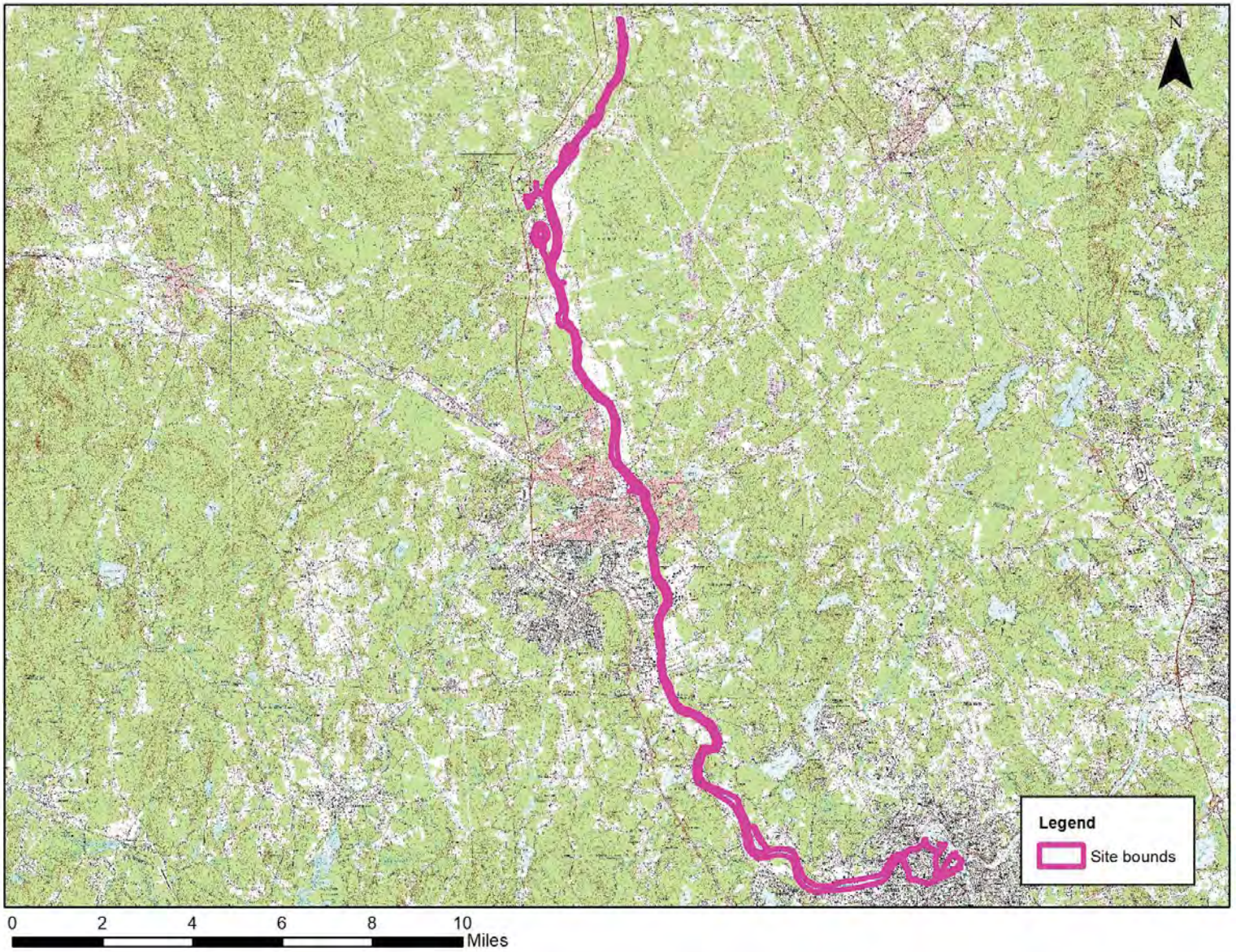
Contact for all animal reviews: Kim Tuttle, NH F&G, (603) 271-6544.

A negative result (no record in our database) does not mean that a sensitive species is not present. Our data can only tell you of known occurrences, based on information gathered by qualified biologists and reported to our office. However, many areas have never been surveyed, or have only been surveyed for certain species. An on-site survey would provide better information on what species and communities are indeed present.

Department of Natural and Cultural Resources
Division of Forests and Lands
(603) 271-2214 fax: 271-6488

DNCR/NHB
172 Pembroke Rd.
Concord, NH 03301

NHB18-1178



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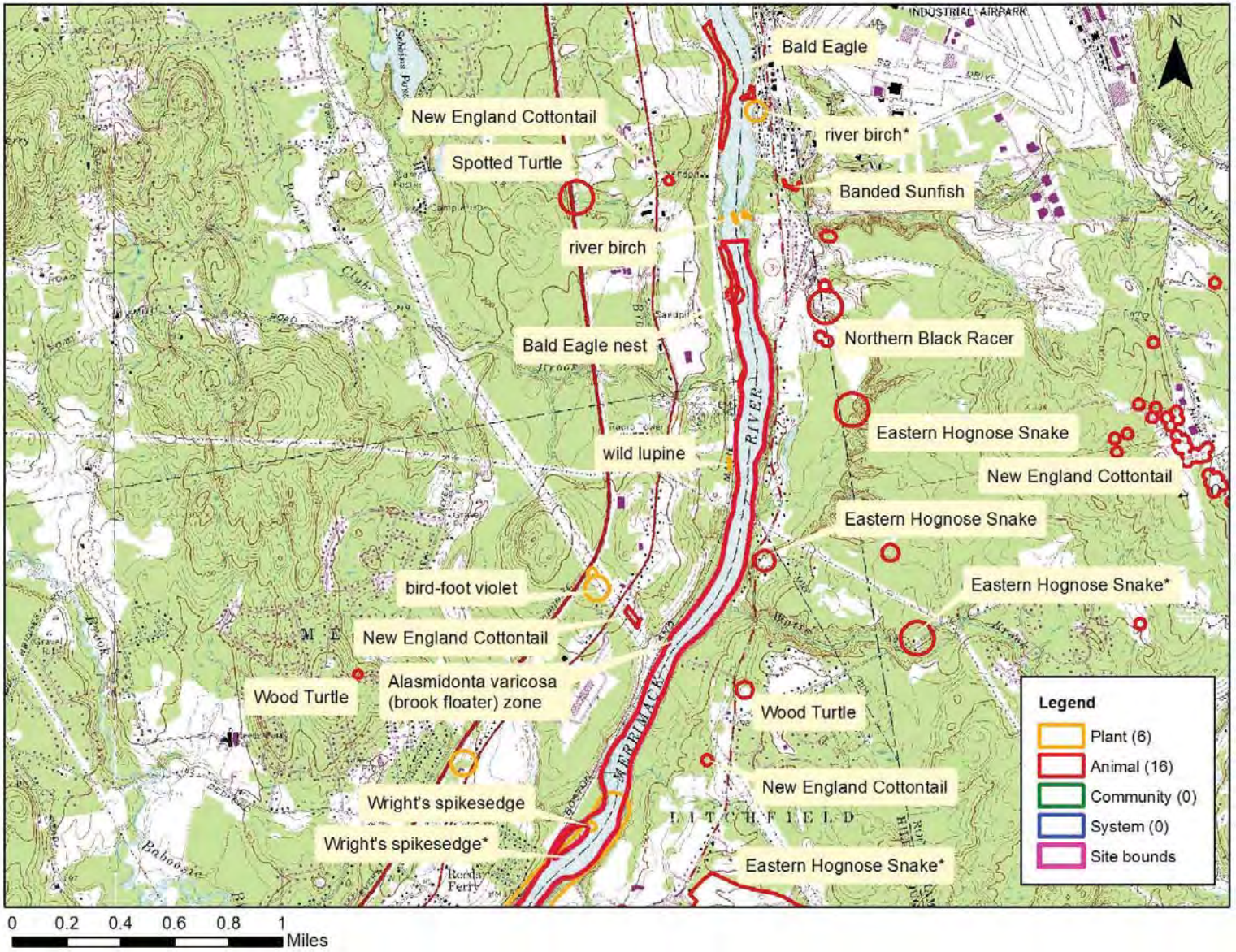

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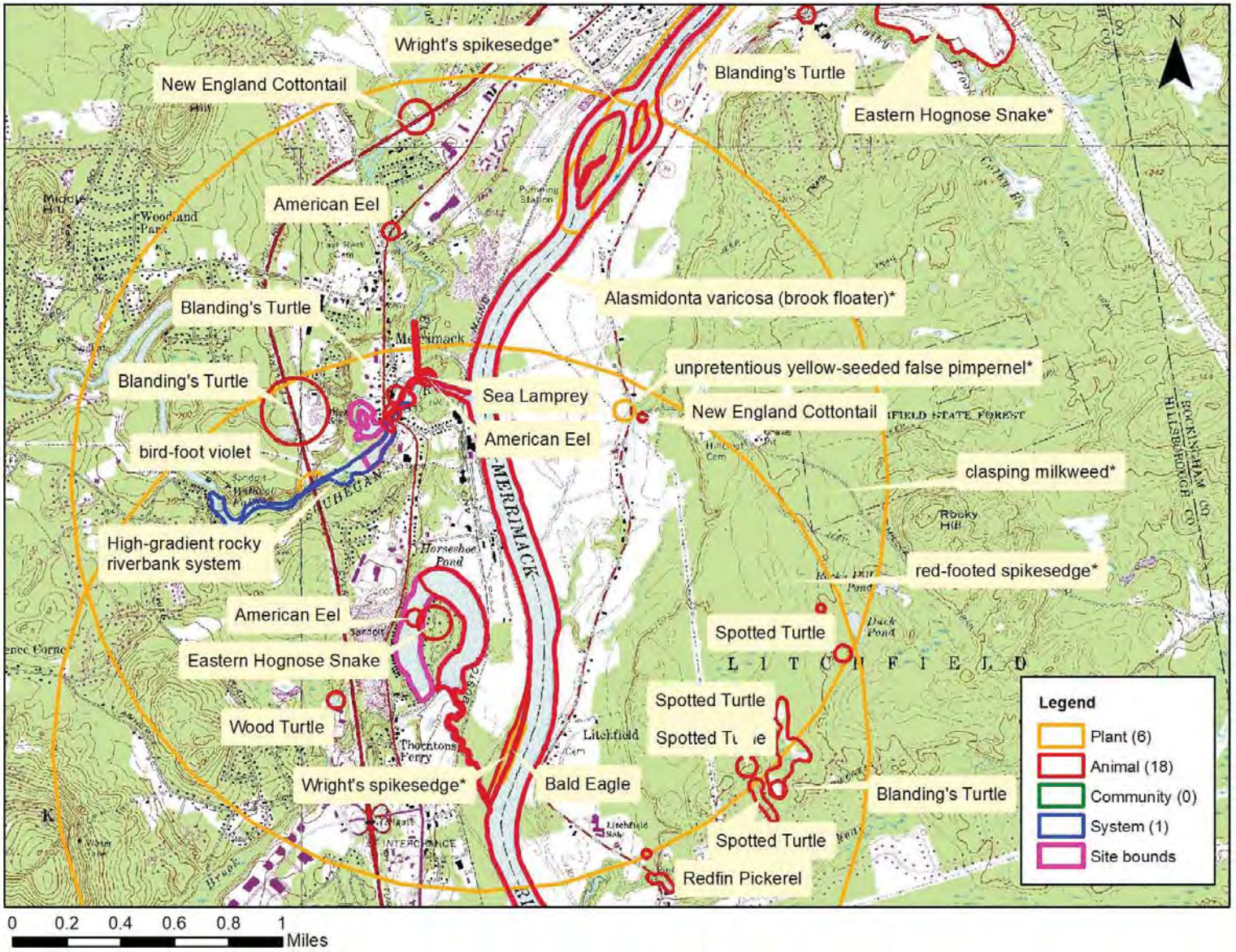

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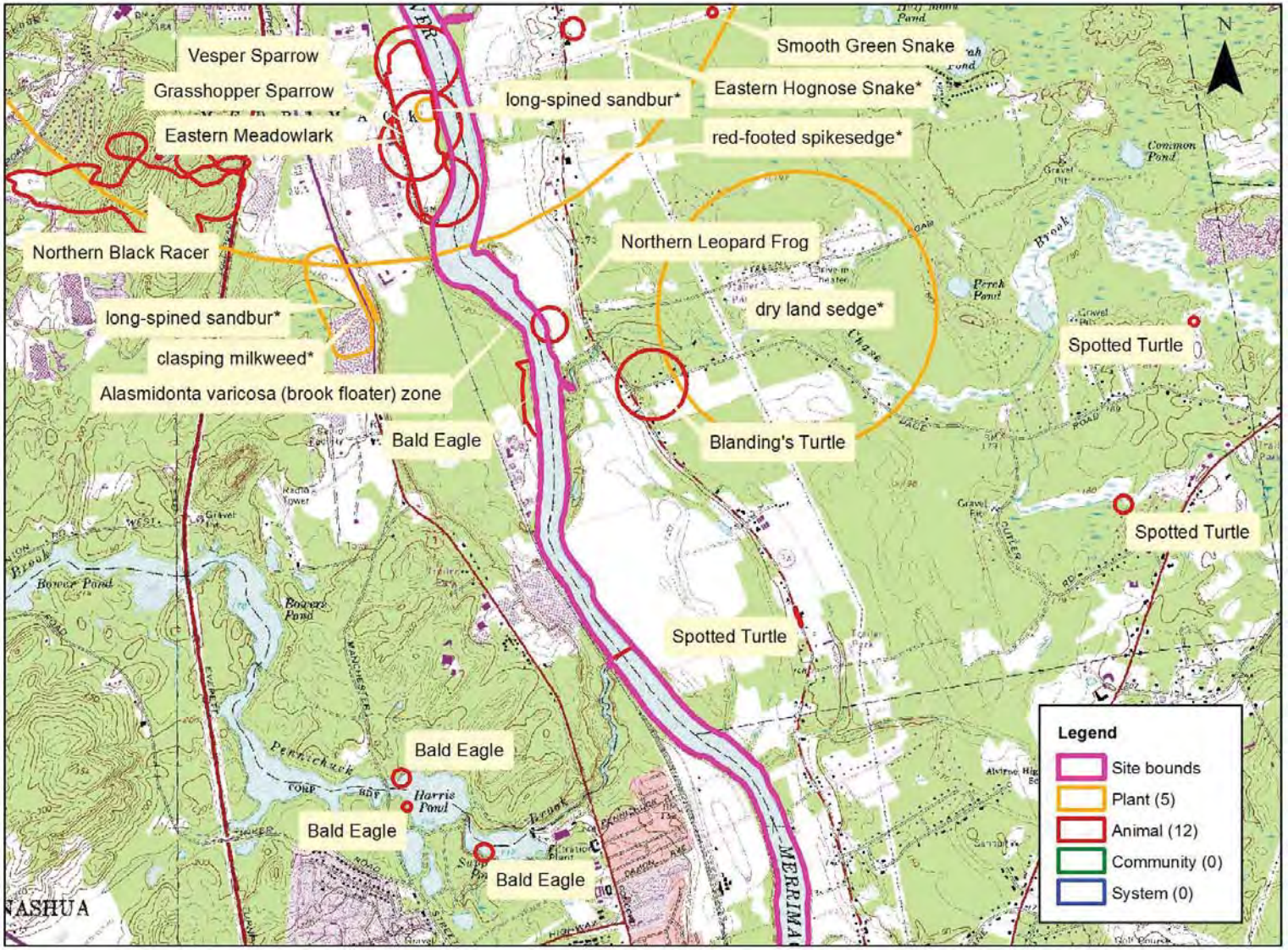

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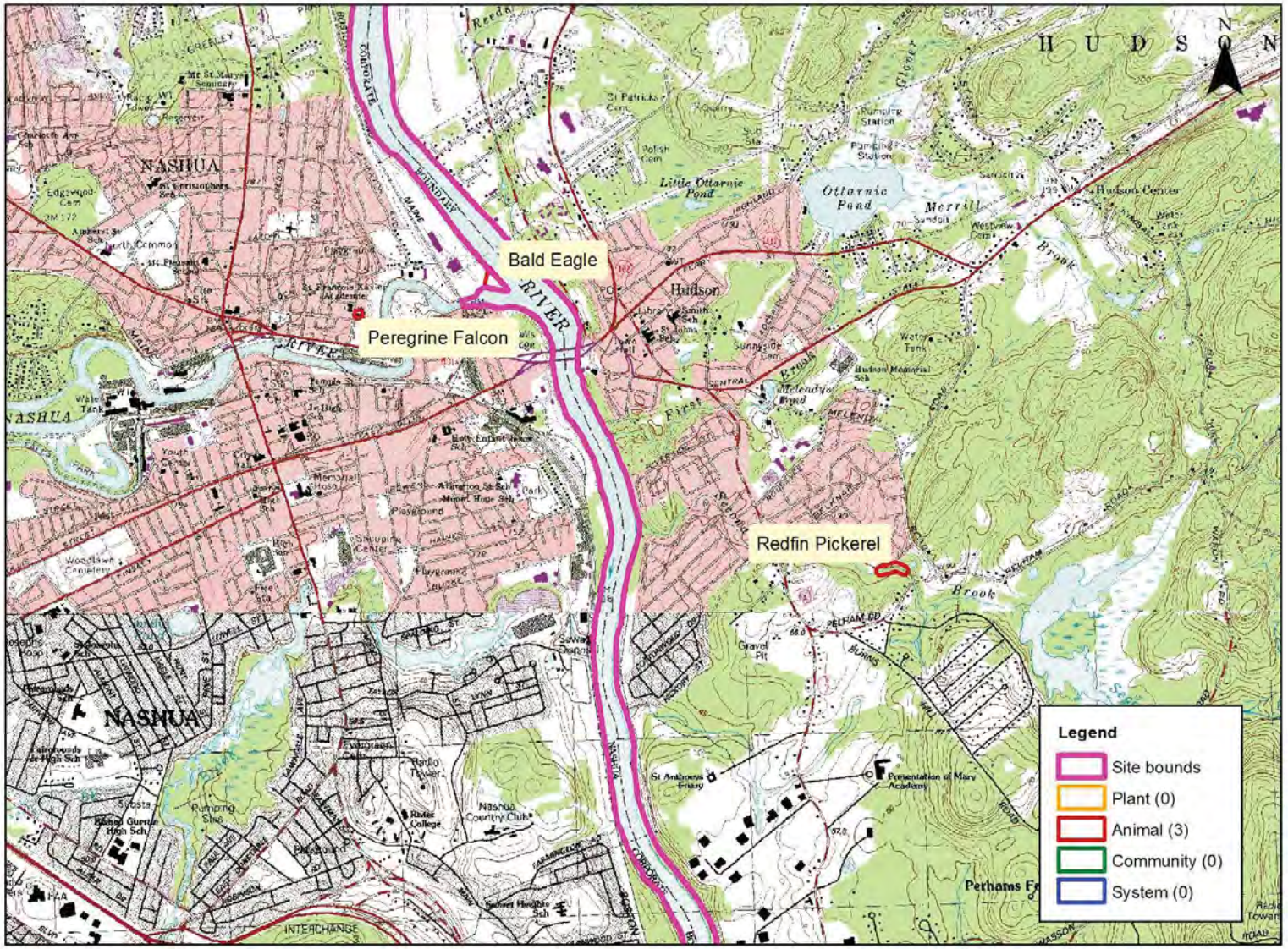

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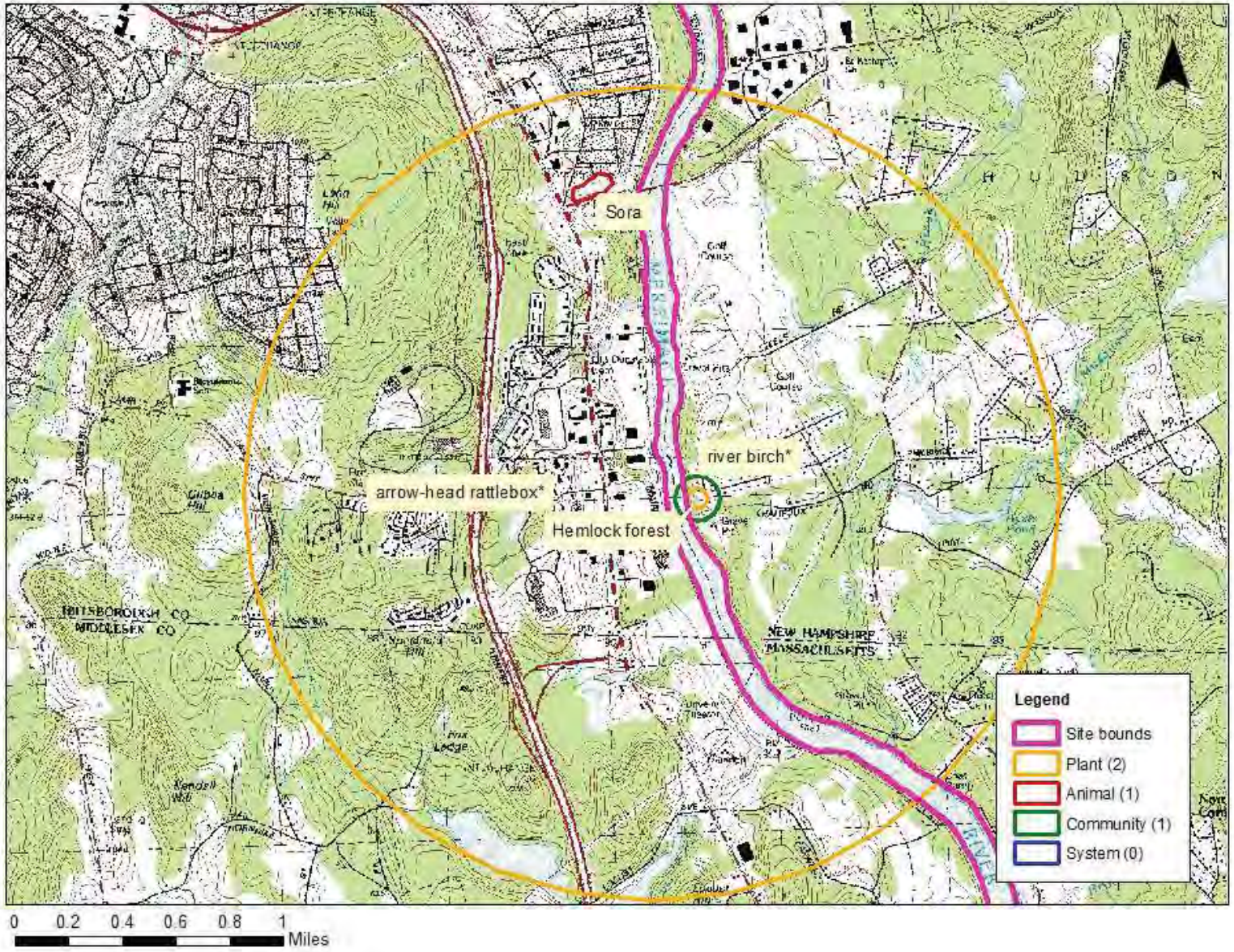

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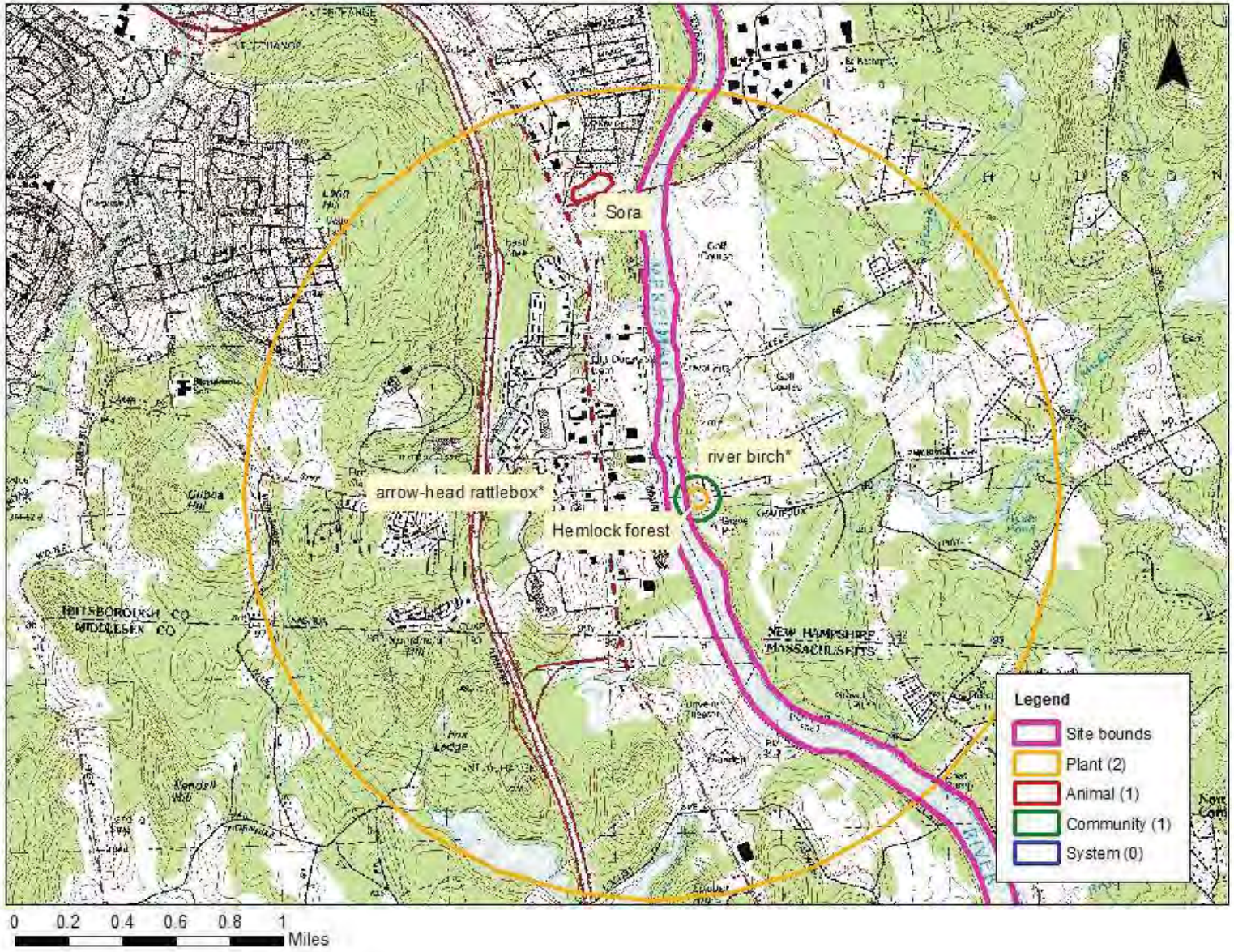

NHB18-1178 EOCODE: CT00000224*004*NH

New Hampshire Natural Heritage Bureau - Community Record

Hemlock forest

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Not ranked (need more information)
State:	Not listed	State:	Apparently secure but with cause for concern

Description at this Location

Conservation Rank:	Historical records only - current condition unknown.
Comments on Rank:	Small, formerly cut over
Detailed Description:	1985: Small area of steep bank with *Thuja* and *Tsuga* dominant. Similar to a disjunct occurrence of *Thuja* on Cape Cod, MA. Both sites with steep western exposure, dense *Tsuga* and access to constant light source from adjacent opening.
General Area:	1985: Steep forested riverbluff above Merrimack River with unusual occurrence of *Thuja*.
General Comments:	Lack of escaped *Thuja* in acidic soils of SNE also supports native probability.
Management Comments:	

Location

Survey Site Name:	Riverbluff West of Chalifoux Road
Managed By:	Hi-Tension Realty Corp.
County:	Hillsborough
Town(s):	Hudson
Size:	13.6 acres
Elevation:	
Precision:	Within (but not necessarily restricted to) the area indicated on the map.
Directions:	Hudson. Riverbluff west of Chalifoux Road. Small, steep bluff along the Merrimack River, due west of Chalifoux Road. Just north of `Sanders'.

Dates documented

First reported:	1985	Last reported:	1985-07-06

New Hampshire Natural Heritage Bureau - System Record

High-gradient rocky riverbank system

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Not ranked (need more information)
State:	Not listed	State:	Rare or uncommon

Description at this Location

Conservation Rank:	Good quality, condition and landscape context ('B' on a scale of A-D).
Comments on Rank:	2010: This is a borderline EO (BC rank for an S3 system). Because this type of system is rare in this part of the state, it is considered exemplary with the BC score.
Detailed Description:	2010: This system supports ***acidic riverbank outcrop***, ***boulder - cobble river channel***, and ***cobble - sand river channel*** communities. Sections of the mapped polygon are also moderate-gradient. 1984: Canopy consists of *Quercus alba*, *Pinus strobus*, *Tsuga canadensis*, and *Acer rubrum*. Possible vegetative stems of *Allium schoenoprasm* var. *sibiricum* found on gravel bar.
General Area:	2010: Upland communities adjacent to river include ***hemlock - beech - oak - pine forest*** and ***dry Appalachian oak forest***. This system crosses below two large roads (F.E. Everett Turnpike and the old Rte. 3 [Daniel Webster Highway]). Residential and commercial land use also occur adjacent to river in several areas. 1984: Steep, sandy, forested riverbank and rocky gorge along steep gradient of river, with sandy gravel bar terraces.
General Comments:	1984: Field check for Allium schoenoprasm var. sibiricum during June or July.
Management Comments:	

Location

Survey Site Name:	Wildcat Falls
Managed By:	Currier Road Conservation Area
County:	Hillsborough
Town(s):	Merrimack
Size:	17.1 acres
Elevation:	

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2010: From Baboosic Lake Road, turn south onto Currier Road and follow to end (0.45 miles). Park at Currier Road Conservation Area trailhead. 1984: Wildcat Falls of the Souhegan River, west of the Daniel Webster Highway (Rte. 3).

Dates documented

First reported:	1984-09-24	Last reported:	2010-09-27

New Hampshire Natural Heritage Bureau - Plant Record

arrow-head rattlebox (*Crotalaria sagittalis*)

Legal Status

Federal: Not listed
State: Listed Endangered

Conservation Status

Global: Demonstrably widespread, abundant, and secure
State: Not ranked (need more information)

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 1958: In limited numbers. Specimen collected.
General Area: Sandplain.
General Comments: First New Hampshire record.
Management Comments:

Location

Survey Site Name: Merrimack River
Managed By: Hi-Tension Realty Corp.

County: Hillsborough
Town(s): Nashua
Size: 4592.3 acres
Elevation:

Precision: Within 1.5 miles of the area indicated on the map (location information is vague or uncertain).

Directions: Nashua. Merrimack River. Sandplain of western side of Merrimack River ca. 1 to 2 miles south of city.

Dates documented

First reported: 1958-09-11
Last reported: 1958-09-11

New Hampshire Natural Heritage Bureau - Plant Record

bird-foot violet (*Viola pedata var. pedata*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank:	Good quality, condition and landscape context ('B' on a scale of A-D).
Comments on Rank:	Plants transplanted; survival and management are questionable.
Detailed Description:	2016: Area 4: 2 plants, 1 mature with 9 blossoms, the other a seedling. 1993: Site 1 (east side) had over 70 plants (flowering and not flowering). Site 1A had over 100 plants (flowering and not flowering). Site 2 had 15 plants in northern subpopulation (more had been transplanted originally), southern sub-population could not be located. Sites 3 and 4 were not visited in 1993. 1991: plants were transplanted from a site that was going to be destroyed. Plants were just beginning to flower.
General Area:	2016: Area 4: The plants were found growing in the mowed grassy shoulder immediately adjacent to the northbound side of the Everett Turnpike and beneath electric transmission corridor. The immediate area where the larger of the 2 plants are growing is moss covered with scattered grasses and herbaceous growth. The seedling is growing in an area with short grasses. 1993: Mowed grassy area on the side of a highway.
General Comments:	All plants were transplanted to these sites.
Management Comments:	2016: Area 4: Management plans for transmission tower maintenance will include maps with plant locations marked as sensitive with instructions to avoid. 1993: DOT is aware that mowing should be done after June (post seed set) or done with a blade at least 6 inches high so that seeds plants are not cut before seed set.

Location

Survey Site Name: Old Toll Booth Site
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 11.1 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2016: Area 4: Side of Everett Turnpike at power line crossing [42.900804, -71.464557].
1993: Five sites along either side of the Everett Turnpike. All are transplants. Site 1 (east) and 1A (west) are on each side of turnpike just north of the Souhegan River crossing. Site 2 is 0.3 miles north of Souhegan River bridge on east side of road, about 30 yards east of road and 20 yards south of lone pine tree. Plants are in 2 groups, 1 group about 20 yards south of lone pine, another about 20 yards south of first group. Site 3 is along the northbound side 0.4 miles north of exit 12. Site 4 is along the northbound side under powerlines ca. 1.1 miles north of exit 12.

Dates documented

First reported: 1991 Last reported: 2016-05-03

NHB18-1178 EOCODE: PDASC02020*003*NH

New Hampshire Natural Heritage Bureau - Plant Record

clasping milkweed (*Asclepias amplexicaulis*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 1963: Hodgdon specimen at NHA (ARH & FLS 12733).
General Area: Dry bank, riverside.
General Comments:
Management Comments:

Location

Survey Site Name: Merrimack River
Managed By: Currier Road Conservation Area

County: Hillsborough
Town(s): Merrimack
Size: 4592.3 acres Elevation:

Precision: Within 1.5 miles of the area indicated on the map (location information is vague or uncertain).

Directions: Merrimack. Merrimack River, western side, on dry roadside bank.

Dates documented

First reported: 1963 Last reported: 1963-07-01

NHB18-1178 EOCODE: PDASC02020*007*NH

New Hampshire Natural Heritage Bureau - Plant Record

clasping milkweed (*Asclepias amplexicaulis*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank: 1 plant, hardly defensible.

Detailed Description: 2010: Searched for but not found. 1984: 1 plant, in fruit.
General Area: 1984: Sandy roadside.
General Comments:
Management Comments:

Location

Survey Site Name: Sanders Trailer Park
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: .1 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 1984: East side of Rte. 3, ca. 100 meters north of entrance to Sanders Trailer Park.

Dates documented

First reported: 1984-09-19 Last reported: 1984-09-19

NHB18-1178 EOCODE: PMCYP03L50*003*NH

New Hampshire Natural Heritage Bureau - Plant Record

dry land sedge (*Carex siccata*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 1931: Specimen collected.
General Area: 1931: Sandy bank.
General Comments:
Management Comments:

Location

Survey Site Name: Darrah Pond, SW of
Managed By: Town of Litchfield Land

County: Hillsborough
Town(s): Litchfield
Size: 494.3 acres Elevation:

Precision: Within 1.5 miles of the area indicated on the map (location information is vague or uncertain).

Directions: 1931: 1 mile SW of Darrah Pond.

Dates documented

First reported: 1931-08-09 Last reported: 1931-08-09

New Hampshire Natural Heritage Bureau - Plant Record

long-spined sandbur (*Cenchrus longispinus*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank:	Historical records only - current condition unknown.
Comments on Rank:	Habitat destroyed by development and road construction.
Detailed Description:	2010: Searched for but not found. Habitat destroyed. Presumed extirpated. But area searched was probably south of the original observation.1984: Abundant ("much").
General Area:	1984: Sandy, disturbed field. [Possibly "a south-facing sandy slope with an abundance of dwarf chestnut oak (*Quercus prinoides*) and pitch pine (*Pinus rigida*)", but this description could refer to another nearby area.]
General Comments:	2010: (Area south of probable original observation): Based on this area now being a parking lot for several BAE (and aerial) systems and the altered nature of the landscape west of the lot (fill, mowing, etc.), suggest changing status to extirpated.
Management Comments:	

Location

Survey Site Name:	Merrimack
Managed By:	Merrimack Technology Park
County:	Hillsborough
Town(s):	Merrimack
Size:	35.2 acres
Elevation:	
Precision:	Within (but not necessarily restricted to) the area indicated on the map.
Directions:	1984: [West side of Rte. 3, sandy disturbed field north of Sanders Associates].

Dates documented

First reported:	1984-09-19	Last reported:	1984-09-19

NHB18-1178 EOCODE: PMPOA1C080*010*NH

New Hampshire Natural Heritage Bureau - Plant Record

long-spined sandbur (*Cenchrus longispinus*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 1986: Details not recorded.
General Area: 1986: Edge of field.
General Comments:
Management Comments:

Location

Survey Site Name: Merrimack River, near Anheuser-Busch Brewery
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 2.8 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: Edge of field behind Anheuser-Busch plant near salt storage barn.

Dates documented

First reported: 1986 Last reported: 1986-09

NHB18-1178 EOCODE: PMCYP090P0*003*NH

New Hampshire Natural Heritage Bureau - Plant Record

red-footed spikesedge (*Eleocharis erythropoda*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 1929: COLLECTED BY PEASE 1929.
General Area: 1929: Sandy riverbank.
General Comments:
Management Comments:

Location

Survey Site Name: Thorntons Ferry
Managed By: Merrimack Village District Land

County: Hillsborough
Town(s): Merrimack
Size: 4592.3 acres Elevation:

Precision: Within 1.5 miles of the area indicated on the map (location information is vague or uncertain).

Directions: Merrimack. Thorntons Ferry. Sandy riverbank.

Dates documented

First reported: 1929 Last reported: 1929

New Hampshire Natural Heritage Bureau - Plant Record

river birch (*Betula nigra*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Fair quality, condition and/or landscape context ('C' on a scale of A-D).
Comments on Rank:

Detailed Description: 2015: Area 1: 8 plants. Area 2: 13 plants. Area 3: 8 plants. Area 4: 7 plants. In addition to the tree and shrub size individuals, seedlings were also observed. The plants are located within a ROW and show evidence of past maintenance. Many of the shrubs are vigorous stump sprouts.
1992: River birch saplings were found growing within riverside outcrop community.

General Area: 2015: Individual shrubs and saplings were tightly associated with the ordinary high water mark of the river, at the base of steep slopes, and on an island in the river.
1992: Riverside outcrop community.

General Comments:

Management Comments: 2015: Trees occur in a power line right-of-way and show evidence of past maintenance. Many of the shrubs are vigororous stump sprouts.

Location

Survey Site Name: Peninsula North of Goffs Falls
Managed By: Merrimack Riverfront

County: Hillsborough
Town(s): Manchester
Size: .5 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2015: Area 1: From the rear (east side) of the industrial building at 15 Iron Horse Drive in Bedford, walk approximately 300 feet east across the railroad and into the powerline corridor to the Merrimack River. Individuals are located on the west bank of the Merrimack River. Area 2: From 285 Hazleton Ave in Manchester where the street intersects the powerline corridor, walk approximately 500 feet west down the corridor to the east bank of the Merrimack River. Individuals are located along the west bank of the roughly 800 foot long island in the river. Note that depending on current water levels, the island may be inaccessible by foot. Areas 3 and 4: From 285 Hazleton Ave in Manchester where the street intersects the powerline corridor, walk approximately 500 feet west down the corridor to the east bank of the Merrimack River. Individuals are located along the bank of the river, and along the east bank of an adjacent island roughly 800 feet long. Note that depending on current water levels, the island may be inaccessible by foot.
Manchester. Island in Merrimack River.

Dates documented

First reported: 1992 Last reported: 2015-09-16

NHB18-1178 EOCODE: PDBET020A0*009*NH

New Hampshire Natural Heritage Bureau - Plant Record

river birch (*Betula nigra*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank: 1 tree seen.

Detailed Description: 1985: 1 tree found, vigourous and mature. On a bench 15 feet above the river.
General Area: Moist bottom land in open light of western aspect. With *Acer saccharinum*, *Quercus rubra*.
General Comments: Searches farther upstream are needed.
Management Comments:

Location

Survey Site Name: Riverbluff West of Chalifoux Road
Managed By:

County: Hillsborough
Town(s): Hudson
Size: 2.8 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: Small, steep bluff along the Merrimack River, due west of Chalifoux Road, just north of `Sander's'.

Dates documented

First reported: 1985 Last reported: 1985-06-07

NHB18-1178 EOCODE: PDBET020A0*011*NH

New Hampshire Natural Heritage Bureau - Plant Record

river birch (*Betula nigra*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 1992: River birch saplings were found growing within riverside outcrop community.
General Area: 1992: Riverside outcrop community.
General Comments:
Management Comments:

Location

Survey Site Name: Peninsula South of Goffs Falls
Managed By:

County: Hillsborough
Town(s): Manchester
Size: 2.8 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: Manchester. Merrimack River corridor subsites. Peninsula south of Goffs Falls.

Dates documented

First reported: 1992 Last reported: 1992

NHB18-1178 EOCODE: PDSCR12041*003*NH

New Hampshire Natural Heritage Bureau - Plant Record

unpretentious yellow-seeded false pimpernel (*Lindernia dubia var. anagallidea*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Apparently secure but with cause for concern
State:	Listed Endangered	State:	Not ranked (need more information)

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 1992: No detailed notes taken. *Lindernia* occurs along with the similar but more common *Lindernia dubia*. Other associated spp include: *Eleocharis ovata*, *Juncus canadensis*, and *Cyperus strigosus*.
General Area: 1992: Disturbed marshy wetland scrape surrounded by golf course.
General Comments:
Management Comments:

Location

Survey Site Name: Litchfield Golf Course
Managed By:

County: Hillsborough
Town(s): Litchfield
Size: 2.8 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: Litchfield. Located just north of the Hillcrest Road and Rte 3A junction in wetland scrape surrounded by golf course and fairly close to the road.

Dates documented

First reported: 1992-09-23 Last reported: 1992-09-23

New Hampshire Natural Heritage Bureau - Plant Record

wild lupine (*Lupinus perennis ssp. perennis*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank:	Fair quality, condition and/or landscape context ('C' on a scale of A-D).
Comments on Rank:	Small population along well-used trail but apparently increasing in size.
Detailed Description:	2011: 22 stems in scattered clumps. 6 plants in flower, 3 plants with seed. Evidence of herbivory on one plant. Population observed for at least two years and the number of plants has increased.2010: No details (see 2011).
General Area:	2011: Flat trail, sandy soil. Associated plants include sweet-fern (*Comptonia peregrina*), eastern white pine (*Pinus strobus*), pitch pine (*P. rigida*), scrub oak (*Quercus ilicifolia*), northern red oak (*Q. rubra*), and common lowbush blueberry (*Vaccinium angustifolium*).
General Comments:	
Management Comments:	

Location

Survey Site Name:	Pointer Club Brook, south of		
Managed By:			
County:	Hillsborough		
Town(s):	Merrimack		
Size:	.0 acres	Elevation:	

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2011: Travel south on Daniel Webster Highway and park at Table of Stone, 759 Daniel Webster Highway. Access the Heritage Trail from adjacent property after getting landowner permission. Alternatively (longer walk), access the Heritage Trail at new bridge over the Merrimack River. Head south on trail to a storage facility (currently named Extra Space Storage). Plants start parallel with unit 560 and continue along both sides of the trail up to the end of the storage facility. There is a fence between the trail and the storage facility.

Dates documented

First reported:	2010	Last reported:	2011-06-10

New Hampshire Natural Heritage Bureau - Plant Record

Wright's spikesedge (*Eleocharis diandra*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Imperiled due to rarity or vulnerability
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2016: 10 plants observed in two locations, in an area totaling approximately 5 x 0.5 meters.
General Area: 2016: Plants are scattered along a very narrow sandy/silty strip that is between the river and the eroded drop-off edge of a vegetation mat, all near the upstream end of the island. The back channel is now impounded by beavers, and significant ATV use has created a worn track a short distance from the bank dropoff. Associated species include nodding beggar-ticks (*Bidens cernua*), two stamens umbrella sedge (*Cyperus diandrus*), red-root umbrella sedge (*Cyperus erythrorhizos*), incurved umbrella sedge (*Cyperus squarrosus*), straw-colored umbrella sedge (*Cyperus strigosus*), American barnyard grass (*Echinochloa muricata*), blunt spikesedge (*Eleocharis obtusa* var. *obtusa*), slender fimbry (*Fimbristylis autumnalis*), clammy hedge-hyssop (*Gratiola neglecta*), dwarf St. John's-wort (*Hypericum mutilum*), Canada rush (*Juncus canadensis*), rice cut grass (*Leersia oryzoides*), red lobelia (*Lobelia cardinalis*), common water-primrose (*Ludwigia palustris*), and purple loosestrife (*Lythrum salicaria*).
General Comments:
Management Comments:

Location

Survey Site Name: Reeds Ferry
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: .4 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2016: [Plants are along water's edge at bottom of eroded bank of sand bar island on west side of river, near Reed's Ferry, Merrimack].

Dates documented

First reported: 2016-10-20 Last reported: 2016-10-20

NHB18-1178 EOCODE: PMCYP092C0*001*NH

New Hampshire Natural Heritage Bureau - Plant Record

Wright's spikesedge (*Eleocharis diandra*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Imperiled due to rarity or vulnerability
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 2016: Searched for but not found.
1929: Specimen collected.
General Area: 1929: Sandy riverbank.
General Comments: 2016: "Chris Kane spent a couple of hours on September 22, 2016 scouring up and downstream of the general site area known as Thornton's Ferry, Merrimack. Knowing exactly where the original collection site was will probably never be known. Very few *Eleocharis* of any kind were observed, the habitat did not look particularly suitable for *Eleocharis diandra*, and none of the notable associated species such as *Cyperus squarrosus* and *Cyperus diandrus* were present."
Management Comments:

Location

Survey Site Name: Thornton's Ferry
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 4.8 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: Thornton's Ferry.

Dates documented

First reported: 1929-07-31 Last reported: 1929-07-31

NHB18-1178 EOCODE: PMCYP092C0*002*NH

New Hampshire Natural Heritage Bureau - Plant Record

Wright's spikesedge (*Eleocharis diandra*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Imperiled due to rarity or vulnerability
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 1931: Specimen collected.
General Area: 1931: Muddy bank.
General Comments:
Management Comments:

Location

Survey Site Name: Reeds Ferry
Managed By: Moores Falls Conservation Area

County: Hillsborough
Town(s): Litchfield
Size: 121.3 acres Elevation:

Precision: Within 1.5 miles of the area indicated on the map (location information is vague or uncertain).

Directions: Reeds Ferry.

Dates documented

First reported: 1931-08-27 Last reported: 1931-08-27

NHB18-1178 EOCODE: AFCEA01010*003*NH

New Hampshire Natural Heritage Bureau - Animal Record

American Eel (*Anguilla rostrata*)

Legal Status	Conservation Status
Federal: Not listed	Global: Apparently secure but with cause for concern
State: Special Concern	State: Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2000: Area 13216: Not enumerated.
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Baboosic Brook
Managed By: Twin Bridges Park

County: Hillsborough
Town(s): Merrimack
Size: 1.9 acres
Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2000: Baboosic Brook

Dates documented

First reported: 2000 Last reported: 2000

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AFCEA01010*097*NH

New Hampshire Natural Heritage Bureau - Animal Record

American Eel (*Anguilla rostrata*)

Legal Status	Conservation Status
Federal: Not listed	Global: Apparently secure but with cause for concern
State: Special Concern	State: Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2008: Area 13321M: 1 observed.2007: Area 13321M: 1 observed.
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Beaver Brook
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 1.9 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2008: Souhegan River, below Merrimack Village Dam to Merrimack River.

Dates documented

First reported: 2007-08-21 Last reported: 2008-07-02

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AFCEA01010*108*NH

New Hampshire Natural Heritage Bureau - Animal Record

American Eel (*Anguilla rostrata*)

Legal Status	Conservation Status
Federal: Not listed	Global: Apparently secure but with cause for concern
State: Special Concern	State: Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2009: Area 13333: 1 observed.
General Area: 2009: Area 13333: Ledge/boulder habitat downstream of Rte. 3.
General Comments:
Management Comments:

Location

Survey Site Name: Beaver Brook
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 1.9 acres
Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2009: Souhegan River

Dates documented

First reported: 2009-08-20 Last reported: 2009-08-20

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AFCEA01010*147*NH

New Hampshire Natural Heritage Bureau - Animal Record

American Eel (*Anguilla rostrata*)

Legal Status	Conservation Status
Federal: Not listed	Global: Apparently secure but with cause for concern
State: Special Concern	State: Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2011: Area 11369: Not enumerated.
General Area: 2011: Area 11369: Good number of downed trees, lots of vegetation (milfoil).
General Comments:
Management Comments:

Location

Survey Site Name: Litchfield Tributaries
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 1.9 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2011: Horseshoe Pond.

Dates documented

First reported: 2011-07-21 Last reported: 2011-07-21

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

New Hampshire Natural Heritage Bureau - Animal Record

Bald Eagle (*Haliaeetus leucocephalus*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Special Concern	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2002-2012: Wintering eagles regularly observed at locations along the Merrimack River, day perching and night roosts:2012: Solitary eagles observed at 2 separate locations on 1/7. Solitary eagles observed at 2 separate locations on 1/31. 2 eagles observed at a single location on 2/7. 1 eagle observed on 2/9. Solitary eagles observed at 3 separate locations on 2/25.2011: 3 eagles observed at a single location and 2 at a separate location on 1/8. 1 eagle observed on 1/9. 1 eagle observed on 1/11. 1 eagle observed on 1/13. 2 eagles observed at a single location on 2/7. 1 eagle observed on 2/9. 1 eagle observed on 2/15. 1 eagle observed on 2/17. 1 eagle observed on 2/22. 1 eagle observed on 3/2. 4 eagles observed at a single location, 2 eagles at 2 separate locations, and a soliltary eagle observed on 2/26. 1 eagle observed on 12/13. 1 eagle observed on 12/15. 2010: 7 eagles observed at a single location, 4 eagles at a single location, 2 eagles at a single location, and solitary eagles at 6 locations on 1/9. Solitary eagles at 2 separate locations on 2/28. 1 eagle observed on 12/17. 1 eagle observed on 12/20. 1 eagle observed on 12/22. 1 eagle observed on 12/30.2009: 4 eagles observed at a single location, 2 eagles observed at 2 separate locations, and solitary eagles at 5 separate locations on 1/10. 4 eagles observed at a single location, and 2 eagles located at 4 separate locations on 2/28.2008: 3 eagles observed at a single location, 2 eagles at a single location, and solitary eagles at 2 separate locations on 1/12. 2 eagles observed at a single location and 1 at a separate location on 2/23.2007: 6 eagles observed at a single location, 2 eagles at a single location, and solitary eagles at 2 separate locations on 2/24.2006: 3 eagles observed at 3 separate locations, 2 eagles at 3 separate locations, and solitary eagles at 7 separate locations on 1/7. 2 eagles observed at a single location and 1 at a separate location on 2/18. 6 eagles observed at a single location, 3 at a single location, 2 eagles at 2 separate locations, and a solitary eagle at 1 location on 2/25.2005: Solitary eagles observed at 6 separate locations on 1/8. 1 eagle observed on 1/10. 12 eagles observed at a single location, 5 eagles at a single location, and 3 eagles at 2 separate locations on 2/4. 5 eagles observed at a single location, 3 eagles at a single location, and solitary eagles at 4 separate locations on 2/26.2004: Solitary eagles observed at 6 separate locations on 1/10. 1 eagle observed on 12/20.2003: 4 locations with 2 eagles observed on 1 location with a single eagle on 1/9. 2 eagles at a single location on 1/11. 1 eagle observed on 1/31. 4 eagles at a single location on 2/1. 5 eagles at one location and 2 at another location on 2/2. 9 eagles at a single location on 2/28. 3 eagles at a single location, 2 eagles at 2 separate locations, and 1 eagle at 2 separate locations on 3/1.2002: 2 eagles observed at separate locations on 1/12. Observations of 2 and 3 eagles at 2 separate locations on 12/22.1993: Near Amoskeag Bridge, suspected roosting behind the Youth Center, perching on north side of bridge. Perching on Amoskeag Islands. Some sightings near mouth of Piscataquog River. Also roosting behind Caldor's, NSS Corporation. Confirmed roosting at Sebbins Brook between Rte 3 and the river. Also at Reed's Ferry islands, Pennichuck Brook, all the way south to the Nashua River. 1991: Consistent perching near Amoskeag Bridge, between Queen City bridge and 101/283. Roosting behind Youth Development Center north of Amoskeag Bridge.
General Area: Eagles perch, sometimes roost in large white pines along the riverbank.
General Comments:
Management Comments:

Location

NHB18-1178 EOCODE: ABNKC10010*003*NH

Survey Site Name: Lower Merrimack River
Managed By: Smiths Ferry Heritage Park

County: Hillsborough
Town(s): Manchester
Size: 116.0 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: Various locations along the banks of the Merrimack River.

Dates documented

First reported: 198? Last reported: 2012-02-25

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ABNKC10010*094*NH

New Hampshire Natural Heritage Bureau - Animal Record

Bald Eagle (*Haliaeetus leucocephalus*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Special Concern	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2017: Nest 3: Nest active, no chicks fledged.
2016: Nest 2: Nest active, no chicks fledged.
2014: Nest 2: 2 chicks fledged.
2013: Nest 1: 2 chicks fledged.
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Pennichuck Brook
Managed By: Pennichuck Water Works

County: Hillsborough
Town(s): Nashua
Size: 4.3 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions:

Dates documented

First reported: 2013 Last reported: 2017

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AFCQB10030*008*NH

New Hampshire Natural Heritage Bureau - Animal Record

Banded Sunfish (*Enneacanthus obesus*)

Legal Status	Conservation Status
Federal: Not listed	Global: Demonstrably widespread, abundant, and secure
State: Special Concern	State: Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2005: Area 8978: 2 observed, age and sex unknown. Area 8972: 1 observed, age and sex unknown. 2000: Area 260: 1 observed, age and sex unknown (Obs_id 368). 1938: Cohas Brook: Specimen collected.

General Area: 2005: Area 8978: Freshwater - stream or river. Area 8972: Freshwater - stream or river. Wide channel with a lot of pickerel weed and submerged vegetation. Marsh and pond-like area. 2000: Area 260: Freshwater - stream or river (Obs_id 368). 1938: Cohas Brook: Vegetation moderate, rushes and *Potamogeton* (pondweed). Partly wooded shore, moderate current.

General Comments: 2000: Area 260: Sampled by DES electrofishing 150 meter index site (Obs_id 368).
Management Comments:

Location

Survey Site Name: Cohas Brook
Managed By: NHDOT Mitigation

County: Hillsborough
Town(s): Manchester
Size: 84.8 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 1938: Cohas Brook: Cohas Brook from I93 W to Little Island Pond. 2000: Area 260: Cohas Brook at DES Station 00m-50. 2005: Area 8978: Little Cohas Brook on Hall Rd. Area 8972: Cohas Brook on Auburn Rd. at sand and gravel pit.

Dates documented

First reported: 1938 Last reported: 2005-10-03

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARAAD04010*075*NH

New Hampshire Natural Heritage Bureau - Animal Record

Blanding's Turtle (*Emydoidea blandingii*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Apparently secure but with cause for concern
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Fair quality, condition and/or landscape context ('C' on a scale of A-D).
Comments on Rank:

Detailed Description: 2001: Area 996: 1 adult male.
General Area: 2001: Area 996: Highway breakdown lane near wetland.
General Comments:
Management Comments:

Location

Survey Site Name: Wildcat Falls
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 30.8 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2001: Area 996: On Rte. 293 north, in breakdown lane just north of wetland (north of Souhegan River).

Dates documented

First reported: 2001-08-06 Last reported: 2001-08-06

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARAAD04010*248*NH

New Hampshire Natural Heritage Bureau - Animal Record

Blanding's Turtle (*Emydoidea blandingii*)

Legal Status	Conservation Status
Federal: Not listed	Global: Apparently secure but with cause for concern
State: Listed Endangered	State: Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2002: Area 1007: 1 turtle.
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Nesenkeag Brook
Managed By:

County: Hillsborough
Town(s): Litchfield
Size: 30.8 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2002: Area 1007: Page Road, couple hundred yards east of Rte. 3A, forested wetlands and stream system of Chase Brook.

Dates documented

First reported: 2002-06-15 Last reported: 2002-06-15

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARAAD04010*560*NH

New Hampshire Natural Heritage Bureau - Animal Record

Blanding's Turtle (*Emydoidea blandingii*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Apparently secure but with cause for concern
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2006: Area 12084: 1 observed.
General Area: 2006: Area 12084: [Sand plain basin marsh].
General Comments:
Management Comments:

Location

Survey Site Name: Nesenkeag Brook
Managed By: Town of Litchfield Land

County: Hillsborough
Town(s): Litchfield
Size: 1.9 acres
Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2006: Area 12084: Grassy Pond at Pinecrest Rd.

Dates documented

First reported: 2006-06-26 Last reported: 2006-06-26

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARAAD04010*741*NH

New Hampshire Natural Heritage Bureau - Animal Record

Blanding's Turtle (*Emydoidea blandingii*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Apparently secure but with cause for concern
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2010: Area 13118: 1 adult observed.
General Area: 2010: Area 13118: Grassy field at town park.
General Comments:
Management Comments:

Location

Survey Site Name: Souhegan River Mouth
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 1.9 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2010: Area 13118: Watson Park, Merrimack.

Dates documented

First reported: 2010-06-23 Last reported: 2010-06-23

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARAAD04010*797*NH

New Hampshire Natural Heritage Bureau - Animal Record

Blanding's Turtle (*Emydoidea blandingii*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Apparently secure but with cause for concern
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2012: Area 13546: 1 adult female observed.
General Area: 2012: Area 13546: Urban/suburban. Near sandy area adjacent to Colby Brook.
General Comments: 2012: Area 13546: Observation comment: Crossing Charles Bancroft Hwy and released in Colby Brook.
Management Comments:

Location

Survey Site Name: Reeds Ferry
Managed By:

County: Hillsborough
Town(s): Litchfield
Size: 1.9 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2012: Area 13546: Charles Bancroft Hwy, Litchfield, NH.

Dates documented

First reported: 2012-06-23 Last reported: 2012-06-23

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

New Hampshire Natural Heritage Bureau - Animal Record

Eastern Hognose Snake (*Heterodon platirhinos*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2012: Area 13089: 1 adult observed, 18-20" in length.2008: Area 11548: 1 adult seen. 1984: Area 12169M: 1 observed.1979: Area 11548a: 1 snake found in garden and killed.1972: Area 6596: 1 seen. Adult. Area 12169M: 1 individual observed, 16-18 inches long.

General Area: 2012: Area 13089: Residential yard in wooded area.2008: Area 11548: It was located just to the north and east of the bigger pond on the north end of the parcel. 1979: Area 11548a: Snake found in garden. 1972: Area 12169M: In a small cemetary. Area shaded and grassy.

General Comments: 2003: Area 12169M: Formerly Pettengill Cemetery. Now busy road.NHNHB was contacted on 29 June 1984 by a neighbor of individual who killed the snake.

Management Comments:

Location

Survey Site Name: Litchfield
Managed By: NHDOT Mitigation

County: Rockingham
Town(s): Londonderry
Size: 12.5 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2012: Area 13089: End of Sunflower Lane in Londonderry. The woods in the back border the Manchester town line.1979: Litchfield. About 4 houses over town line from Manchester on Rte. 3. 1972: Area 6596: Bill Boucher residence, 272 Litchfield Road, 1/2 mile east of Route 3A at the junction of Watts Brook. Area 12169M: Londonderry. Found in a small old cemetary on north side of Pettingill Road which runs west off of Harvey Road. Near Little Cohas Marsh.

Dates documented

First reported: 1972-07-01 Last reported: 2012-09-02

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARADB17020*020*NH

New Hampshire Natural Heritage Bureau - Animal Record

Eastern Hognose Snake (*Heterodon platirhinos*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2004: 1 seen. Adult. (Obs_id 2004.0093).
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Horseshoe Pond
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 7.7 acres
Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2004: Near Horseshoe Pond. 79 Island Drive in yard (Obs_id 2004.0093).

Dates documented

First reported: 2004-06-05 Last reported: 2004-06-05

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARADB17020*013*NH

New Hampshire Natural Heritage Bureau - Animal Record

Eastern Hognose Snake (*Heterodon platirhinos*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 1966: 1 individual 18 inches long seen.
General Area: 1966: Pine knoll in field.
General Comments:
Management Comments:

Location

Survey Site Name: Litchfield Field
Managed By:

County: Hillsborough
Town(s): Litchfield
Size: 60.7 acres Elevation:

Precision: Within 1.5 miles of the area indicated on the map (location information is vague or uncertain).

Directions: North of Colby Brook on pine knoll in field between brook and powerline right-of-way to east of Rte 3A.

Dates documented

First reported: 1966 Last reported: 1966

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARADB17020*014*NH

New Hampshire Natural Heritage Bureau - Animal Record

Eastern Hognose Snake (*Heterodon platirhinos*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 1993: Ca. 7.5 inches; run over by lawnmower.
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Litchfield
Managed By:

County: Hillsborough
Town(s): Litchfield
Size: 2.8 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: Litchfield. Whittemore Drive, sandy area near open fields and powerlines.

Dates documented

First reported: 1993-09-11 Last reported: 1993-09-11

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARADB17020*022*NH

New Hampshire Natural Heritage Bureau - Animal Record

Eastern Hognose Snake (*Heterodon platirhinos*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Historical records only - current condition unknown.
Comments on Rank:

Detailed Description: 1972: Area 6596: 1 seen. Adult.
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Watts Brook
Managed By: The Pathway Common Land

County: Rockingham
Town(s): Londonderry
Size: 7.7 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 1972: Area 6596: Bill Boucher residence, 272 Litchfield Road, 1/2 mile east of Route 3A at the junction of Watts Brook.

Dates documented

First reported: 1972-07-01 Last reported: 1972-07-01

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ABPBXB2020*012*NH

New Hampshire Natural Heritage Bureau - Animal Record

Eastern Meadowlark (*Sturnella magna*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Not ranked (need more information)

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2011: 2 observed between 5/24 and 7/5.
2005: 2 observed on 5/17, including nest with 5 eggs.
2004: 2 observed on 5/27.
2003: 5 observed between 5/22 and 7/10, including nest with 5 eggs, juveniles.
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Merrimack River, near Anheuser-Busch Brewery
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 48.7 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions:

Dates documented

First reported: 2003-05-22 Last reported: 2011-07-05

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

New Hampshire Natural Heritage Bureau - Animal Record

Grasshopper Sparrow (*Ammodramus savannarum*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Not ranked (need more information)

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2011: Searched for, not found.
2006: Searched for, not found.
2005: Field Polygon: 3 observed on 7/14, including 1 juvenile.
2004: 1 adult male, 1 adult female. How observed: heard, seen (Obs_id 2444).
2002: 2 adult males, 1 adult female seen (Obs_id 147). 2002: 2 adult males, 1 adult female, 2 immature, sex unknown seen (Obs_id 148).
2001: 1 adult male seen, also singing (Obs_id 253). 2001: 1 adult male, 1 adult, sex unknown seen. Perched on "No Trespassing" sign (Obs_id 252).
1999: 2 adult males seen and heard (Obs_id 268). 1999: 2 adult males, 1 adult, sex unknown seen. Two birds singing. (Obs_id 265). 1999: 3 adult males, 2 adult, sex unknown seen. Three birds singing, two non-singing birds probably females (Obs_id 266). 1999: 1 adult male seen and heard singing, 1 adult female seen (Obs_id 267).
1998: 1 adult male seen, also singing (Obs_id 255).
1996: 1 adult, sex unknown seen on mullien stalk with grub in beak, flew down (Obs_id 254).
General Area: 2004, 2002, 2001, 1999, 1998, 1996: Terrestrial - Grassland / Field.
General Comments:
Management Comments:

Location

Survey Site Name: Merrimack River, near Anheuser-Busch Brewery
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 101.2 acres Elevation:

Precision: Within 1.5 miles of the area indicated on the map (location information is vague or uncertain).

Directions: 2004: North end of fields behind Anheuser-Busch [along Merrimack River (Obs_id 2444).

Dates documented

First reported: 1996-07-10 Last reported: 2005-07-14

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

New Hampshire Natural Heritage Bureau - Animal Record

New England Cottontail (*Sylvilagus transitionalis*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Rare or uncommon
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2002: Seen (Obs_id 450).
General Area: 2002: (Obs_id 450).
General Comments: 2002: Results from J. Litvaitis Regional NEC survey; small patch (Obs_id 450). Everett Turnpike. 780 (Obs_id 450).
Management Comments:

Location

Survey Site Name: Bumbo Hill, east of
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 7.7 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2002: Everett Turnpike (Obs_id 450).

Dates documented

First reported: 2002-01-01 Last reported: 2002-01-01

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AMAEB01110*011*NH

New Hampshire Natural Heritage Bureau - Animal Record

New England Cottontail (*Sylvilagus transitionalis*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Rare or uncommon
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2002: 2 age and sex unknowns (Obs_id 734).
General Area: 2002: Terrestrial: scrub / shrubland (Obs_id 734).
General Comments: 2002: Results from J. Litvaitis Regional Study - 2003 (Obs_id 734).
Management Comments:

Location

Survey Site Name: Merrimack River, west of
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 1.0 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2002: Powerlines [east of] Rte. 3 (Obs_id 734).

Dates documented

First reported: 2002-01-30 Last reported: 2002-01-30

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AMAEB01110*012*NH

New Hampshire Natural Heritage Bureau - Animal Record

New England Cottontail (*Sylvilagus transitionalis*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Rare or uncommon
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2002: 1 age and sex unknown (Obs_id 736).
General Area: 2002: (Obs_id 736).
General Comments: 2002: Results of J. Litvaitis Regional NEC Survey - 2003 (Obs_id 736).
Management Comments:

Location

Survey Site Name: Sebbins Brook, east of
Managed By:

County: Hillsborough
Town(s): Bedford
Size: .4 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2002: Sports complex, [east of] Rte. 3 (Obs_id 736).

Dates documented

First reported: 2002-01-30 Last reported: 2002-01-30

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AMAEB01110*018*NH

New Hampshire Natural Heritage Bureau - Animal Record

New England Cottontail (*Sylvilagus transitionalis*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Rare or uncommon
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2002: 1+ age and sex unknowns (Obs_id 742).
General Area: 2002: (Obs_id 742).
General Comments: 2002: Results of J. Litvaitis Regional NEC Survey-2003 (Obs_id 742).
Management Comments:

Location

Survey Site Name: Hillcrest Cemetery, west of
Managed By:

County: Hillsborough
Town(s): Litchfield
Size: .4 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2002: Rte. 3A and Hillcrest Rd (Obs_id 742).

Dates documented

First reported: 2002-02-02 Last reported: 2002-02-02

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

New Hampshire Natural Heritage Bureau - Animal Record

New England Cottontail (*Sylvilagus transitionalis*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Rare or uncommon
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2017: Winter observation at 1 point.
2016: Winter observations at 3 points.
2015: Winter observations at 5 points.
2014: Winter observations at 3 points.
2013: Winter observations at 13 points.
2011: Winter observations at 32 points.
2002: 1+ age and sex unknowns (Obs_id 744).
General Area: 2002: Terrestrial: grassland / field (Obs_id 744).
General Comments: 2002: Results of J. Litvaitis Regional NEC Survey - 2003 (Obs_id 744).
Management Comments:

Location

Survey Site Name: Little Cohas Brook, south of
Managed By: NHDOT Mitigation

County: Rockingham
Town(s): Londonderry
Size: 32.6 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2002: Stonyfield Farm (Obs_id 744).

Dates documented

First reported: 2002-02-02 Last reported: 2017

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AMAEB01110*024*NH

New Hampshire Natural Heritage Bureau - Animal Record

New England Cottontail (*Sylvilagus transitionalis*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Rare or uncommon
State:	Listed Endangered	State:	Critically imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2018: Winter observation of 1 individual (pellet).
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Moores Falls
Managed By:

County: Hillsborough
Town(s): Litchfield
Size: .7 acres
Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2018: Moores Falls Conservation Area, Litchfield.

Dates documented

First reported: 2018-01-26 Last reported: 2018-01-26

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARADB0701D*019*NH

New Hampshire Natural Heritage Bureau - Animal Record

Northern Black Racer (*Coluber constrictor constrictor*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2004: 1 seen. Adult. (Obs_id 2004.0054).
General Area: 2004: Dirt road next to field with old grass, near beaver pond. Restored gravel pit. Lots of dirt bike/ATV trails. Big housing development nearby. (Obs_id 2004.0054).
General Comments:
Management Comments:

Location

Survey Site Name: Manchester Industrial Park, south of
Managed By:

County: Rockingham
Town(s): Londonderry
Size: 7.7 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2004: Rehabilitated gravel pit on west end of Pettingil Road (Obs_id 2004.0054).

Dates documented

First reported: 2004-04-27 Last reported: 2004-04-27

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

New Hampshire Natural Heritage Bureau - Animal Record

Northern Black Racer (*Coluber constrictor constrictor*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank:	Extirpated - no longer present at this site.
Comments on Rank:	2011: Habitat destroyed according to herpetologists with NH Fish and Game.
Detailed Description:	2010: R005, R008, R009: 3 radiotracked individuals (later relocated to site in Hopkinton, EO ID 7399). 2009: Area 12296: 1 observed. Areas 12418-12422: 1 individual observed at each of 5 sites.
General Area:	2010: R005, R008, R009: Habitat apparently destroyed by development. 2009: Area 12296: Forest around cell tower.
General Comments:	
Management Comments:	

Location

Survey Site Name: Industrial Dirve, Merrimack
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 106.3 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2009: Area 12296: Woods around cell tower north of Industrial Drive.

Dates documented

First reported: 2009-04-27 Last reported: 2010-08-21

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AAABH01170*021*NH

New Hampshire Natural Heritage Bureau - Animal Record

Northern Leopard Frog (*Lithobates pipiens*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Special Concern	State:	Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2006: Area 11937: 1 observed.
General Area: 2006: Area 11937: Riverbank adjacent to old field habitat.
General Comments:
Management Comments:

Location

Survey Site Name: Merrimack River, Litchfield
Managed By:

County: Hillsborough
Town(s): Litchfield
Size: 7.7 acres
Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2006: Area 11937: [Along Merrimack River bank, west of the intersection of Rte.3A and Talent Rd.]

Dates documented

First reported: 2006-10-18 Last reported: 2006-10-18

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ABNKD06071*038*NH

New Hampshire Natural Heritage Bureau - Animal Record

Peregrine Falcon (*Falco peregrinus anatum*)

Legal Status

Federal: Not listed
State: Listed Threatened

Conservation Status

Global: Apparently secure but with cause for concern
State: Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2016: Nest 1: 2 chicks fledged.
2015: Nest 1: 3 chicks fledged.
2014: Nest 1: 2 chicks fledged.
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Nashua
Managed By:

County: Hillsborough
Town(s): Nashua
Size: .4 acres
Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2014: Nest 1: St. Mary and Archangel Michael Coptic Orthodox Church, Nashua.

Dates documented

First reported: 2014
Last reported: 2016

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AFCHD01011*003*NH

New Hampshire Natural Heritage Bureau - Animal Record

Redfin Pickerel (*Esox americanus americanus*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Special Concern	State:	Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2000: Area 625: 1 individual observed.
General Area: 2000: Area 625: Freshwater stream.
General Comments:
Management Comments:

Location

Survey Site Name: Nesenkeag Brook
Managed By: Parker Park

County: Hillsborough
Town(s): Litchfield
Size: 2.3 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2000: Area 625: Nesenkeag Brook at Rte. 3A in Litchfield.

Dates documented

First reported: 2000-07-03 Last reported: 2000-07-03

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AFCHD01011*005*NH

New Hampshire Natural Heritage Bureau - Animal Record

Redfin Pickerel (*Esox americanus americanus*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Special Concern	State:	Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2000: Area 627: 3 individuals observed.
General Area: 2000: Area 627: Freshwater stream.
General Comments:
Management Comments:

Location

Survey Site Name: Second Brook, south of Tate Street
Managed By:

County: Hillsborough
Town(s): Hudson
Size: 2.2 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2000: Area 627: Second Brook just upstream of crossing at Pelham Road, south of the bend in Tate Street, in Hudson.

Dates documented

First reported: 2000-07-03 Last reported: 2000-07-03

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: AFBAA03010*003*NH

New Hampshire Natural Heritage Bureau - Animal Record

Sea Lamprey (*Petromyzon marinus*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Special Concern	State:	Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2008: 1 observed.
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Souhegan River
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 1.9 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2008: Below Merrimack Village Dam to Merrimack River.

Dates documented

First reported: 2008-07-02 Last reported: 2008-07-02

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARADB47010*053*NH

New Hampshire Natural Heritage Bureau - Animal Record

Smooth Green Snake (*Opheodrys vernalis*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Special Concern	State:	Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2015: Area 13999: 1 adult male observed.
2011: Area 12919: 1 adult observed, 12" long.
General Area: 2015: Area 13999: Consisting of mostly dense shrubs within survey parcel. Small path, slash pile, and wetland areas identified as potential habitat.
2011: Area 12919: Residential yard.
General Comments:
Management Comments:

Location

Survey Site Name: Nesenkeag Brook
Managed By:

County: Rockingham
Town(s): Londonderry
Size: 2.4 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2015: Area 13999: Powerline between Brickyard Drive and Hamel Circle, Litchfield.
2011: Area 12919: 22 Colonial Drive, Londonderry.

Dates documented

First reported: 2011-09-10 Last reported: 2015-08-28

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ABNME08020*006*NH

New Hampshire Natural Heritage Bureau - Animal Record

Sora (*Porzana carolina*)

Legal Status

Federal: Not listed
State: Special Concern

Conservation Status

Global: Demonstrably widespread, abundant, and secure
State: Not ranked (need more information)

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2010: 4 observed, including copulating pair, between 6/25 and 7/2.
General Area:
General Comments:
Management Comments:

Location

Survey Site Name: Long Hill, east of
Managed By:

County: Hillsborough
Town(s): Nashua
Size: 5.5 acres
Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions:

Dates documented

First reported: 2010-06-25
Last reported: 2010-07-02

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

New Hampshire Natural Heritage Bureau - Animal Record

Spotted Turtle (*Clemmys guttata*)

Legal Status	Conservation Status
Federal: Not listed	Global: Demonstrably widespread, abundant, and secure
State: Listed Threatened	State: Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2013: Area 13405: 1 adult female observed.
 2012: Area 13084: 1 adult observed. Area 13545: 1 adult female observed laying eggs.
 1999: Area 1652: 1 young seen (hatchling).
 1996: Area 6456: 1 female seen. Adult.
 1993: 1 seen by Jim Taylor.

General Area: 2013: Area 13405: Roadside, coniferous forest.
 2012: Area 13084: Crossing road. Area 13545: Roadside, suburban area near woodland.
 1999, 1996: Area 1652, Area 6456: NE basin marsh vernal pool.

General Comments:
Management Comments:

Location

Survey Site Name: Grassy Pond
Managed By: Litchfield School Conservation Area

County: Hillsborough
Town(s): Litchfield
Size: 24.0 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2013: Area 13405: Albuquerque Avenue, Litchfield. Crossing Road.
 2012: Area 13084: Crossing Albuquerque Avenue at Meadowbrook Lane, Litchfield. Area 13545: Pinecrest Road, Litchfield.
 1999: Area 1652: Grassy pond.
 1996: Area 6456: Whittemore Dr. - Crossing Rd.
 1993: Grassy pond.

Dates documented

First reported: 1993 Last reported: 2013-07-11

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

New Hampshire Natural Heritage Bureau - Animal Record

Spotted Turtle (*Clemmys guttata*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Good quality, condition and landscape context ('B' on a scale of A-D).
Comments on Rank:

Detailed Description: 2015: Area 14083: 1 adult observed, sex unknown.
2005: Area 9306: 1 adult male turtle observed.
1992: Four adult turtles observed: one 12-14 year old with carapace 114 cm and plastron 92 cm, sex undetermined; one ca. 12 year old very active female with carapace 125 cm and plastron 100 cm; one 11 or 12 year old very inactive female with carapace 127 cm and plastron 100 cm; and one 14-15 year old female with carapace 115 cm and plastron 92 cm.
General Area: 2015: Area 14083: Residential yard [property backs up to wetlands associated with Chase Brook].
2005: Area 9306: Residential lot surrounded by some agriculture.
1992: Adjacent to a large wetland.
General Comments: 1992: Drawings of each turtle's most distinctive spots and other markings included.
Management Comments:

Location

Survey Site Name: Cutler Road, north of
Managed By:

County: Hillsborough
Town(s): Litchfield
Size: 2.6 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2015: Area 14083: In yard at 21 Mayflower Drive, Litchfield.
2005: Area 9306: [Rte 3A ca. 2.8 miles north of the junction with Rte. 111 in Nashua.]
1992: Adjacent to a large wetland at 19 Woodburn Drive, near Cutler Road, [west of Rte. 102, in the southeast corner of Litchfield.]

Dates documented

First reported: 1992-06-08 Last reported: 2015-06-15

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARAAD02010*074*NH

New Hampshire Natural Heritage Bureau - Animal Record

Spotted Turtle (*Clemmys guttata*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Listed Threatened	State:	Imperiled due to rarity or vulnerability

Description at this Location

Conservation Rank: Fair quality, condition and/or landscape context ('C' on a scale of A-D).
Comments on Rank:

Detailed Description: 2004: 1 seen, dead on road. Adult. (Obs_id 2004.0122).
General Area:
General Comments: 2004: Roadkill (Obs_id 2004.0122).
Management Comments:

Location

Survey Site Name: Stebbins Brook
Managed By: Reeds Ferry State Forest

County: Hillsborough
Town(s): Bedford
Size: 7.7 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2004: Approximately where Stebbins Brook crosses Everett Turnpike (Obs_id 2004.0122).

Dates documented

First reported: 2004-07-07 Last reported: 2004-07-07

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ABPBX95010*002*NH

New Hampshire Natural Heritage Bureau - Animal Record

Vesper Sparrow (*Pooecetes gramineus*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Demonstrably widespread, abundant, and secure
State:	Special Concern	State:	Not ranked (need more information)

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2002: 1 seen (Obs_id 149). 1999: 1 adult male heard (Obs_id 548).
General Area: 2002, 1999: Terrestrial - Grassland / Field (Obs_id 149, 548).
General Comments:
Management Comments:

Location

Survey Site Name: Merrimack River, near Anheuser-Busch Brewery
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 48.6 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: Fields behind Anheuser-Busch brewery (Obs_id 149, 548).

Dates documented

First reported: 1999-07-03 Last reported: 2002-06-20

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARAAD02020*176*NH

New Hampshire Natural Heritage Bureau - Animal Record

Wood Turtle (*Glyptemys insculpta*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Rare or uncommon
State:	Special Concern	State:	Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2005: Area 11962: 1 observed.
General Area: 2005: Area 11962: Residential yard with pool.
General Comments:
Management Comments:

Location

Survey Site Name: Watts Brook
Managed By:

County: Hillsborough
Town(s): Litchfield
Size: 1.9 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2005: Area 11962: [Behind house on Rte. 3A in Litchfield, just north of intersection with Corning Rd.].

Dates documented

First reported: 2005-06-19 Last reported: 2005-06-19

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARAAD02020*237*NH

New Hampshire Natural Heritage Bureau - Animal Record

Wood Turtle (*Glyptemys insculpta*)

Legal Status		Conservation Status	
Federal:	Not listed	Global:	Rare or uncommon
State:	Special Concern	State:	Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2013: Area 13484: 1 adult observed, sex unknown.
General Area: 2013: Area 13484: Parking lot near highway. Turtle was emerging from a small water course next to the parking lot which is directly next to Route 3 south.
General Comments:
Management Comments:

Location

Survey Site Name: Horseshoe Pond, west of
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: 1.9 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions: 2013: Area 13484: 9 Executive Park Drive, Merrimack. Nashua Regional Planning Commission parking lot.

Dates documented

First reported: 2013-08-26 Last reported: 2013-08-26

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

NHB18-1178 EOCODE: ARAAD02020*262*NH

New Hampshire Natural Heritage Bureau - Animal Record

Wood Turtle (*Glyptemys insculpta*)

Legal Status		**Conservation Status**	
Federal:	Not listed	Global:	Rare or uncommon
State:	Special Concern	State:	Rare or uncommon

Description at this Location

Conservation Rank: Not ranked
Comments on Rank:

Detailed Description: 2015: 1 adult male observed.
General Area: 2015: Residential road.
General Comments:
Management Comments:

Location

Survey Site Name: Belmont Drive, Merrimack
Managed By:

County: Hillsborough
Town(s): Merrimack
Size: .4 acres Elevation:

Precision: Within (but not necessarily restricted to) the area indicated on the map.

Directions:

Dates documented

First reported: 2015-03-31 Last reported: 2015-03-31

The New Hampshire Fish & Game Department has jurisdiction over rare wildlife in New Hampshire. Please contact them at 11 Hazen Drive, Concord, NH 03301 or at (603) 271-2461.

MASSWILDLIFE

DIVISION OF
FISHERIES & WILDLIFE

1 Rabbit Hill Road, Westborough, MA 01581
p: (508) 389-6300 | f: (508) 389-7890
MASS.GOV/MASSWILDLIFE

Jack Buckley, *Director*

April 18, 2018

Kelly MacVane
HDR Engineering, Inc
970 Baxter Boulevard, Suite 301
Portland ME 04103

RE: Project Location: Lowell Hydroelectric Project, Merrimack River
Town: LOWELL
NHESP Tracking No.: 07-21482

To Whom It May Concern:

Thank you for contacting the Natural Heritage and Endangered Species Program of the MA Division of Fisheries & Wildlife (the "Division") for information regarding state-listed rare species in the vicinity of the above referenced site. Based on the information provided, this project site, or a portion thereof, is located **within** *Priority Habitat 1987* (PH 1987) and *Estimated Habitat 1320* (EH 1320) as indicated in the *Massachusetts Natural Heritage Atlas* (14th Edition). Our database indicates that the following state-listed rare species have been found in the vicinity of the site:

Scientific name	Common Name	Taxonomic Group	State Status
Haliaeetus leucocephalus	Bald Eagle	Bird	Threatened
Stylurus amnicola	Riverine Clubtail	Dragonfly	Endangered

The species listed above are protected under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) and its implementing regulations (321 CMR 10.00). State-listed wildlife are also protected under the state's Wetlands Protection Act (WPA) (M.G.L. c. 131, s. 40) and its implementing regulations (310 CMR 10.00). Fact sheets for most state-listed rare species can be found on our website (www.mass.gov/nhesp).

Please note that projects and activities located within Priority and/or Estimated Habitat **must** be reviewed by the Division for compliance with the state-listed rare species protection provisions of MESA (321 CMR 10.00) and/or the WPA (310 CMR 10.00).

Wetlands Protection Act (WPA)
If the project site is within Estimated Habitat and a Notice of Intent (NOI) is required, then a copy of the NOI must be submitted to the Division so that it is received at the same time as the local conservation commission. If the Division determines that the proposed project will adversely affect the actual Resource Area habitat of state-protected wildlife, then the proposed project may not be permitted (310 CMR 10.37, 10.58(4)(b) & 10.59). In such a case, the project proponent may request a consultation with the Division to discuss potential project design modifications that would avoid adverse effects to rare wildlife habitat.

A streamlined joint MESA/WPA review process is available. When filing a Notice of Intent (NOI), the applicant may file concurrently under the MESA on the same NOI form and qualify for a 30-day streamlined joint review. For a copy of the NOI form, please visit the MA Department of Environmental Protection's website: http://www.mass.gov/eea/agencies/massdep/service/approvals/wpa-form-3.html.

MA Endangered Species Act (MESA)

If the proposed project is located within Priority Habitat and is not exempt from review (see 321 CMR 10.14), then project plans, a fee, and other required materials must be sent to Natural Heritage Regulatory Review to determine whether a probable Take under the MA Endangered Species Act would occur (321 CMR 10.18). Please note that all proposed and anticipated development must be disclosed, as MESA does not allow project segmentation (321 CMR 10.16). For a MESA filing checklist and additional information please see our website: www.mass.gov/dfw/nhesp/regulatory-review.

We recommend that rare species habitat concerns be addressed during the project design phase prior to submission of a formal MESA filing, as avoidance and minimization of impacts to rare species and their habitats is likely to expedite endangered species regulatory review.

This evaluation is based on the most recent information available in the Natural Heritage database, which is constantly being expanded and updated through ongoing research and inventory. If the purpose of your inquiry is to generate a species list to fulfill the federal Endangered Species Act (16 U.S.C. 1531 et seq.) information requirements for a permit, proposal, or authorization of any kind from a federal agency, we recommend that you contact the National Marine Fisheries Service at (978)281-9328 and use the U.S. Fish and Wildlife Service's Information for Planning and Conservation website (https://ecos.fws.gov/ipac). If you have any questions regarding this letter please contact Emily Holt, Endangered Species Review Assistant, at (508) 389-6385.

Sincerely,

Thomas W. French

Thomas W. French, Ph.D.
Assistant Director

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Appendix D - Exhibit G Maps

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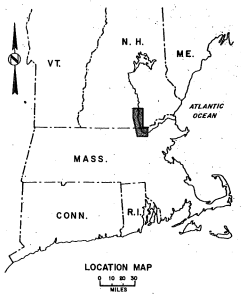


LEGEND

- PROJECT BOUNDRY
- PROPERTY OWNED BY APPLICANTS
- PUBLIC LAND
- LOWELL NATIONAL HISTORICAL PARK
- LOWELL HISTORICAL PRESERVATION DISTRICT

NOTE

TOPOGRAPHY ON THIS DRAWING WAS REPRODUCED FROM USGS QUADRANGLE MAPS.

EXHIBIT G-1

BOOTT MILLS

LOWELL HYDROELECTRIC PROJECT

GENERAL MAP OF PROJECT AREA

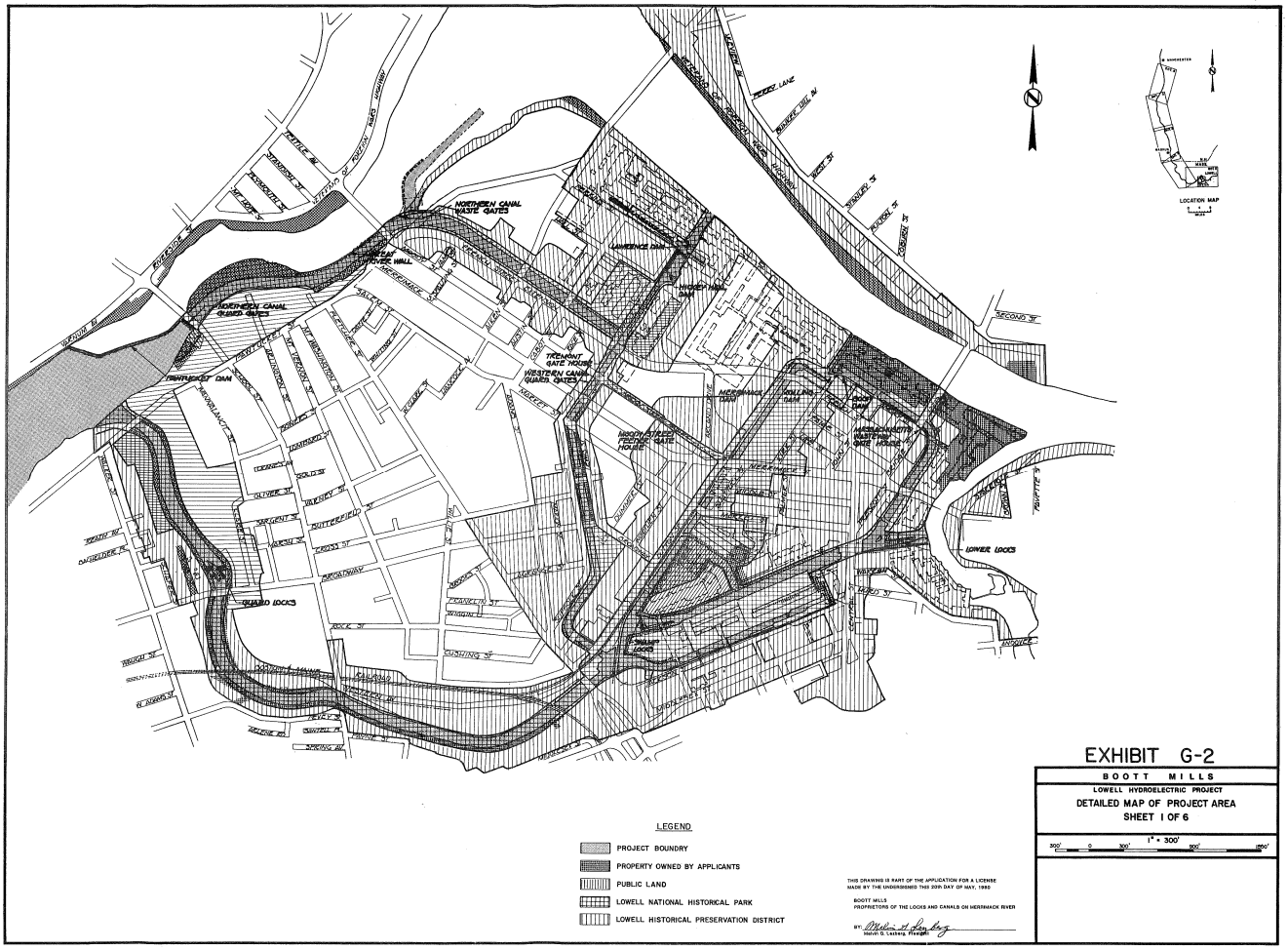
1" = 1 MILE

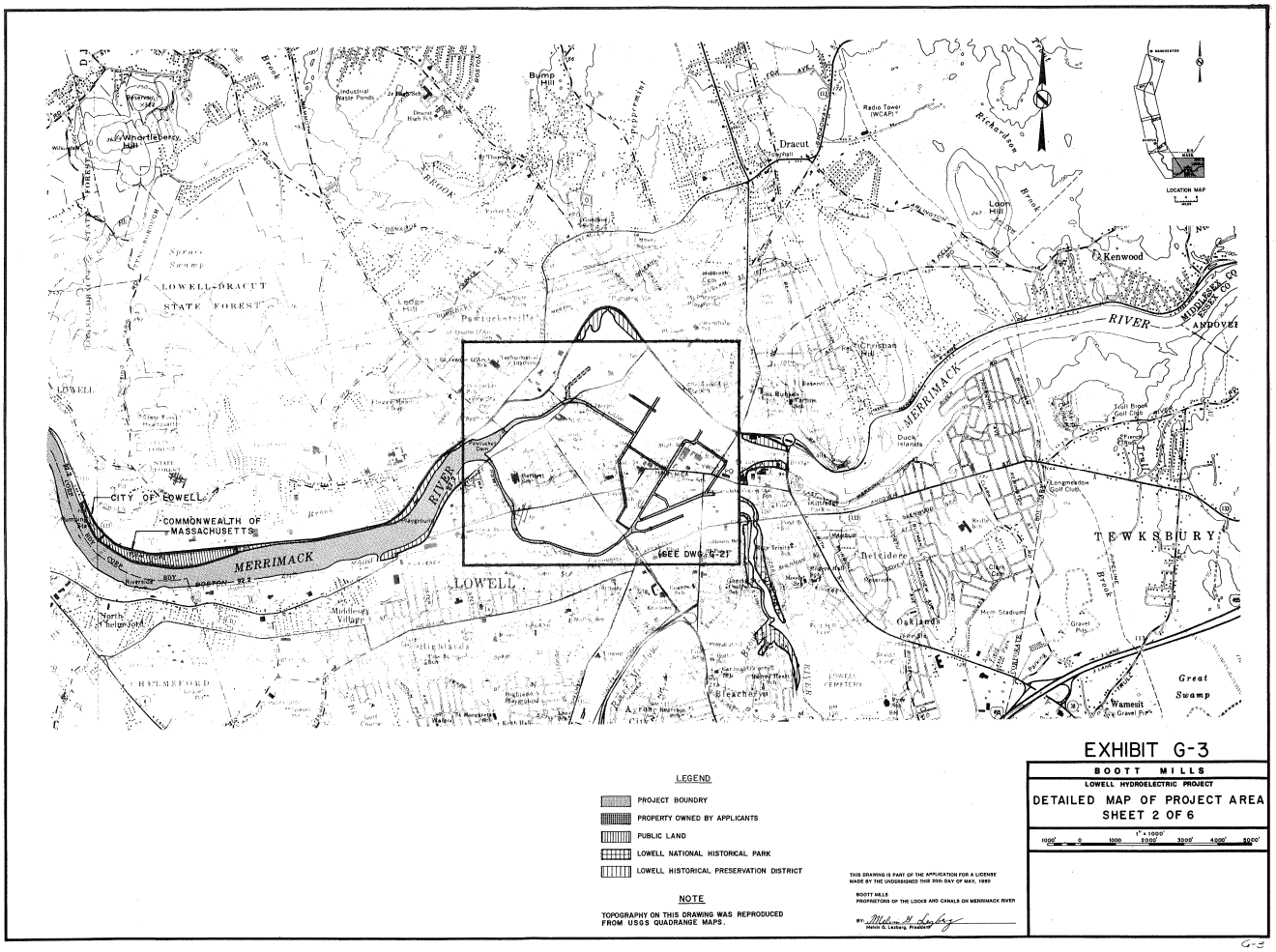
0 1 2 3 4

THIS DRAWING IS PART OF THE APPLICATION FOR A LICENSE MADE BY THE UNDERSIGNED THIS 29th DAY OF MAY, 1980

BOOTT MILLS
PROPRIETORS OF THE LOCKS AND CANALS ON MERRIMACK RIVER

BY: Melvin G. Laubenberg
Melvin G. Laubenberg, President





LEGEND

- PROJECT BOUNDRY
- PROPERTY OWNED BY APPLICANTS
- PUBLIC LAND
- LOWELL NATIONAL HISTORICAL PARK
- LOWELL HISTORICAL PRESERVATION DISTRICT

NOTE

TOPOGRAPHY ON THIS DRAWING WAS REPRODUCED FROM USGS QUADRANGE MAPS.

THIS DRAWING IS PART OF THE APPLICATION FOR A LICENSE MADE BY THE UNDERSIGNED THIS 20th DAY OF MAY, 1980

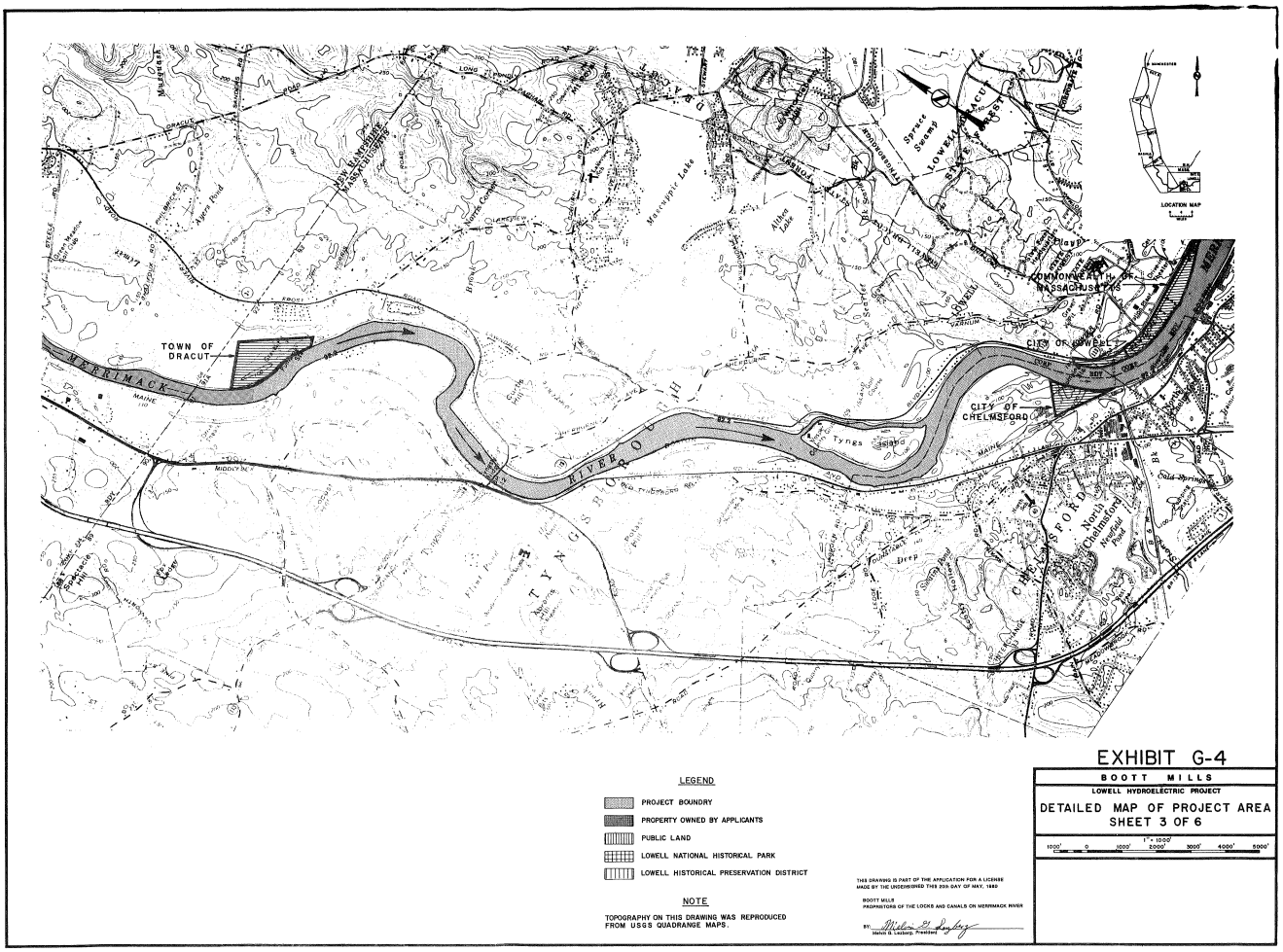
BOOTT MILLS
PROPRIETORS OF THE LOCKS AND CANALS ON MERRIMACK RIVER

BY: William H. Lashley
WILLIAM H. LASHLEY, PRESIDENT

EXHIBIT G-3

BOOTT MILLS
LOWELL HYDROELECTRIC PROJECT
DETAILED MAP OF PROJECT AREA
SHEET 2 OF 6

1" = 1000'
1000' 0 1000 2000 3000' 4000' 5000'



LEGEND

- PROJECT BOUNDRY
- PROPERTY OWNED BY APPLICANTS
- PUBLIC LAND
- LOWELL NATIONAL HISTORICAL PARK
- LOWELL HISTORICAL PRESERVATION DISTRICT

NOTE

TOPOGRAPHY ON THIS DRAWING WAS REPRODUCED FROM USGS QUADRANGE MAPS.

THIS DRAWING IS PART OF THE APPLICATION FOR A LICENSE MADE BY THE UNDERSIGNED THIS 20th DAY OF MAY, 1980

BOOTT MILLS
PROPRIETORS OF THE LOCKS AND CANALS ON MERRIMACK RIVER

BY: Milton W. Bagley
Milton W. Bagley, President

EXHIBIT G-4

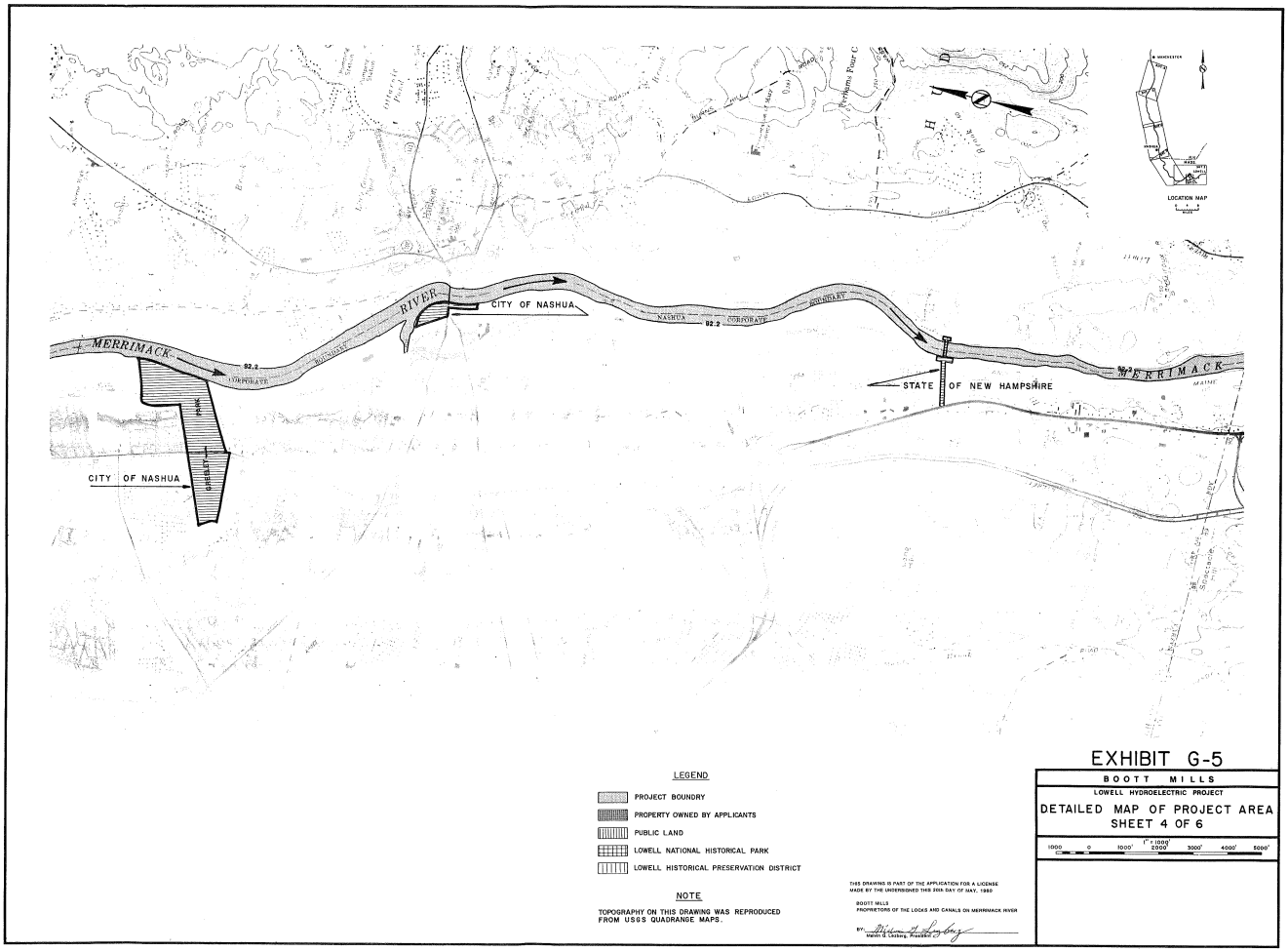
BOOTT MILLS

LOWELL HYDROELECTRIC PROJECT

DETAILED MAP OF PROJECT AREA
SHEET 3 OF 6

1" = 1000'

1000' 0 1000' 2000' 3000' 4000' 5000'



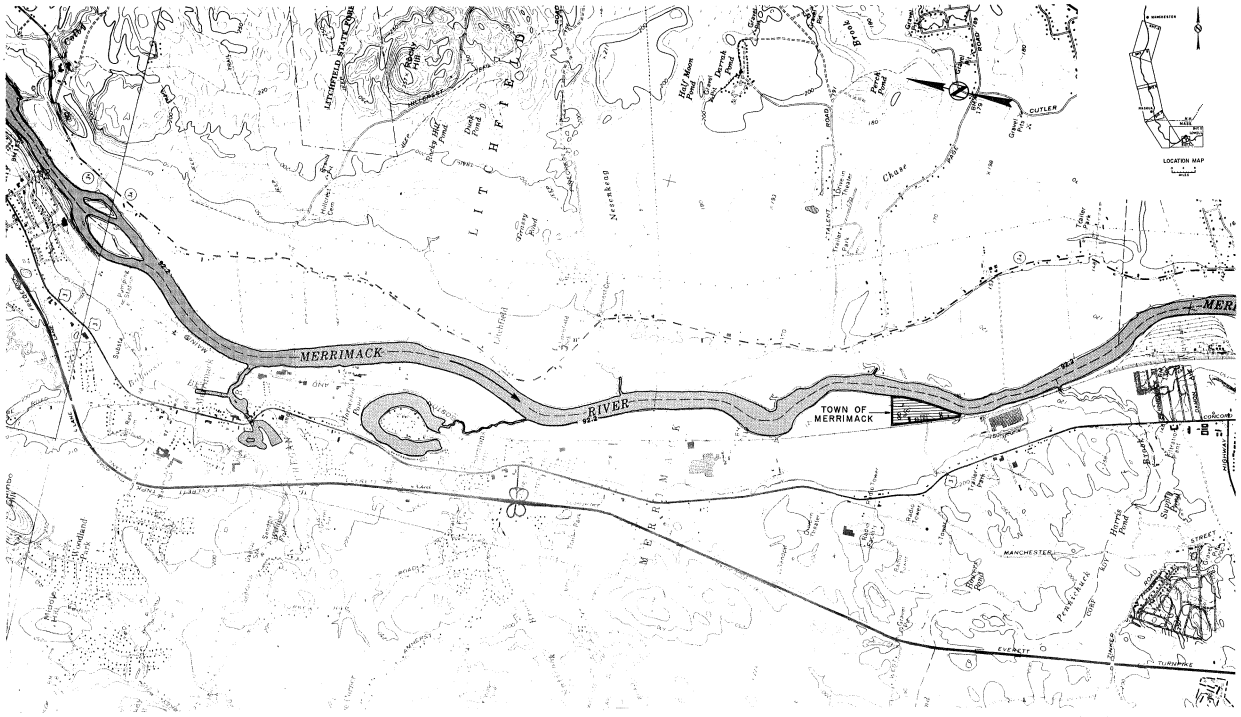


EXHIBIT G-6

BOOTT MILLS
LOWELL HYDROELECTRIC PROJECT
DETAILED MAP OF PROJECT AREA
SHEET 5 OF 6

SCALE 1" = 1,000'

LEGEND

- PROJECT BOUNDRY
- PROPERTY OWNED BY APPLICANTS
- PUBLIC LAND
- LOWELL NATIONAL HISTORICAL PARK
- LOWELL HISTORICAL PRESERVATION DISTRICT

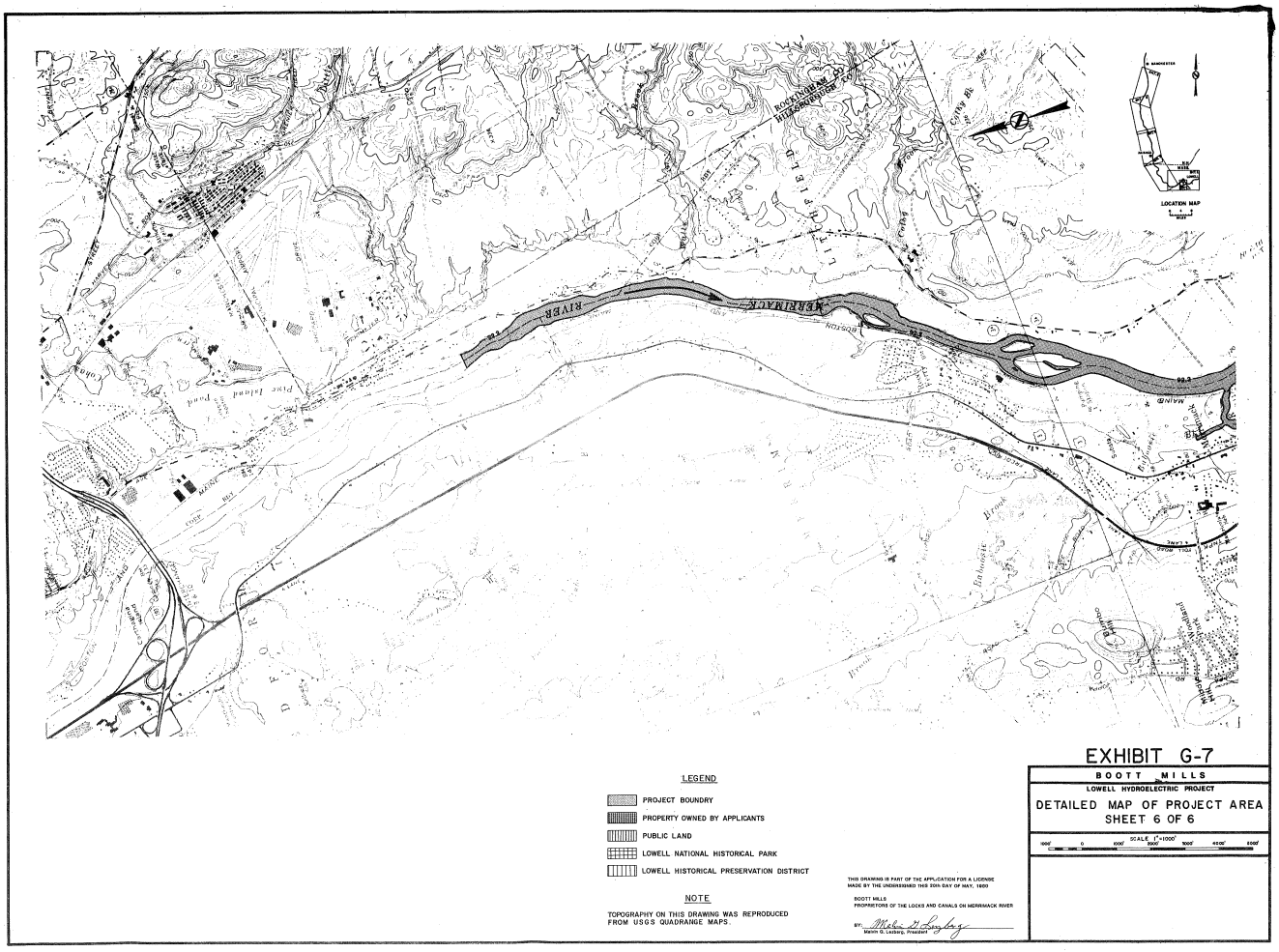
NOTE

TOPOGRAPHY ON THIS DRAWING WAS REPRODUCED FROM USGS QUADRANGE MAPS.

THIS DRAWING IS PART OF THE APPLICATION FOR A LICENSE MADE BY THE UNDERSIGNED THIS 29th DAY OF MAY, 1980.

BOOTT MILLS
PROPRIETORS OF THE LOCKS AND CANALS ON MERRIMACK RIVER

BY: Melvin D. Lastberg
Melvin D. Lastberg, President



LEGEND

- PROJECT BOUNDRY
- PROPERTY OWNED BY APPLICANTS
- PUBLIC LAND
- LOWELL NATIONAL HISTORICAL PARK
- LOWELL HISTORICAL PRESERVATION DISTRICT

NOTE

TOPOGRAPHY ON THIS DRAWING WAS REPRODUCED FROM USGS QUADRANGLE MAPS.

THIS DRAWING IS PART OF THE APPLICATION FOR A LICENSE MADE BY THE UNDERSIGNED THIS 20th DAY OF MAY, 1980

BOOTT MILLS
PROPRIETORS OF THE LOCKS AND CANALS ON MERRIMACK RIVER

BY: Melvin H. Lashaway
Melvin G. Lashaway, President

EXHIBIT G-7

BOOTT MILLS
LOWELL HYDROELECTRIC PROJECT
DETAILED MAP OF PROJECT AREA
SHEET 6 OF 6

SCALE 1"=1000'

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Appendix E - License Order and Amendments

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Hector Perez
376-9819
400 - 1st Street
Room 208 RB - RC723
TDRS: A03-E605

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Boott Mills and Proprietors of the Locks and Canals on Merrimack River) Project No. 2790-000

ORDER ISSUING LICENSE (MAJOR)

APR 13 1983

Boott Mills and Proprietors of the Locks and Canals on the Merrimack River (Boott Mills) filed an application for license under Part I of the Federal Power Act (Act) to construct, operate, and maintain the Lowell Hydroelectric Project No. 2790. 1/ The project would be located at the Pawtucket Dam and adjoining canal system on the Merrimack River, a navigable waterway of the United States, in Middlesex County, Massachusetts. 2/

Notice of the application has been published and comments have been received from interested Federal, state, and local agencies. No protests have been received, and none of the agencies objected to issuance of the license. The Massachusetts Municipal Wholesale Electric Company, Massachusetts Hydro Associates, Atlantic Associates, New Hampshire Hydro Associates, Dr. Patrick J. Morgan, Appleton Trust and James T. Lichoulas, Jr., Trustee, and Lawrence Hydroelectric Associates and Essex Company were granted intervenor status. 3/ The significant concerns of the intervenors and commenting agencies are discussed below.

1/ Authority to act on this matter is delegated to the Director, Office of Electric Power Regulation, under §375.308 of the Commission's regulations, 18 C.F.R. §375.308 (1982), FERC Statutes and Regulations ¶30,238. This order may be appealed to the Commission by any party within 30 days of its issuance pursuant to Rule 1902, 18 C.F.R. 385.1902, FERC Statutes and Regulations ¶29,052, 47 Fed. Reg. 19014 (1982). Filing an appeal and final Commission action on that appeal are prerequisites for filing an application for rehearing as provided in Section 313(a) of the Act. Filing an appeal does not operate as a stay of the effective date of this order or any other date specified in this order, except as specifically directed by the Commission.

2/ Merrimack River was found navigable in the Order Issuing License for Project No. 1893, issued May 5, 1949.

3/ Dr. Patrick J. Morgan, Appleton Trust and James T. Lichoulas, Jr., Trustee withdrew their intervention.

Project History and Description

The project would consist of: (1) the existing masonry gravity Pawtucket Dam; (2) a reservoir with a storage capacity of about 3,960 acre-feet; (3) the Northern and Pawtucket Canal System comprised of several small dams and gatehouses; (4) four existing power plants located along the canal system in old mill buildings with a total installed capacity of 7,915 kW; (5) a new powerhouse drawing water from the Northern Canal, with an installed capacity of 15,000 kW (Lowell Power Station); (6) a new tailrace channel; (7) fishway facilities at the dam and proposed powerhouse; and (8) a new transmission line. A more detailed project description is contained in ordering paragraph (B).

The Assets Power Station was constructed in 1911 and additional capacity was installed in 1913. The Bridge Street Power Station was constructed in 1910 and additional capacity was installed in 1918, 1920 and 1921. The Hamilton Power Station was constructed in 1918 and additional capacity was installed in 1919, 1920 and 1922. The John Street Power Station was constructed in 1919 and additional capacity was installed in 1923 and 1949.

Safety and Adequacy

The Pawtucket Dam was analyzed for stability and found to be safe against sliding and overturning for loading conditions of flood-waters through submergence, normal reservoir, ice, and earthquake. During maximum flood flows the Pawtucket Dam would be submerged, but should it fail it would not significantly increase the downstream peak flow further endangering downstream life and property. The spillway capacity is adequate.

The water retaining structures in the canal system act as check structures maintaining an environmentally pleasing water surface elevation, impounding very little storage, and would not pose a threat to downstream life or property if they should fail.

The existing project structures are adequately maintained and are stable.

Economic Feasibility

The project would essentially be operated as a run-of-river facility, however, the project does have the capability of impounding a small amount of water for daily peaking capability. The new 15 MW power-house would generate 74,250,000 kWh with a 57% plant factor. When river flows exceed the hydraulic capacity of the proposed power-house, the existing hydroelectric equipment on the canals would be

utilized producing an additional 5,750,000 kWh, with an 8% plant factor. The total hydroelectric energy produced by the project represents a fuel savings of 127,000 barrels of oil or 37,000 tons of coal annually.

Boott Mills has entered into an agreement to sell all project power output to the Commonwealth Electric Company, a Massachusetts corporation. 4/ 5/ Based upon the terms of the agreement and the estimated annual cost of the project, the project is deemed economically feasible.

Cultural Resources

The area to be affected by the proposed project is located within the Locks and Canals Historic District, a property listed on the National Register of Historic Places. In addition, the project would be within the boundaries of the Lowell National Historical Park, and is situated in the Preservation District established by the Lowell Historic Preservation Commission. The area is also designated as a National Landmark, attesting to its significance in the history of the United States. The area also remains as one of the most important historic engineering resources in the northeast.

Historical properties within the immediate impact area include the Northern Canal, the Great River Wall, River Walk, Pawtucket Dam, Northern Canal Gatehouse and Lock, and the Northern Canal Waste gate structure.

The New Hampshire State Historic Preservation Officer (SHPO) concluded that the proposed project would have no effect on significant historic and archeological resources, located on upstream portions of the Merrimack River in New Hampshire.

Pursuant to extensive consultations with the Massachusetts SHPO and the National Park Service (NPS), Boott Mills has agreed to relocate the proposed powerhouse in order to avoid destroying the historic Waste Gates on the Northern Canal, and to repair, at its own expense, the Northern Canal Gates, and to restore them to their original condition. At the same time, Boott Mills has modified its plans for fish passage facilities so as to avoid any impacts to the Northern Canal Gatehouse, while still providing for the movement of anadromous fish past project facilities.

4/ Power Sales Contract dated January 10, 1983.

5/ The Massachusetts Municipal Wholesale Electric Company was ~~granted~~ intervenor status as a possible purchaser of power from the project.

Finally, Boott Mills has proposed the construction of a set of locks at the site of the new diversion/control structure in the Northern Canal to provide for passage of boat traffic, and to avoid any loss of historic function of the canal system.

As mitigation for the remaining effects of the project on historic properties, Boott Mills has advanced a series of proposals designed to minimize the impacts of introducing new structures into the historic district and historic park. These proposals include: (1) to compensate for impacts to the canal wall, cut ledge, and walkway, historical research designed to provide cultural and engineering data, and to produce plans and elevations for affected features; (2) field recording of any historic and engineering features, to include photographs, sketches, and notes; (3) reconstruction of a segment of the Northern Canal Walkway, using the original stones from the existing walkway; (4) landscaping treatments that would emphasize the revegetation of disturbed areas with native plant material, the integration of new facilities into existing state and Federal park designs, and the placement of transmission lines in inconspicuous or underground locations.

The Massachusetts SHPO has concluded that the proposed project would result in no adverse effect on the Locks and Canals Historic District provided that: (1) the SHPO would have an opportunity to review and comment upon the preliminary design of the power structure, that the structure would be designed to meet the Secretary of the Interior's standards for new construction adjacent to historic properties, and that the power structure would be compatible with the historic properties in size, scale, massing, and materials; (2) the SHPO would be provided with an opportunity to review and comment upon the design of the fish ladder with respect to its impacts on the Pawtucket Dam, and Boott Mills would develop a program to record the structural details of the dam in accordance with the standards of the Historic American Engineering Record; (3) any future action related to the hydroelectric project that would change the mean seasonal water level in the canal system, or would impair navigability, would be reviewed in accordance with the Advisory Council on Historic Preservation's regulations; and (4) the project would include a set of locks to allow passage around the diversion/control structure to be constructed across the Northern Canal. Boott Mills has agreed to all of the Massachusetts SHPO's conditions.

The NPS has concurred with the conditions of agreement between the SHPO and Boott Mills. According to the NPS, the conditions are consistent with NPS positions on the proposed project, and the NPS has reached an agreement with Boott Mills on two of the issues addressed by the SHPO--the regulation of water levels in the lower Pawtucket Canal and the construction of the bypass lock around the diversion/control structure.

Staff's review of the effects of the Lowell Hydroelectric Project on the Locks and Canals Historic District indicates that Boott Mills' design changes, and its proposed mitigative measures, will safeguard the historic characteristics that qualify the distict, and its individual components, for listing on the National Register of Historic Places. Boott Mills has agreed, at considerable additional cost, to design its project to avoid impacts to the historic waste gate structures, to provide for fish passage without affecting the historic Northern Canal Gatehouse, to repair and restore the Northern Canal Gates, to restore and preserve the Northern Canal Walkway, and to provide visitor facilties illustrating the similarities and contrasts between historic and modern power generation on the Lowell canal system. In addition, although the project will introduce new structures and features into the historic district, Boott Mills has agreed that the SHPO will be provided an opportunity to ensure compatibility with existing historic features. Moreover, when physical changes are made that would affect historic properties, the modifications will be preceded by a documentation program carried out in conformance with the standards of the Historic American Engineering Record. The Advisory Council on Historic Preservation has concurred with the staff's evaluation of effects on historic properties.

For the above reasons, it is concluded that the project as modified, with the mitigative measures agreed to among Boott Mills, the SHPO, and the NPS, will result in no adverse effect on the Locks and Canals Historic District. License Article 33 specifies the mitigative measures agreed to with the Massachusetts SHPO and concurred in by the Advisory Council on Historic Preservation.

Fish and Wildlife Resources

The U.S. Fish and Wildlife Service (FWS) stated that except for occasional transient individuals, no federally listed or proposed threatened or endangered species are known to exist in the project impact area.

FWS and the Massachusetts Division of Fish and Wildlife stated that the conceptual design of the fishway, modified channel, and fish elevator were adequate, and that submission of final plans to Federal and state agencies for approval prior to starting construction of the fish passage facilities would be necessary. These agencies concluded that: (1) the operating schedule for the fish passage facilties should be developed by the appropriate Federal and state agencies; (2) flows proposed by Boott Mills for operation of the fish passage facilities would have to be assessed for adequacy; and (3) downstream migrant facilities would be required.

Boott Mills stated that additional study and observation must be made in order to precisely define flows and the extent of channel modifications needed, and that studies utilizing tagged fish would have to be conducted to determine the suitability of the proposed fish passage facilities. Until studies are completed, however, Boott Mills requested that the project be licensed with their proposed mode of operation of the fish passage facilities, and further stated that operation could be modified in coordination with the Commission and other appropriate agencies if the studies indicate that such operation is inadequate.

It is concluded that the success of fish passage through the Northern Canal and Gatehouse should be assessed and studies conducted to determine if Boott Mills' proposed flows of 300 and 500 cubic feet per second (cfs) are adequate. Further, specific operating criteria and flow releases would have to be developed for the fish lift. Downstream migrant facilities would be needed at the project. This would require the Licensee to design such facilities, and file functional design drawings for approval. License Articles 34 and 35 require that appropriate studies be conducted, and functional design drawings be filed with the Commission for approval.

Water Quality and Quantity

The U.S. Department of Interior (Interior) noted that Boott Mills' proposal contained no information on providing flows through the canal system for maintenance of canal water quality. Boott Mills responded that flows would be provided for that purpose. Further, the Massachusetts State Division of Water Pollution Control (WPC) requires in its water quality certificate issued for the project on July 26, 1982, a study to determine the impacts of the project flows on the canal system water quality.

FWS recommended Aquatic Base Flows (ABF) of 4.0, 0.5, and 1.0 cubic feet per second per square mile of drainage area (cfsm) for the spring, summer and fall critical periods, respectively. Interior stated that the major concern was the impact of flows on late, adult migrant salmon in June and on juvenile shad migration in the fall. The FWS later stated that the above flow recommendations were preliminary and that an ABF of 0.5 cfsm or 1,990 cfs was appropriate to protect and maintain fishery resources. FWS also indicated that the ABF of 0.5 cfsm could be lowered provided that additional studies demonstrate that lower flows provide adequate protection and enhancement of resident and anadromous fishery resources.

The Environmental Protection Agency recommended that the project be operated in a manner that provides for an instantaneous minimum flow release equal to or greater than 862 cfs. WPC in its water

quality certificate requires Boott Mills to release a minimum continuous flow of 905 cfs. This flow would be released as a combination of flows from the fish passage facilities, the dam, as leakage through the dam, the proposed powerhouse, the John Street Power Station, and other points of leakage.

It is concluded that a minimum flow release of 905 cfs from the project would maintain downstream water quality, but may not adequately protect and enhance resident and anadromous fishes below the project. Similarly, it has not been demonstrated that the ABF of 0.5 cfsm, or 1,990 cfs, would provide the necessary protection and enhancement to fishery resources. Article 35 requires Boott Mills to perform studies to determine the effectiveness of passage facilities in assisting the migration of anadromous fish. It is concluded that a study is also warranted to determine the minimum flow release from the project for the protection and enhancement of aquatic habitat and for the mitigation of anadromous fish. License Articles 36 and 37 require the Licensee to release an interim flow of 905 cfs from the project, and to conduct studies to determine the flow releases needed to protect and enhance fishery resources.

Recreation

The Massachusetts Department of Environmental Management (DEM) stated that it has reached agreement with Boott Mills concerning acquisition of certain canal properties and water rights for the Lowell Heritage State Park, subject to issuance of an FERC license. Further, DEM stated that Boott Mills' responsibility to provide recreational benefits as a condition of an FERC license has been partially satisfied through Boott Mills' commitments to: (1) construct a navigation lock at the Northern Canal control structure; (2) construct a visitor facility at the powerhouse; (3) restore portions of the Northern Canal Walkway near the powerhouse; and (4) repair the Northern Canal gates. DEM, however, requested that since various details related to the agreement are in the process of being resolved, Boott Mills' Report on Recreational Resources (formerly Exhibit R) should not be approved until all elements of the agreement can be included therein. As noted previously, the National Park Service stated that since Boott Mills has agreed to lower canal water levels approximately 6 inches during the May 15 to October 15 recreational season and to provide a navigation lock at the Northern Canal control structure, it would not object

Boott Mills did not object to delaying approval of the recreation report pending resolution of details dealing with land transfers and other recreational matters still under discussion. Boott Mills also stated that any remaining issues associated with the agreements would not adversely affect its ability to operate the project as

proposed. License Article 38 requires the Licensee to file for Commission approval a revised Report on Recreational Resources.

Environmental Impacts

Construction activities would produce some minor short-term environmental impacts such as dust and noise from vehicles and machinery, and periods of turbidity and attendent sedimentation in the Merrimack River near the powerhouse, tailrace channel, and fishway sites. Further, minor long-term impacts to historic properties are expected to occur. Boott Mills, in cooperation with the appropriate state and Federal agencies, has proposed mitigative measures to safeguard the historic characteristics of the project area.

During project operation, natural river flows would be reduced in the reach of the river from the Pawtucket Dam to below the proposed project and for periods of time in the reach of the river from the proposed project to Essex Dam at Lawrence. While the changes in the natural flow regime of the Merrimack River could impact anadromous fish migration, resident fish populations, and water quality, Boott Millss proposed mitigative measures, license articles contained herein, and the conditions imposed on Boott Mills through the water quality certification should ensure that no significant long-term adverse impacts would occur to those resources.

Boott Mills has agreed to provide fish passage and visitor facilities at the powerhouse, to restore several historic structures along the canal system, and to maintain canal navigability and water quality in cooperation with the appropriate state and Federal agencies.

On the basis of the record, and staff's independent analysis, we conclude that issuance of a license for the project as conditioned herein would not constitute a major Federal action significantly affecting the quality of the human environment.

Other Aspects of Comprehensive Development

Massachusetts Hydro Associates and Atlantic Associates were granted intervenor status to protect their interests as owners and operators of certain hydroelectric facilities and mill powers adjacent to the proposed project. 6/

6/ Pursuant to written agreement with Applicant dated February 1, 1982, Intervenors state that they support license application.

New Hampshire Hydro Associates, Permittee for Moore's Falls Project No. 3094, 7/ and Lawrence Hydroelectric Associates and Essex Company, Licensees for the Lawrence Project No. 2800, both on the Merrimack River, were granted intervenor status to ensure that the proposed project does not adversely affect their respective projects.

It is concluded that the project will make good use of the flow and fall of the Merrimack River, is not in conflict with any existing, planned or potential development and will be best adapted to the comprehensive development of the river basin, as conditioned in this license.

License Term and Annual Charges

The proposed new capacity project using an existing dam is similar to relicensing an existing licensed project at which a moderate amount of new development is proposed; therefore, consistent with the Commission's policy, this license will terminate on April 30, 2023. 8/

The existing project was the subject of a jurisdictional proceeding prior to the filing of this application for license. As noted earlier, power generation was first installed at the site in 1916.

For projects having no valid (pre-1920) Federal permit and located on a navigable stream, past Commission policy under the Androscoggin rule 9/ has been to issue a license effective as of April 1, 1962, or the date when a Commission finding of navigability has been made, whichever is earlier. Because of the 50-year maximum statutory license period, however, this license will be made effective May 1, 1973.

In accordance with the order issuing a license for the Shoshone Falls Project, 10/ annual charges will be based upon the effective date, but this license will also be conditioned upon payment of an amount equivalent to the annual charges that would otherwise have been due for the period from May 1, 1949 (the first day of the month in which the river was found navigable) to April 30, 1973. This payment is not a penalty, but is intended to place the Applicant as nearly as possible in the same position it would

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7/ New Hampshire Hydro Associates surrendered its permit and is no longer pursuing the development of Project No. 3094.

8/ Village of Lyndonville Electric Department, 7 FERC ¶61,324 (June 29, 1979).

9/ See Public Service Company of New Hampshire, Project No. 2288, 27 FPC 830 (1962).

10/ See Idaho Power Company, Project No. 2778, issued June 13, 1979.

have been in before our change in termination date policy, and the same position as similarly situated Licensees who received their license before that change in policy.

It is ordered that:

(A) This license is issued to Boott Mills and Proprietors of the Locks and Canals on Merrimack River (Licensee) under Part I of the Federal Power Act (Act) for a period of 50 years, effective May 1, 1973, for construction, operation, and maintenance of the Lowell Hydroelectric Project No. 2790, located in Middlesex County, Massachusetts, on the Merrimack River, a navigable waterway of the United States. This license is subject to the terms and conditions of the Act, which is incorporated by reference as part of this license, and subject to the regulations the Commission issues under the provisions of the Act.

(B) The Lowell Hydroelectric Project No. 2790 would consist of:

(1) All lands, to the extent of the Licensee's interests in those lands, constituting the project area and enclosed by the project boundary. The project area and boundary are shown and described by certain exhibits that form part of the application for license and that are designated and described as:

Exhibit	FERC No. 2790-	Showing
G-1	38	General Map of Project Area
G-2	39	Detail Map of Project Area
G-3	40	Detail Map of Project Area
G-4	41	Detail Map of Project Area
G-5	41	Detail Map of Project Area
G-6	42	Detail Map of Project Area
G-7	43	Detail Map of Project Area
G-8	44	Detail Map of Project Area

(2) Project works consisting of: (1) the 1,093-foot-long and 15-foot-high Pawtucket Dam with 5-foot-high collapsible flashboards; (2) a reservoir with a storage capacity of 3,960 acre-feet; (3) the 5.5-mile-long Northern and Pawtucket Canal System; (4) four power stations housed in nineteenth century mill buildings along the canal system; and (5) a new power station drawing water from the Northern Canal.

The five power stations components description follows:

a. The Hamilton Power Station consists of: (1) five turbine-generator units with a total installed capacity of 1,180 kW; (2) 600-volt generator leads and 600-volt switchgear for each of the five generators; (3) a 600-volt generator bus and 600-volt main feeder breaker; (4) a single 600-volt station service feeder and associated 600-volt switchgear; (5) a single 600 VAC/125 VDC motor-generator exciter; and (6) other appurtenances.

b. The Assets Power Station consists of: (1) three turbine-generator units with a total installed capacity of 795 kW; (2) 600-volt generator leads and 600-volt switchgear for each of the three generators; (3) a single 600-volt switchgear; (4) a single 50 600-volt VAC/125 VDC motor-generator exciter; and (5) other appurtenances.

c. The Bridge Street Power Station consists of: (1) six turbine-generator units with a total installed capacity of 2,440 kw; (2) 600-volt generator leads and 600-volt switchgear for each of the six generators; (3) three 600-volt station service feeders and associated 600-volt switchgear; (4) three 600-volt VAC/125 VDC motor-generator exciters; and (5) other appurtenances.

d. The John Street Power Station consists of: (1) five turbine-generator units with a total installed capacity of 2,500 kW; (2) 600-volt generator leads and 600-volt switchgear for each of the five generators; (3) two 600-volt generator busses and two 600-volt main feeder breakers; (4) three 600-volt station service feeders and associated 600-volt switchgear; (5) five 600 VAC/125 VDC motor-generator exciter sets; and (6) other appurtenances.

e. The Lowell Power Station would consist of: (1) a powerhouse with 4 turbine-generator units with a total installed capacity of 15,000 kW; (2) a 1,000-foot-long tailrace; (3) fish passage facilities; (4) a canal control structure and navigation lock; (5) four 4.16 kV generator leads and 5 kV switchgear; (6) a 4.16 kV generator bus and 5 kW cables connecting the bus to the main step-up transformer and the station service transformer; (7) a 4.16/23 kV main step-up transformer; (8) a 141-foot-long, 23 kV cable and a 4,200-foot-long, 23 kV overhead line; (9) a 23 kV oil circuit recloser; and (10) other appurtenances.

The location, nature, and character of these project works are more specifically shown and described by the exhibits cited above and by certain other exhibits which also form part of the application for license and which are designated and described as:

Exhibit	FERC No. 2790-	Subject
F-1	5	Key Plan
F-2	6	Powerhouse Control Structure and Lock
F-3 (revised)	7	Powerhouse and Fish Passageway
F-4 (revised)	8	Powerhouse and Fish Passageway
F-5	9	Tailrace Channel
F-6	10	Pawtucket Dam
F-7 (revised)	11	Pawtucket Dam and Passageway
F-8	12	Assets Power Station
F-9	13	Assets Power Station
F-10	14	Bridge Street Power Station
F-11	15	Bridge Street Power Station
F-12	16	Hamilton Power Station
F-13	17	Hamilton Power Station
F-14	18	John Street Power Station
F-15	19	John Street Power Station
F-16	20	Northern Canal Gatehouse
F-17	21	Northern Canal Wastegates, Old Guard Locks and Gate
F-18	22	Moody Street Feeder Gatehouse
F-19	23	Lawrence Dam, Tremont Wasteway and Hall Street Dam

Exhibit	FERC No. 2790-	Subject
F-20	24	Lower Lake and Dam, and Swamp Locks and Dam
F-21	25	Rolling Dam, Merrimack Dam, and Bottom Dam
F-22	26	Canal and River Plan
F-23	27	Canal and River Plan
F-24	28	Canal and River Plan
F-25	29	Canal and River Plan
F-26	30	Canal and River Plan
F-27	31	Canal and River Plan
F-28	32	Canal and River Plan
F-29	33	River Sections
F-30	34	River Sections
F-31	35	Canal Sections
F-32	36	Canal Sections
F-33	37	Canal Sections

(3) All of the structures, fixtures, equipment, or facilities used or useful in the operation or maintenance of the project and located within the project boundary, all portable property that may be employed in connection with the project, located within or outside the project boundary, as approved by the Commission, and all riparian or other rights that are necessary or appropriate in the operation or maintenance of the project.

(C) Exhibits F and G, designated in ordering paragraph (B) above are approved and made a part of the license.

(D) This license is also subject to Article 1 through 28 set forth in Form L-4 (revised October, 1975), entitled "Terms and Conditions of License for Unconstructed Major Project Affecting Navigable Waters of the United States," attached to and made a part of this license. This license is also subject to the following additional articles:

Article 29. The Licensee shall review and approve the design of contractor-designed cofferdams and deep excavations prior to the start of construction and shall ensure that construction of cofferdams and deep excavations are consistent with the approved design. At least 30 days prior to start of construction of the cofferdam, the Licensee shall file with the Commission's Regional Engineer and Director, Office of Electric Power Regulation, one copy of the approved cofferdam construction drawings and specifications and a copy of the letter(s) of approval.

Article 30. The Licensee shall file with the Commission's Regional Engineer and the Director, Office of Electric Power Regulation, one copy each of the final contract drawings and specifications for pertinent features of the project such as water retention structures, powerhouse and water conveyance structures, at least 60 days prior to the start of construction. The Director, Office of Electric Power Regulation may require changes in the plans and specifications to ensure a safe and adequate project.

Article 31. The Licensee shall commence the construction of the project within one year of the date of issuance of the license and shall thereafter in good faith and with due diligence prosecute and complete such construction of project works within three years of the date of issuance of the license.

Article 32. The Licensee shall pay the United States the following annual charges, as determined in accordance with th provisions of the Commission's regulations in effect from time to time, for the purpose of reimbursing the United States for the cost of administration of Part I of the Act:

(1) For the period from May 1, 1949, through April 30, 1973, an amount equal to the annual charges that would have applied for the period if the project had been licensed during that period. The authorized installed capacity for this purpose is 10,550 horsepower.

(2) For the period from May 1, 1973, through April 30, 1983, the annual charges ordinarily due in accordance with the Commission's regulations. The authorized installed capacity for this purpose is 10,550 horsepower.

(3) From May 1, 1983, the full annual charge computed in accordance with the Commission's regulations. The authorized installed capacity for this purpose is 30,500 horsepower.

Article 33. The Licensee shall, prior to the commencement of any construction activities that would affect historical properties, cooperate with the Massachusetts State Historic Preservation officer (SHPO) and the National Park Service (NPS) to carry out a mitigation program, as concurred in by the Advisory Council on Historical Preservation, for avoiding or minimizing adverse effects on the Locks and Canals Historic District and the Lowell National Historical Park. The Licensee, as part of its mitigation program, shall: (1) conduct historical research designed to provide cultural and engineering data on structures to be affected by the project, and to produce plans and elevations for affected features; (2) record the historic and engineering characteristics of properties to be altered, through photographs, sketches, and field notes; (3) reconstruct impacted segments of the Northern Canal Walkway, using the original stones from the existing walkway; (4) employ landscaping treatments that emphasize revegetation of disturbed areas with native plant materials, the integration of new facilities into existing state and Federal park designs, and the placement of transmission lines in inconspicuous or underground locations; (5) provide the SHPO with an opportunity to review and comment upon the preliminary design of the power structure, to ensure that the structure would be designed to meet the Secretary of the Interior's standards for new construction adjacent to historic properties, and design the power structure to be compatible with existing historic properties in size, scale, massing, and materials; (6) allow the SHPO to review and comment upon the design of the proposed fish ladder with respect to its impacts on the Pawtucket Dam, and design a program to record the structural details of the dam that would be affected by the new ladder; (7) allow the Advisory Council on Historic Preservation to review and comment upon any future actions related to the project that would change the mean seasonal water levels in the canal system or that would impair navigability in the system; (8) construct a set of locks to allow passage around the control structure to be constructed across the Northern Canal; (9) repair the Northern Canal Gates and restore them to their original condition; and (10) provide visitor facilities, illustrating the similarities and contrasts between historic and modern power generation on the Lowell canal system. Licensee shall also make available funds in a reasonable amount for the mitigative measures required and shall ensure that any recording work is performed in accordance with the standards of the Historic American Engineering Record.

If any previously undiscovered archeological sites are found during the course of project construction, those activities shall be halted, a qualified archeologist shall be consulted to determine the significance of the resources, and the Licensee shall consult with the SHPO to develop a mitigation plan for the protection of

significant archeolgical resources. If the Licensee and the SHPO cannot agree on the amount of money to be expended on historical and archeological work at the project, the Commission reserves the right to require the Licensee to conduct, at its own expense, any work found necessary.

Article 34. The Licensee shall, within 3 months from the date of issuance of this license, file for Commission approval functional design drawings of the upstream and downstream fish passage facilities to include drawings of the improved natural channel, a construction schedule, and cost estimates for the facilities, prepared in consultation with the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the Massachusetts Division of Fisheries and Wildlife, and the Massachusetts State Historic Preservation Officer. Letters of comment on the proposed facilities from the above agencies shall be attached to the filing. Further, Licensee shall file "as-built" drawings with the Commission within 6 months after completion of the passage facilities.

Article 35. The Licensee shall, in cooperation with the U.S. Fish and Wildife Service, National Marine Fisheries Service, and the Massachusetts Division of Fisheries and Wildlife, conduct or pay for others to conduct an operational study to determine the effectiveness of the fish passage facilities, as required by Article 34, during a 2-year period following completion of construction.

A final report containing the results of the study, and recommendations for further studies or for changes in operation of the fish passage facilities, shall be filed with the Commission within 6 months following completion of the study. The Commission reserves the right, after notice and opportunity for hearing, to require additional studies or such reasonable changes in the project's fish passage facilities and operations as may be found necessary to maintain anadromous fish migrations past the projec

Article 36. The Licensee shall, after consultation with the Massachusetts Division of Fisheries and Wildlife, the National Marine Fisheries Service, and the U.S. Fish and Wildlife Service, develop (1) an instream flow study plan to determine the relationship between project discharges and downstream aquatic habitat, and (2) a fishery study plan to determine project discharges necessary to provide for the migration of anadromous fish. Within 4 months from the date of issuance of this license, the Licensee shall file with the Commission for approval with copies to the agencies consulted, the instream flow and fishery study plans, and a schedule for completion. Documentation of agency consultation on the study plans shall be included in the filing.

Licensee shall conduct the instream flow and fishery studies as approved by the Commission and in accordance with the schedule. Within 3 months from the date of completion of the studies, the Licensee shall file, with copies to the agencies consulted, a report on the results of the studies, and, for Commission approval, recommendations for flow releases from the project. Documentation of agency consultation on the report and recommendations shall be included in the filing.

Article 37. The Licensee shall discharge from the Lowell Hydroelectric Project an interim continuous minimum flow of 905 cubic feet per second, as measured immediately downstream from the project, or the inflow to the reservoir, whichever is less, for the purpose of protecting fish and wildlife resources. The interim minimum flow may be temporarily modified if required by operating emergencies beyond the control of the Licensee, for the minimum flow study required by Article 36, and for short periods for fishery management purposes upon mutual agreement between the Licensee and the Massachusetts Division of Fisheries and Wildlife.

Article 38. Licensee shall within 1 year from the date of issuance of this license and in consultation with the Massachusetts Department of Environmental Management, the Massachusetts State Historic Preservation Officer, and the National Park Service, prepare and file for Commission approval, a revised Report on Recreational Resources for the Lowell Hydroelectric Project. The report shall include, but not be limited to: (1) functional plans, site development costs, and schedules for constructing a navigation lock at the Northern Canal control structure, for restoring the Northern Canal walkway near the powerhouse, for repairing the Northern Canal Gates, and for providing a visitor facility at the powerhouse; and (2) a canal system water elevation maintenance plan to allow National Park Service tour boats to navigate on the lower canal system. The report shall also include copies of agreements with cooperating entities and letters of comment on the report from those agencies consulted.

Article 39. (a) In accordance with the provisions of this article, the Licensee shall have the authority to grant permission for certain types of use and occupancy of project lands and waters and to convey certain interests in project lands and waters for certain other types of use and occupancy, without prior Commission approval. The Licensee may exercise the authority only if the proposed use and occupancy is consistent with the pruposes of protecting and enhancing the scenic, recreational, and other environmental values of the project. For those purposes, the Licensee shall also have continuing responsibility to supervise and control the uses and occupancies for which it grants permission,

and to monitor the use of, and to ensure compliance with the covenants of the instrument of conveyance for any interests that it has conveyed under this article. If a permitted use and occupancy violates any condition of this article or any other condition imposed by the Licensee for protection and enhancement of the project's scenic, recreational, or other environmental values, or if a covenant of a conveyance made under the authority of this article is violated, the Licensee thall take any lawful action necessary to correct the violation. For a permitted use or occupancy that action includes, if necessary, cancelling the permission to use and occupy the project lands and waters and requiring the removal of any non-complying structures and facilities.

(b) The types of use and occupancy of project lands and waters for which the Licensee may grant permission without prior Commission approval are: (1) landscape plantings; (2) non-commercial piers, landings, boat docks, or similar structures and facilities that can accommodate no more than 10 watercraft at a time where said facility is intended to serve single-family type dwellings; and (3) embankments, bulkheads, retaining walls, or similar structures for erosion control to protect the existing shoreline. To the extent feasible and desirable to protect and enhance the project's scenic, recreational, and other environmental values, the Licensee shall require multiple use and occupancy of facilities for access to project lands or waters. The Licensee shall also ensure, to the satisfaction of the Commission's authorized representative, that the uses and occupancies for which it grants permission are maintained in good repair and comply with applicable State and local health and safety requirements. Before granting permission for construction of bulkheads or retaining walls, the Licensee shall: (1) inspect the site of the proposed construction, (2) consider whether the planting of vegetation or the use of riprap would be adequate to control erosion at the site, and (3) determine that the proposed construction is needed and would not change the basic contour of the reservoir shoreline. To implement this paragraph (b), the Licensee may, among other things, establish a program for issuing permits for the specified types of use and occupancy of project lands and waters, which may be subject to the payment of a reasonable fee to cover the Licensee's costs of administering the permit program. The Commission reserves the right to require the Licensee to file a description of its standards, guidelines, and procedures for implementing this paragraph (b) and to require modification of those standards, guidelines, or procedures.

(c) The Licensee may convey easements or rights-of-way across, or leases of, project lands for: (1) replacement, expansion, realignment, or maintenance of bridges and roads for which all necessary State and Federal approvals have been obtained; (2) storm drains and water mains; (3) sewers that do not discharge into project waters; (4) minor access roads; (5) telephone, gas, and

electric utility distribution lines; (6) non-project overhead electric transmission lines that do not require erection of support structures within the project boundary; (7) submarine, overhead, or underground major telephone distribution cables or major electric distribution lines (69-kV or less); and (8) water intake or pumping facilities that do not extract more than one million gallons per day from a project reservoir. No later than January 31 of each year, the Licensee shall file three copies of a report briefly describing for each conveyance made under this paragraph (c) during the prior calendar year, the type of interest conveyed, the location of the lands subject to the conveyance, and the nature of the use for which the interest was conveyed.

(d) The Licensee may convey fee titles to, easements or rights-of-way across, or leases of project lands for: (1) construction of new bridges or roads for which all necessary State and Federal approvals have been obtained; (2) sewer or effluent lines that discharge into project waters, for which all necessary Federal and State water quality certificates or permits have been obtained; (3) other pipelines that cross project lands or waters but do not discharge into project waters; (4) non-project overhead electric transmission lines that require erection of support structures within the project boundary, for which all necessary Federal and State approvals have been obtained; (5) private or public marinas that can accommodate no more that 10 watercraft at a time and are located at least one-half mile from any other private or public marina; (6) recreational development consistent with an approved Exhibit R or approved report on recreational resources of an Exhibit E; and (7) other uses, if: (i) the amount of land conveyed for a particular use is five acres or less; (ii) all of the land conveyed is located at least 75 feet, measured horizontally, from the edge of the project reservoir at normal maximum surface elevation; and (iii) no more than 50 total acres of project lands for each project development are conveyed under this clause (d)(7) in any calendar year. At least 45 days before conveying any interest in project lands under this paragraph (d), the Licensee must file a letter to the Director, Office of Electric Power Regulation, stating its intent to convey the interest and briefly describing the type of interest and location of the lands to be conveyed (a marked Exhibit G or K map may be used), the nature of the proposed use, the identity of any Federal or State agency official consulted, and any Federal or State approvals required for the proposed use. Unless the Director, within 45 days from the filing date, requires the Licensee to file an application for prior approval, the Licensee may convey the intended interest at the end of that period.

(e) The following additional conditions apply to any intended conveyance under paragraphs (c) or (d) of this article:

(1) Before conveying the interest, the Licensee shall consult with Federal and State fish and wildlife or recreation agencies, as appropriate, and the State Historic Preservation Officer.

(2) Before conveying the interest, the Licensee shall determine that the proposed use of the lands to be conveyed is not inconsistent with any approved Exhibit R or approved report on recreational resources of an Exhibit E; or, if the project does not have an approved Exhibit R or approved report on recreational resources, that the lands to be conveyed do not have recreational value.

(3) The instrument of conveyance must include covenants running with the land adequate to ensure that: (i) the use of the lands conveyed shall not endanger health, create a nuisance, or otherwise be incompatible with overall project recreational use; and (ii) the grantee shall take all reasonable precautions to ensure that the construction, operation, and maintenance of structures or facilities on the conveyed lands will occur in a manner that will protect the scenic, recreational, and environmental values of the project.

(4) The Commission reserves the right to require the Licensee to take reasonable remedial action to correct any violation of the terms and conditions of this article, for the protection and enhancement of the project's scenic, recreational, and other environmental values.

(f) The conveyance of an interest in project lands under this article does not in itself change the project boundaries. The project boundaries may be changed to exclude land conveyed under this article only upon approval of revised Exhibit G or K drawings (project boundary maps) reflecting exclusion of that land. Lands conveyed under this article will be excluded from the project only upon a determination that the lands are not necessary for project purposes, such as operation and maintenance, flowage, recreation, public access, protection of environmental resources, and shoreline control, including shoreline aesthetic values. Absent extraordinary circumstances, proposals to exclude lands conveyed under this article from the project shall be consolidated for consideration when revised Exhibit G or K drawings would be filed for approval for other purposes.

Article 40. Pursuant to Section 10(d) of the Act, after the first 20 years of operation of the project under license, a specified reasonable rate of return upon the net investment in the project shall be used for determining surplus earnings of the project for the establishment and maintenance of amortization

reserves. One half of the project surplus earnings, if any, accumulated after the first 20 years of operation under the license, in excess of the specified rate of return per annum on the net investment, shall be set aside in a project amortization reserve account at the end of each fiscal year. To the extent that there is a deficiency of project earnings below the specified rate of return per annum for any fiscal year after the first 20 years of operation under the license, the amount of that deficiency shall be deducted from the amount of any surplus earnings subsequently accumulated, until absorbed. One-half of the remaining surplus earnings, if any, cumulatively computed, shall be set aside in the project amortization reserve account. The amounts established in the project amortization reserve account shall be maintained until further order of the Commission.

The annual specified reasonable rate of return shall be the sum of the annual weighted costs of long-term debt, preferred stock, and common equity, as defined below. The annual weighted cost for each component of the reasonable rate of return is the product of its capital ratio and cost rate. The annual capital ratio for each component of the rate of return shall be calculated based on an average of 13 monthly balances of amounts properly includable in the Licensee's long-term debt and proprietary capital accounts as listed in the Commission's Uniform System of Accounts. The cost rates for long-term debt and preferred stock shall be their respective weighted average costs for the year, and the cost of common equity shall be the interest rate on 10-year government bonds (reported as the Treasury Department's 10 year constant maturity series) computed on the monthly average for the year in question plus four percentage points (400 basis points).

Article 41. The Licensee shall clear and keep clear to an adequate width lands along open conduits and shall dispose of all temporary structures, unused timber, brush, refuse, or other material unnecessary for the purposes of the project which results from the clearing of lands or from the maintenance of alteration of the project works. In addition, all trees along the periphery of project reservoirs which may die during operations of the project shall be removed. All clearing of the lands and disposal of the unnecessary material shall be done with due diligence and to the satisfaction of the authorized representative of the Commission and in accordance with appropriate Federal, State, and local statutes and regulations.

Article 42. Within 90 days from the date of acceptance of this license, the Licensee shall file a statement under oath showing the gross amount of power generation for the project in kilowatt-hours for each calendar year commencing May 1, 1949, in accordance with the provisions of Section 11.20(a)(4) of the Commission's regulations.

(E) The Licensee's failure to file a petition appealing this order to the Commission shall constitute acceptance of this license. In acknowledgment of acceptance of this order and its terms and conditions, it shall be signed by the Licensee and returned to the Commission within 60 days from the date this order is issued.

Lawrence R. Anderson

Lawrence R. Anderson
Director, Office of Electric
Power Regulation

Project No. 2790-000

IN TESTIMONY of their acknowledgment of acceptance of all of the terms and conditions of this Order, Boott Mills and Proprietors of the Locks and Canals on Merrimack River this thirteenth day of June, 1983 have caused their corporate names to be signed hereto by Melvin G. Lezberg, their President, and their corporate seal to be affixed hereto and attested by Marshall L. Field, their Secretary, pursuant to a resolution of their Boards of Directors duly adopted on the thirteenth day of June, 1983, a certified copy of the record of which is attached hereto.

By Melvin G. Lezberg
Melvin G. Lezberg, President
of Boott Mills and Proprietors
of the Locks and Canals on
Merrimack River

Attest:

Marshall L. Field, Clerk of
Boott Mills and Proprietors
of the Locks and Canals on
Merrimack River

CLERK'S CERTIFICATE

I, Marshall L. Field, do hereby certify that I have been duly elected to, and now hold, the office of Clerk of Boott Mills and Proprietors of the Locks and Canals on Merrimack River, both corporations duly organized and existing under the laws of The Commonwealth of Massachusetts; that by Consent of the Boards of Directors of said corporations dated June 13, 1983, the following Resolution was unanimously adopted, that said Resolution is in full force and effect as of the date hereof without any change whatsoever:

"RESOLVED: That the President of Boott Mills and Proprietors of the Locks and Canals on Merrimack River, Melvin G. Lezberg, is hereby authorized to accept on behalf of Boott Mills and Proprietors of the Locks and Canals on Merrimack River the License for the Lowell Hydroelectric Project issued on April 13, 1983 by the Federal Energy Regulatory Commission in Project No. 2790-000."

I hereby further certify that there are no provisions in the Charter or Bylaws of said corporations limiting the power of the Boards of Directors to adopt the foregoing Resolution and that the same is in conformity with the provisions of said Charter and Bylaws.

IN WITNESS WHEREOF, I have hereunto set my hand and the seal of said corporations this thirteenth day of June, 1983.

_____
Marshall L. Field, Clerk

Form L-4
(Revised October, 1979)

FEDERAL ENERGY REGULATORY COMMISSION

TERMS AND CONDITIONS OF LICENSE FOR
UNCONSTRUCTED MAJOR PROJECT AFFECTING
NAVIGABLE WATERS IN THE UNITED STATES

Article 1. The entire project, as described in this order of the Commission, shall be subject to all of the provisions, terms, and conditions of the license.

Article 2. No substantial change shall be made in the maps, plans, specifications, and statements described and designated as exhibits and approved by the Commission in its order as a part of the license until such change shall have been approved by the Commission: Provided, however, That if the Licensee or the Commission deems it necessary or desirable that said approved exhibits, or any of them, be changed, there shall be submitted to the Commission for approval a revised, or additional exhibit or exhibits covering the proposed change which, upon approval by the Commission, shall become a part of the license and shall supersede, in whole or in part, such exhibit or exhibits theretofore made a part of the license as may be specified by the Commission.

Article 3. The project works shall be constructed in substantial conformity with the approved exhibits referred to in Article 2 herein or as changed in accordance with the provisions of said article. Except when emergency shall require for the protection of navigation, life, health, or property, there shall not be made without prior approval of the Commission any substantial alteration or addition not in conformity with the approved plans to any dam or other project works under the license or any substantial use of project lands and waters not authorized herein; and any emergency alteration, addition, or use so made shall thereafter be subject to such modification and change as the Commission may direct. Minor changes in project works, or in uses of project lands and waters, or divergence from such approved exhibits may be made if such changes will not result in a decrease in efficiency, in a material increase in cost, in an adverse environmental impact, or in impairment of the general scheme of development; but any of such minor changes made without the prior approval of the Commission, which in its judgment have produced or will produce any of such results, shall be subject to such alteration as the Commission may direct.

Upon the completion of the project, or at such other time as the Commission may direct, the Licensee shall submit to the Commission for approval revised exhibits insofar as necessary to show any divergence from or variations in the project area and project boundary as finally located or in the project works as actually constructed when compared with the area and boundary shown and the works described in the license or in the exhibits approved by the Commission, together with a statement in writing setting forth the reasons which in the opinion of the Licensee necessitated or justified variation in or divergence from the approved exhibits. Such revised exhibits shall, if and when approved by the Commission, be made a part of the license under the provisions of Article 2 hereof.

Article 4. The construction, operation, and maintenance of the project and any work incidental to additions or alterations shall be subject to the inspection and supervision of the Regional Engineer, Federal Power Commission, in the region wherein the project is located, or of such other officer or agent as the Commission may designate, who shall be the authorized representative of the Commission for such purposes. The Licensee shall cooperate fully with said representative and shall furnish him a detailed program of inspection by the Licensee that will provide for an adequate and qualified inspection force for construction of the project and for any subsequent alterations to the project. Construction of the project works or any feature or alteration thereof shall not be initiated until the program of inspection for the project works or any such feature thereof has been approved by said representative. The Licensee shall also furnish to said representative such further information as he may require concerning the construction, operation, and maintenance of the project, and of any alteration thereof, and shall notify him of the date upon which work will begin, as far in advance thereof as said representative may reasonably specify, and shall notify him promptly in writing of any suspension of work for a period of more than one week, and of its resumption and completion. The Licensee shall allow said representative and other officers or employees of the United States, showing proper credentials, free and unrestricted access to, through, and across the project lands and project works in the performance of their official duties. The Licensee shall comply with such rules and regulations of general or special applicability as the Commission may prescribe from time to time for the protection of life, health, or property.

Article 5. The Licensee, within five years from the date of issuance of the license, shall acquire title in fee or the right to use in perpetuity lands, other than lands of the United States, necessary or appropriate for the construction, maintenance, and operation of the project. The Licensee or its successors and assigns shall, during the period of the license, retain the possession of all project property covered by the license as issued or as later amended, including the project area, the project works, and all franchises, easements, water rights, and rights of occupancy and use; and none of such properties shall be voluntarily sold, leased, transferred, abandoned, or otherwise desposed of without the prior written approval of the Commission, except that the Licensee may lease or otherwise dispose of interest in project lands or property without specific written approval of the Commission pursuant to the than current regulations of the Commission. The provisions of this article are not intended to prevent the abandonment or the retirement from service of structures, equipment, or other project works in connection with replacements thereof when they become obsolete, inadequate, or inefficient for further service due to wear and tear; and mortgage or trust deeds or judicial sales made thereunder, or tax sales, shall not be deemed voluntary transfers within the meaning of this article.

Article 6. In the event the project is taken over by the United States upon the termination of the license as provided in Section 14 of the Federal Power Act, or is transferred to a new licensee or to a non-power licensee under the provisions of Section 15 of said Act, the Licensee, its successors and assigns shall be responsible for, and shall make good any defect of title to, or of right of occupancy and use in, any of such project property that is necessary or appropriate or valuable and serviceable in the maintenance and operation of the project, and shall pay and discharge, or shall assume responsibility for payment and discharge of, all liens or encumbrances upon the project or project property created by the Licensee or created or incurred after the issuance of the lisense: Provided, That the provisions of this article are not intended to require the Licensee, for the purpose of transferring the project to the United States or to a new licensee, to acquire any different title in, or right of occupancy and use in, any of such project property than was necessary to acquire for its own purpose as the Licensee.

Article 7. The actual legitimate original cost of the project, and of any addition thereto or betterment thereof, shall be determined by the Commission in accordance with the Federal Power Act and the Commission's Rules and Regulations thereunder.

Article 8. The Licensee shall install and thereafter maintain gages and stream-gaging stations for the purpose of determining the stage and flow of the stream or streams on which the project is located, the amount of water held in and withdrawn from storage, and the effective head on the turbines, shall provide for the required reading of such gages and for the adequate rating of such stations; and shall install and maintain standard meters adequate for the determination of the amount of electric energy generated by the project works. The number, character, and location of gages, meters, or other measuring devices, and the method of operation thereof, shall at all times be satisfactory to the Commission or its authorized representative. The Commission reserves the right, after notice and opportunity for hearing, to require such alterations in the number, character, and location of gages, meters, or other measuring devices, and the method of operation thereof, as are necessary to secure adequate determinations. The installation of gages, the rating of said stream or streams, and the determination of the flow thereof, shall be under the supervision of, or in cooperation with, the District Engineer of the United States Geological Survey having charge of stream-gaging operations in the region of the project, and the Licensee shall advance to the United States Geological Survey the amount of funds estimated to be necessary for such supervision, or cooperation for such periods as may be mutually agreed upon. The Licensee shall keep accurate and sufficient records of the foregoing determinations to the satisfaction of the Commission, and shall make return of such records annually at such time and in such form as the Commission may prescribe.

Article 9. The Licensee shall, after notice and opportunity for hearing, install additional capacity or make other changes in the project as directed by the Commission, to the extent that it is economically sound and in the public interest to do so.

Article 10. The Licensee shall, after notice and opportunity for hearing, coordinate the operation of the project, electrically and hydraulically, with such other projects or power systems and in such manner as the Commission may direct in the interest of power and other beneficial public uses of water resources, and on such conditions conerning the equitable sharing of benefits by the Licensee as the Commission may order.

Article 11. Whenever the Licensee is directly benefited by the construction work of another licensee a permitee, or the United States on a storage reservoir or other headwater improvement, the Licensee shall reimburse the owner of the headwater improvement for such part of the annual charges for interest, maintenance, and depreciation thereof as the Commission shall determine to be equitable, and shall pay to the United States the cost of making such determination as fixed by the Commission. For benefits provided by a storage reservoir or other headwater improvement of the United States, the Licensee shall pay to the Commission the amounts for which it is billed from time to time for such headwater benefits and for the cost of making the determinations pursuant to the then current regulations of the Commission under the Federal Power Act.

Article 12. The United States specifically retains and safeguards the right to use water in such amount, to be determined by the Secretary of the Army, as may be necessary for the purposes of navigation on the navigable waterway affected; and the operations of the Licensee, so far as they affect the use, storage and discharge from storage of waters affected by the license, shall at all times be controlled by such reasonable rules and regulations as the Secretary of the Army may prescribe in the interest of navigation, and as the Commission may prescribe for the protection of life, health, and property, and in the interest of the fullest practicable conservation and utilization of such waters for power purposes and for other beneficial public uses, including recreational purposes, and the Licensee shall release water from the project reservoir at such rate in cubic feet per second, or such volume in acre-foot per specified period of time, as the Secretary of the Army may prescribe in the interest of navigation, or as the Commission may prescribe for the other purposes hereinafter mentioned.

Article 13. On the application of any person, association, corporation, Federal agency, State or municipality, the Licensee shall permit such reasonable use of its reservoir or other project properties, including works, lands, and water rights, or parts thereof, as may be ordered by the Commission, after notice and opportunity for hearing, in the interest of comprehensive development of the waterway or waterways involved and the conservation and utilization of the water resources of the region for water supply or for the purposes of steam-electric, irrigation, industrial, municipal, or similar uses. The Licensee shall receive reasonable compensation for use of its reservoir or other project properties or parts thereof for such purposes, to include at least full reimbursement for any damages or expenses which the joint use causes the Licensee to incur. Any such compensation shall be fixed by the Commission either by approval of an agreement between the Licensee and the party or parties benefiting or after notice and opportunity of hearing. Applications shall contain information in sufficient detail to afford a full understanding of the proposed use, including satisfactory evidence that the applicant possesses necessary water rights pursuant to applicable State law, or a showing of cause why such evidence cannot concurrently be submitted, and a statement as to the relationship of the proposed use to any State or municipal plans or orders which may have been adopted with respect to the use of such waters.

Article 14. In the construction or maintenance of the project works, the Licensee shall place and maintain suitable structures and devices to reduce to a reasonable degree the liability of contact between its transmission lines and telegraph, telephone and other signal wires or power transmission lines constructed prior to its transmission lines and not owned by the Licensee, and shall also place and maintain suitable structures and devices to reduce to a reasonable degree the liability of any structures or wires falling or obstructing traffic or endangering life. None of the provisions of this article are intended to relieve the Licensee from any responsibility or requirement which may be imposed by any other lawful authority for avoiding or eliminating inductive interference.

Article 15. The Licensee shall, for the conservation and development of fish and wildlife resources, construct, maintain, and operate, or arrange for the construction, maintenance, and operation of such reasonable facilities, and comply with such reasonable modifications of the project structures and operation, as may be ordered by the Commission upon its own motion or upon the recommendation of the Secretary of the Interior or the fish and wildlife agency or agencies of any State in which the project or a part thereof is located, after notice and opportunity for hearing.

Article 16. Whenever the United States shall desire, in connection with the project, to construct fish and wildlife facilities or to improve the existing fish and wildlife facilities at its own expense, the Licensee shall permit the United States or its designated agency to use, free of cost, such of the Licensee's lands and interest in lands, reservoirs, waterways and project works as may be reasonably required to complete such facilities or such improvements thereof. In addition, after notice and opportunity for hearing, the Licensee shall modify the project operation as may be reasonably prescribed by the Commission in order to permit the maintenance and operation of the fish and wildlife facilities constructed or improved by the United States under the provisions of this article. This article shall not be interpreted to place any obligation on the United States to construct or improve fish and wildlife facilities or to relieve the Licensee of any obligation under this license.

Article 17. The Licensee shall construct, maintain, and operate or shall arrange for the construction, maintenance, and operation of such reasonable recreational facilities, including modifications thereto, such as access roads, wharves, launching ramps, beaches, picnic and camping areas, sanitary facilities, and utilities, giving consideration to the needs of the physically handicapped, and shall comply with such reasonable modifications of the project, as may be prescribed hereafter by the Commission during the term of this license upon its own motion or upon the recommendation of the Secretary of the Interior or other interested Federal or State agencies, after notice and opportunity for hearing.

Article 18. So far as is consistent with proper operation of the project, the Licensee shall allow the public free access, to a reasonable extent, to project waters and adjacent project lands owned by the Licensee for the purpose of full public utilization of such lands and waters for navigation and for outdoor recreational purposes, including fishing and hunting: Provided, That the Licensee may reserve from public access such portions of the project waters, adjacent lands, and project facilities as may be necessary for the protection of life, health, and property.

Article 19. In the construction, maintenance, or operation of the project, the Licensee shall be responsible for, and shall take reasonable measures to prevent, soil erosion on lands adjacent to streams or other waters, stream sedimentation, and any form of water or air pollution. The Commission, upon request or upon its own motion, may order the Licnesee to take such measures as the Commission finds to be necessary for these purposes, after notice and opportunity for hearing.

Article 20. The Licensee shall consult with the appropriate State and Federal agencies and, within one year of the date of issuance of this license, shall submit for Commission approval, a plan for clearing the reservoir area. Further, the Licensee shall clear and keep clear to an adequate width lands along open conduits and shall dispose of all temporary structures, unused timber, brush, refuse, or other material unnecessary for the purposes of the project which results from the clearing of lands or from the maintenance or alteration of the project works. In addition, all trees along the periphery of project reservoirs which may die during operations of the project shall be removed. Upon approval of the clearing plan all clearing of the lands and disposal of the unnecessary material shall be done with due deligence and to the satisfaction of the authorized representative of the Commission and in accordance with appropriate Federal, State, and local statutes and regulations.

Article 21. Material may be dredged or excavated from or placed as fill in, project lands and/or waters only in the prosecution of work specifically authorized under the license; in the maintenance of the project; or after obtaining Commission approval, as appropriate. Any such material shall be removed and/or deposited in such manner as to reasonably preserve the

environmental values of the project and so as not to interfere with traffic on land or water. Dredging and filling in a navigable water of the United States shall also be done to the satisfaction of the District Engineer, Department of the Army, in charge of the locality.

Article 22. Whenever the United States shall desire to construct, complete, or improve navigation facilities in connection with the project, the Licensee shall convey to the United States, free of cost, such of its lands and rights-of-way and such rights of passage through its dams or other structures, and shall permit such control of its pools, as may be required to complete and maintian such navigation facilities.

Article 23. The operation of any navigation facilities which may be constructed as a part of, or in connection with, any dam or diversion structure constituting a part of the project works shall at all times be controlled by such reasonable rules and regulations in the interest of navigation, including control of the level of the pool caused by such dam or diversion structure, as may be made from time to time by the Secretary of the Army.

Article 24. The Licensee shall furnish power free of cost to the United States for the operation and maintenance of navigation facilities in the vicinity of the project at the voltage and frequency required by such facilities and at a point adjacent thereto, whether said facilities are constructed by the Licensee or by the United States.

Article 25. The Licensee shall construct, maintain, and operate at its own expense such lights and other signals for the protection of navigation as may be directed by the Secretary of the Department in which the Coast Guard is operating.

Article 26. If the Licensee shall cause or suffer essential project property to be removed or destroyed or to become unfit for use, without adequate replacemment, or shall abandon or discontinue good faith operation of the project or refuse or neglect to comply with the terms of the license and the lawful orders of the Commission mailed to the record address of the Licensee or its agent, the Commission will deem it to be the

intent of the Licensee to surrender the license. The Commission, after notice and opportunity for hearing, may require the Licensee to remove any or all structures, equipment and power lines within the project boundary and to take any such other action necessary to restore the project waters, lands, and facilities remaining within the project boundary to a condition satisfactory to the United States agency having jurisdiction over its lands or the Commission's authorized representative, as appropriate, or to provide for the continued operation and maintenance of nonpower facilities and fulfill such other obligations under the license as the Commission may prescribe. In addition, the Commission in its discretion, after notice and opportunity for hearing, may also agree to the surrender of the license when the Commission, for the reasons recited herein, deems it to be the intent of the Licensee to surrender the license.

Article 27. The right of the Licensee and of its successors and assigns to use or occupy waters over which the United States has jurisdiction, or lands of the United States under the license, for the purpose of maintaining the project works or otherwise, shall absolutely cease at the end of the license period, unless the Licensee has obtained a new license pursuant to the then existing laws and regulations, or an annual license under the terms and conditions of this license.

Article 28. The terms and conditions expressly set forth in the license shall not be construed as impairing any terms and conditions of the Federal Power Act which are not expressly set forth herein.

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Boott Mills Proprietors of the Locks and Canals on Merrimack River Boott Hydropower, Inc. General Electric Credit Corporation	)	Project No. 2790-002

ERRATA NOTICE

(December 29, 1983)

ORDER APPROVING TRANSFER OF LICENSE
(Issued December 15, 1983)

Footnote 5, page 2 should be revised to read in part:

> ... The Licensees have entered into an agreement with Commonwealth Electric Co. to sell all project power output based on Commonwealth's avoided cost.

Kenneth F. Plumb
Secretary

DC-A-24

19840104-0328 FERC PDF (Unofficial) 12/29/1983

Document Content(s)

UNITED STATES OF AMERICA 55FERC ¶ 62, 62,333
FEDERAL ENERGY REGULATORY COMMISSION

Boott Hydropower, Inc. Project No. 2790-014
Massachusetts

ORDER REVISING LICENSE ARTICLE
(Issued June 28, 1991)

The license for the Lowell Hydropower Project, 1/ FERC No. 2790, authorized an installed capacity of 21,915-kW. The project includes five power stations. Prior to the commencement of project construction, in October 1983, during the review of plans and specifications, the authorized capacity at the Lowell Power Station was increased from 15,000-kW to 17,308-kW. Since the completion of project construction in December 1985, the licensee has been operating the Lowell Power Station at the increased capacity. The installed capacity at the Bridge Street Station is 3,440-kW, which was incorrectly stated in the original license as 2,440-kW. Additionally, on September 6, 1990, the authorized capacity at the John Street Station was decreased from 2,500-kW to 2,100-kW.

These revisions change the total installed capacity for the Lowell Hydroelectric Project from 21,915-kW to 24,823-kW. Therefore, article 32 of the license should be revised to reflect the correct authorized installed capacity.

The Director orders:

(A) The ordering paragraph (B)(2) of the license is revised in part to read as follows:

c. The Bridge Street Power Station consists of: (1) six turbine-generator units with a total installed capacity of 3,440-kW; (2) 600-volt generator leads and 600-volt switchgear for each of the six generators; (3) three 600-volt station service feeders and associated 600-volt switchgear; (4) three 600-volt VAC/125 VDC motor-generator exciters; and (5) other appurtenances.

d. The John Street Power Station consists of: (1) four turbine-generator units with a total installed capacity of 2,100-kW; (2) 600-volt generator leads and 600-volt switchgear for each of the four generators; (3) two 600-volt generator busses and two 600-volt main feeder breakers; (4) three 600-volt station service

1/ 23 FERC ¶ 62,043, issued April 13, 1983.

feeders and associated 600-volt switchgear; (5) Four 600 VAC/125 VDC motor-generator exciter sets; and (6) other appurtenances.

e. The Lowell Power Station consists of: (1) a powerhouse with 2 turbine generator units with a total installed capacity of 17,308-kW; (2) a 1,000-foot-long tailrace; (3) fish passage facilities; (4) a canal control structure and navigation; (5) two 4.16 kV generator leads and 5 kV switchgear; ...

(B) Article 32 of the license is revised to read as follows:

Article 32. The licensee shall pay the United States the following annual charges, as determined in accordance with the provisions of the Commission's regulations in effect from time to time, for the purpose of reimbursing the United States for the cost of administration of Part I of the Act:

(1) For the period from May 1, 1949, through April 30, 1973, an amount equal to the annual charges that would have applied for the period if the project had been licensed during that period. The authorized installed capacity for this purpose is 10,020 horsepower.

(2) For the period from May 1, 1973, through April 30, 1983, the annual charges ordinarily due in accordance with the Commission's regulations. The authorized installed capacity for this purpose is 10,020 horsepower.

(3) For the period from May 1, 1983, to September 5, 1990, the annual charges ordinarily due in accordance with the Commission's regulations. The authorized installed capacity for that purpose is 33,500 horsepower.

(4) From September 6, 1990, the full annual charge computed in accordance with the Commission's regulations. The authorized installed capacity for this purpose is 33,000 horsepower.

♀

(C) This order constitutes final agency action. Requests for rehearing by the Commission may be filed within 30 days of the date of issuance of this order, pursuant to 18 C.F.R. ⊥385.713.

J. Mark Robinson
Director, Division of Project
Compliance and Administration

♀

143 FERC ¶ 61,048
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Boott Hydropower, Inc., and
Eldred L. Field Hydroelectric Facility Trust

Project No. 2790-055

ORDER AMENDING LICENSE

(Issued April 18, 2013)

1. On July 6, 2010, Boott Hydropower, Inc., and Eldred L. Field Hydroelectric Facility Trust (Boott or the licensees) filed an application to amend the license for the Lowell Hydroelectric Project No. 2790, located on the Merrimack River in the City of Lowell in Middlesex County, Massachusetts. The project does not occupy any federal land but is located within the administrative boundary of the Lowell National Historical Park (Lowell Park). The licensees request authorization to replace the existing Pawtucket Dam's wooden flashboards with a pneumatic crest gate system, and to change the configuration of the wooden flashboard system while the new crest gate system is being constructed.

2. The application is contested. Among other things, Pawtucket Dam is listed on the National Register of Historic Places as part of the Lowell Park and two historic districts, one of which is a National Historic Landmark. Participants disagree about whether it is acceptable to alter the crest control structure on top of the dam and whether the effects of doing so can be adequately mitigated. They also disagree about whether and how well the various options considered would help alleviate upstream flooding during times of high flows. As discussed below, we find that the proposed pneumatic crest gate system can be installed without unacceptably altering the dam or adversely affecting the park and historic districts. The crest gate system will also provide important benefits to recreation, fish passage, dam and worker safety, and project generation, and will help alleviate upstream backwater and flooding effects to the maximum extent possible. We therefore grant the licensees' amendment request, subject to additional conditions as discussed in this order.

Background

3. On April 13, 1983, the Commission issued an original license to Boott Mills and Proprietors of the Locks and Canals on Merrimack River to construct, operate, and

maintain the Lowell Hydroelectric Project.[1] The Commission approved a transfer of the license to the current licensees on April 1, 2005.[2]

4. The Lowell Project as licensed consists of: (1) the 1,093-foot-long and 15-foot-high Pawtucket Dam; (2) a reservoir with a storage capacity of 3,960 acre-feet; (3) the 5.5-mile-long Northern and Pawtucket Canal System comprised of several small dams and gatehouses; (4) four existing power plants with a total installed capacity of 7,515 kilowatts (kW) housed in nineteenth century mill buildings along the canal system; and (5) a new power station with an installed capacity of 17,308 kW drawing water from the Northern Canal, (6) a new tailrace channel; (7) fishway facilities at the dam and new powerhouse, and (8) a new transmission line.[3] The dam includes 5-foot-high flashboards, which are designed to collapse when water levels in the reservoir overtop the flashboards. The collapse of the flashboards allows additional water to spill over the dam, reducing pressure on the dam and also reducing upstream flooding.

5. This amendment proceeding had its origins in August 2007, when the Commission received a number of complaints from homeowners along Clay Pit Brook, a tributary to the Merrimack River, concerning flooding that occurred in May 2006 and April 2007.[4] The homeowners asserted that the flooding was caused by flashboards on Pawtucket Dam and requested the Commission to reduce the height of flashboards from 5 feet to 4 feet. In response to these concerns, Commission staff requested in a January 22, 2008 letter that Boott provide information on project operation from January 1, 2004, through

[1] *Boott Mills and Proprietors of the Locks and Canals on Merrimack River*, 23 FERC ¶ 62,043 (1983) *(Boott Mills).* On December 15, 1983, the Commission approved a transfer of the license to Boott Hydropower, Inc. and General Electric Credit Corporation. *Boott Mills and Proprietors of the Locks and Canals on Merrimack River*, 25 FERC ¶ 61,386 (1983).

[2] *Boott Hydropower, Inc.*, 111 FERC ¶ 62,001 (2005).

[3] The above figures for the project's authorized installed capacity reflect corrections and changes made in 1991. *See Boott Hydropower, Inc.*, 55 FERC ¶ 62,233 (1991).

[4] Both the flooding issue and the proposal to replace flashboards with a crest control system had arisen earlier. The Commission first received a complaint about flooding in the area in December 2003. *See* letter to Skip Medford, Boott, from Mohammad Fayyad, Commission staff (Jan. 15, 2004). The Park Service had objected to Boott's two previous proposals to install an inflatable crest control system in 1999 and 2006. *See* letter to Ian Bowles, Massachusetts Executive Office of Energy & Environmental Affairs, from Michael Creasy, Lowell Park (filed June 16, 2010).

December 31, 2007, as well as information on the design failure mode of the flashboards, the frequency of failure, and its effect on upstream flooding during that period.

6. Boott filed the requested information on February 26, 2008. Based on that information, staff requested Boott to conduct a backwater analysis to determine the effect of flashboards on flooding upstream of the Pawtucket Dam along Clay Pit Brook.[5]

7. During its review of the flooding complaints, staff found a discrepancy between the flashboards as authorized and as built. The license authorized 5-foot-high collapsible flashboards on the Pawtucket Dam supported by 5-foot-high pins, set in the dam's granite capstones on 20-inch (average) centers.[6] According to Boott's February 26, 2008 filing, the flashboards then installed on the Pawtucket Dam consisted of 4 foot-high sheets of plywood laid on edge, with an additional one-foot of boards (top boards) nailed to the plywood to make up the 5 foot authorized height, and supporting pins with an effective pin height of 4.5 feet. Boott stated that the flashboards were designed to fail when overtopped by 2 feet of water, which can occur at a spill flow of 10,000 cubic feet per second (cfs) or a total river flow of 20,000 cfs if all of the Lowell Project's units are operating.

8. Staff found that the flashboards did not fail when the Merrimack River flows were in the range of 20,000 to 37,000 cfs during the months of March and April 2008, so that they did not meet their design specifications. By a May 28, 2008 letter, staff ordered Boott to remove the flashboards and provide a new design for supporting pins that would fail as originally designed.

9. In a May 30, 2008 filing, Boott proposed a flashboard system with corrective measures that included reducing the number of pins and installing longer pins, which were expected to allow the flashboards to fail properly. By a June 4, 2008 letter, staff authorized Boott to reinstall the flashboards with those measures.

10. In a July 21, 2008 filing, Boott provided details on the reinstalled flashboard system. The current design consists of steel bars supporting 8-foot-long, 5-foot-high flashboards. The bars are 5.5 feet long, are set 0.5 feet in the dam crest, and extend 5 feet to the top of the boards. The bars are spaced at an average of about 20 inches (varying

[5] *See* letter to Kevin Webb, Boott, from Mohamad Fayaad, Commission staff (April 8, 2008).

[6] The license order describes the project works as including the Pawtucket Dam with 5-foot-high collapsible flashboards. *Boott Mills*, 23 FERC at 63,067. The height, diameter, composition (mild steel), and average spacing of the pins are specified in the approved Exhibit F-6 drawing, which is part of the license. The strength of the pins is established by design calculations.

from 10 to 48 inches due to limitations with existing capstones), with no more than 6 bars per flashboard. Boott removed some of the flashboard pins to achieve this average spacing. The flashboard panels are the same as they were in the 4+1 configuration; that is, they consist of 4-foot-high by 8-foot-long sheets of ¾ inch thick plywood laid on edge, with additional 16-inch-wide ¾ inch thick plywood top boards nailed on top of the plywood sheets with 4 inches of overlap, to make up the 5-foot authorized flashboard height. The main difference is the 5-foot-long pins, which support the entire height of the flashboards. With the longer pins, the flashboard system is designed to begin to fail when overtopped by less than one foot of water.

11. On August 13, 2008, Boott filed the required backwater analysis report. Staff's review of the report found that both 4-foot-high and 5-foot-high flashboards can contribute to flooding along the Clay Pit neighborhood during high flows if the boards do not fail completely. However, the reinstalled flashboard system with the longer pins had not been in use long enough to determine if it would fail appropriately during high flows. Therefore, in a September 25, 2008 letter, staff asked Boott to discuss the results of the backwater analysis with the National Park Service (Park Service) and other stakeholders to determine options for implementing a flashboard system that can be ensured to be completely down during high flows in the Merrimack River.

12. Beginning in November 2008, Boott held a series of meetings with various stakeholders, including the City of Lowell, the Park Service, Congressional representatives, and citizens from the affected areas, to determine the spillway crest control options for the Pawtucket Dam to alleviate flooding. On September 18, 2009, Boott filed a technical assessment report evaluating what it regarded as the three most likely alternatives for spillway crest control for the Pawtucket Dam.

13. As described in the report, Option A is the flashboard system that was in use historically and until May 30, 2008 (also referred to as 4+1). The flashboards would be 4-foot-high by 8-foot long panels with one-foot top boards as described above. The pins would be 5-feet long by 1.75-inch diameter steel, set in the capstones at an average depth of approximately 0.5 feet, resulting in an effective pin height of 4.5 feet. Option B is the existing flashboard system. This is identical to Option A except that the flashboard pins are 5.5 feet long with an effective height of 5 feet, fully supporting the top of the boards. Option C is a 5-foot-high pneumatic crest gate system (a rubber membrane installed in four panels on top of the dam that can be raised and lowered mechanically by inflating it with pressurized air).

14. The report found that the pneumatic crest control system would enhance project operational control and generation and would provide significant advantages for other resources that are dependent on water levels, including flood control, recreation, and fish passage.

15. Before filing the amendment application with the Commission, the licensees consulted with federal and state resource agencies, Indian tribes, and Lowell Park.[7] The Massachusetts Division of Fisheries and Wildlife (Massachusetts DFW) in a May 14, 2010 letter strongly endorsed Boott's proposal to replace the wooden flashboards with an inflatable crest control system. In a June 23, 2010 letter, the National Marine Fisheries Service (NMFS) stated that installing the proposed crest gate system would maintain more consistent water levels, reduce water leakage from the dam, and minimize the need for impoundment drawdowns, all contributing to improved fish passage to spawning habitat. The Park Service opposed the proposal in a June 15, 2010 letter, asserting that the crest gate would substantially and adversely affect the historic appearance of the dam, and that construction of the crest gates would shut down for two or more years boat tours that it conducts on the Pawtucket Canal.

16. The licensees filed their amendment application on July 6, 2010. They request authorization to replace the existing 5-foot-high wooden flashboards on the Pawtucket Dam with a pneumatic crest control system identical in height. There would be no change in the authorized normal pool elevation of 92.2 feet mean sea level (msl) (National Geodetic Vertical Datum 1929). Also, during the interim period after the amendment is approved and before construction of the pneumatic crest control system is completed, the licensees request permission to operate the wooden flashboard system with a 4+1 configuration of 4-foot high panels with 1-foot-high top boards and 4.5-foot-high support pins (Option A). The licensees state that this configuration would allow the top 1-foot boards to collapse when overtopped by 1 foot of water, and that the remaining 4-foot-high boards would fail when overtopped by 2 feet of water.

17. On August 10, 2010, the Commission issued a Notice of Application for Amendment of License and Soliciting Comments, Motions to Intervene, and Protests. The City of Lowell, Lowell Flood Owners Group, Town of Tyngsboro, and the U.S.

[7] The licensees consulted with the following entities: U.S. Department of Agriculture, Forest Service; National Marine Fisheries Service; U.S. Fish and Wildlife Service; Lowell National Historical Park; U.S. Environmental Protection Agency, Region 1; Massachusetts Division of Fisheries and Wildlife; Massachusetts Division of Marine Fisheries; Massachusetts Department of Environmental Protection; Massachusetts Department of Conservation and Recreation; New Hampshire Department of Fish and Game; New Hampshire Department of Environmental Services; Wampanoag Tribe of Gay Head (Aquinnah) of Massachusetts; Mashpee Wampanoag Tribal Council; and Massachusetts Historical Commission.

Department of the Interior (Interior) filed motions to intervene.[8] Numerous entities filed comments.[9] Commission staff requested additional information about the amendment application on September 10, 2010, which Boott provided on October 12, 2010.

18. As discussed in more detail later in this order, those who oppose the amendment are primarily concerned with flooding issues and effects on historic properties. The City of Lowell, town of Chelmsford, Williamsburg Condo Trust, Lowell Flood Owners Group, and others expressed concerns that the proposed crest gate system would pose a greater risk of flooding to homes and properties in the floodplain along the river, including the Clay Pit Brook area. A number of federal and state agencies expressed concerns about the effect of the proposed crest gate system on the historic integrity of Pawtucket Dam, including the Park Service, Massachusetts State Historic Preservation Officer (Massachusetts SHPO), Lowell Park, and Advisory Council on Historic Preservation (Advisory Council). In particular, Lowell Park commented that three intermediate concrete piers proposed as part of the project were not visually compatible with the dam. The Massachusetts Department of Conservation and Recreation supported the amendment with recommendations for improvements to recreational opportunities.

19. In response to these latter concerns, Boott modified its proposal on March 21, 2011, to include additional measures intended to mitigate the potential effects of the proposed amendment on historic properties. Boott proposed to eliminate the intermediate piers, change the color of the inflatable bladders from black to brown, and install additional black retaining straps on the panels at 20-inch centers, stating that these changes would make the crest gate system appear more similar to the existing flashboards.

20. On April 26, 2011, Commission staff wrote to the Massachusetts SHPO, Park Service, Lowell Park, and Advisory Council, requesting comments on the proposed amendment pursuant to section 106 of the National Historic Preservation Act (NHPA). Staff found that Pawtucket Dam was not individually eligible for listing in the National Register and that installing the pneumatic crest gate would not have an adverse effect on historic properties.

21. On May 16, 2011, the Massachusetts SHPO filed a response disagreeing with Commission staff's determinations of eligibility and effect, stating that the dam was

[8] Because their motions to intervene were timely and no one filed an answer in opposition, these entities became parties to the proceeding 15 days after their motions were filed. *See* 18 C.F.R. § 385.214(c) (2012).

[9] A complete list of agencies and organizations who filed comments and their filing dates appears on page 12 of the final Environmental Assessment (EA), issued on Dec. 19, 2011. A list of individual commenters appears in Appendix A to the EA.

individually eligible and that the proposed action would adversely affect the dam's historic fabric and integrity. On May 25, 2011, Lowell Park filed a letter objecting to staff's finding of no adverse effect and disagreeing with staff's determination of the area of potential effect for the proposed amendment. On June 7, 2011, the Advisory Council filed comments for staff's consideration in the section 106 process.

22. On August 8, 2011, Commission staff requested documentation of the dam's eligibility for listing in the National Register from the Massachusetts SHPO, Park Service, and Advisory Council. On August 19, 2011, the Advisory Council informed staff that it would participate in the consultation process for the proposed amendment. On September 1, 2011, the Advisory Council requested that the Commission seek an eligibility determination for the dam from the Keeper of the National Register. The Massachusetts SHPO and the U.S. Department of the Interior on behalf of Lowell Park filed further comments in opposition to staff's determinations on September 6 and 7, 2011, respectively.

23. On September 19, 2011, Commission staff requested a determination of eligibility for Pawtucket Dam from the Keeper of the National Register. The Keeper requested photographs of the dam on October 18, 2011, which staff provided on October 20, 2011. On October 26, 2011, the Keeper of the National Register determined that Pawtucket Dam is individually eligible for listing because of its historic and engineering significance.

24. As a result of the Keeper's determination, staff found that the proposed amendment would have an adverse effect on Pawtucket Dam, because it would alter the dam's architecture. Consistent with NHPA procedures, staff prepared a draft Memorandum of Agreement (MOA) to address this adverse effect, and sent it for comment to the Advisory Council, Massachusetts SHPO, Lowell Park, and City of Lowell on December 8, 2011. Staff proposed in the MOA that Boott be required to develop two interpretive exhibits at the project, one with a replica of a portion of the original flashboard system and one with the new crest gate system, to enhance visitors' understanding of the history of the dam and the Lowell Project. To mimic the existing dam's appearance, the MOA would require that Boott use a brown-colored bladder, paint the downstream side of the crest gate panels brown, and install black retaining straps at an average of 20 inches on center. The MOA would also require that Boott design and construct the compressor house associated with the crest gate with materials that are compatible with the historic fabric of the adjacent architecture, to ensure that the building resembles the nearby Northern Canal Gatehouse and other nineteenth century buildings in Lowell.

25. Meanwhile, Commission staff had issued a draft Environmental Assessment (EA) on June 10, 2011, finding that approval of the licensees' proposal would have long-term beneficial effects for recreational resources, fish passage efficiency, and controlling water

levels. Staff issued a final EA, which addressed numerous comments made on the draft EA, on December 19, 2011. The EA stated:

> The licensee's proposed pneumatic crest gate system would reduce upstream backwater and flooding effects associated with the operation of the project by allowing the crest of the proposed system to be lowered in anticipation of and during high flows and flooding events. As compared to the wooden flashboard system and the interim modification, the proposed pneumatic crest gate system would maintain more stable water level elevations at 92.2 feet during normal operations.
>
> The proposed pneumatic crest gate system likely would reduce the false attraction for upstream migrating fish by reducing the amount of leakage from the dam and would improve upstream passage efficiencies. Resident fish upstream of the project would benefit from the reduced frequency of sudden and extended drawdowns because the river would behave more like an unregulated river and nearshore spawning and nursery habitat would remain submerged.
>
> . . . .
>
> The crest gate system would modify a dam that has undergone numerous modifications since its original construction. The alteration, however, would not adversely affect the qualities of the historic district, of which the dam is a part, that make the district eligible for the National Register of Historic Places. The licensee's proposal to construct two exhibits, one of wooden flashboards that would replicate the historic flashboard system and one of the crest gate system, at a location suitable for viewing by Lowell National Historic Park visitors and area residents alike, would ensure that the visiting public can see how the dam looked and operated prior to the installation of the crest gate system.[10]

26. Staff recommended approval of Boott's proposed amendment, with staff-recommended changes and additional measures, including an erosion and soil control plan; consultation with the Park Service regarding the staging area locations (including barge use), site restoration, and construction schedule; signs to inform the public about the need for the construction; access for tours below the dam, if safety permits, and a gate and access point for these tours; coordination with the tenant at the gatekeeper's house to minimize disruption; and a debris monitoring and removal plan.

[10] EA at vii-viii.

27. After issuing the final EA, staff continued to attempt to resolve historic preservation issues with the consulting parties. In response to staff's December 8, 2011 letter transmitting the draft MOA, Lowell Park issued a letter on December 13, 2011, declining to participate in the proposed MOA, because the proposed alterations would substantially and adversely change the historical appearance and functionality of the dam as a National Historic Landmark. On January 5, 2012, the Advisory Council informed Commission staff that, given Lowell Park's position, pursuing development of an MOA was not appropriate. That same day, the Massachusetts Historical Commission (which includes the Massachusetts SHPO) informed staff that, because of Lowell Park's comments, it was concerned that the proposed MOA would be inconsistent with applicable federal law and regulations.[11]

28. On February 2, 2012, Boott filed a letter proposing additional measures to mitigate the adverse effects of installing the pneumatic crest system on Pawtucket Dam. Boott proposed an alternative way to install the crest gates that would eliminate the fixed steel piers and avoid the need to cover the dam capstones with concrete, thus avoiding irreversible changes to the dam. Boott stated that this method would also allow the work to be done without lowering the impoundment, thus avoiding adverse effects on the Lowell Park's boating program.

29. By letter dated February 7, 2012, the Advisory Council informed Commission staff, among other things, that Boott's February 2, 2012 letter presented an alternative for installing the crest gates that had not yet been considered and that might serve as the basis for further consultation on alternatives. By letter dated February 15, 2012, Interior filed comments concurring in the Advisory Council's comments. Interior suggested that Boott's revised proposal might warrant further consideration, and stated that the Park Service would be willing to consult concerning a range of possible alternatives to avoid or minimize impacts to historic properties.

30. On March 22, 2012, staff responded to the Advisory Council's letter with copies to the Massachusetts SHPO, Lowell Park, and Interior's Office of the Solicitor. Staff also outlined its view that the proposed action could proceed without adversely affecting the historic district and Lowell Park. Staff addressed arguments regarding whether a supplement to the EA would be required and whether the legislation establishing Lowell Park would prohibit the Commission from approving the proposed amendment. Staff explained that, to date, no one had suggested any alternatives to the crest gate system that would mitigate the backwatering effects of the dam during high water conditions to the maximum extent possible, and would protect the long-term integrity of the dam by

[11] Based on these letters, Commission staff initially determined by letter dated January 19, 2012, that further consultation would not be productive, but then continued consulting based on Boott's February 2, 2012 proposal.

eliminating damage to the capstones caused by the existing flashboard pins. Staff stated that it would consult further on Boott's revised proposal if all parties agreed that there was a reasonable basis for doing so, and requested the parties' comments on whether there was any basis for further consultation on proposed changes to the Lowell Hydroelectric Project.

31. On April 19, 2012, Interior responded that it and the Park Service were willing to consult further based on Boott's new proposal. Interior offered to convene a consultation meeting in Lowell, Massachusetts for Commission staff, Boott, the Massachusetts SHPO, and the Advisory Council to meet with Park Service staff to consult concerning the applicant's revised design. By letter dated April 24, 2012, the Advisory Council reiterated its view that Boott's revised design proposal might serve as the basis for continuing consultation and indicated its support for the proposed consultation meeting. That same day, the Massachusetts SHPO sent a letter agreeing that a consultation meeting would be productive.[12]

32. On May 24, 2012, the consulting parties participated in a section 106 consultation meeting in Lowell to discuss options and provide an opportunity for Boott to answer any technical questions about the proposals. At the meeting, Boott described the benefits of the crest gate system and discussed details of its proposed installation techniques and mitigation measures, and responded to questions from Park Service staff. At the meeting's end, Boott and the Park Service agreed to meet again to resolve outstanding issues and explore several other alternatives that participants had suggested at the meeting.

33. Boott and the Park Service met on July 26, 2012, to discuss design issues and mitigation, as well as a hybrid system of part flashboards and part inflatable crest gates. As discussed in their subsequent letters to Commission staff, they did not resolve the issues at that meeting and did not schedule any further meetings.

34. On October 11, 2012, Commission staff requested that the consulting parties provide a written progress report on consultation and a schedule of any further meetings to resolve outstanding issues. On October 18, 2012, the Park Service provided a summary of the July 26 meeting and stated that in the interest of a final attempt at settlement, it would be willing to accept a hybrid system that would allow crest gates on

[12] Only the City of Lowell disagreed, stating in a letter dated April 25, 2012, that it was unable to concur with any proposed MOA unless Boott agreed to follow certain restrictions regarding the use of flashboards on Pawtucket Dam, as set forth in a 1980 agreement regarding flashboard operation (the Wang Agreement). We discuss the Wang Agreement below in connection with Boott's request for interim modifications to the flashboard system while the crest gate system is being constructed.

about 40 percent of the dam beyond the fish ladder and would retain flashboards on the rest of the dam. The Park Service added that mitigation would have to include restoring the historic individual flashboard system and discontinuing the use of plywood in that area of the dam.

35. On October 31, 2012, Boott filed its response, stating that the Park Service's summary was generally accurate but incomplete. Boott added that it could not support the Park Service's preferred alternative because the hybrid system would not fully attenuate typical spring run-off flows.

36. The Park Service responded on December 3, 2012, stating that Boott had rejected the Park Service's proposals and had proposed no new alternatives. The Park Service stated that it and others continued to question the effectiveness of the crest gate system to accomplish flood mitigation. The Park Service also reiterated its view that the crest gate system was not justified against the loss of essential features of the National Historic Landmark dam, and that the Commission could not approve the amendment without violating the legislation establishing Lowell Park.

37. By letter dated December 28, 2012, the Advisory Council provided comments on a number of issues raised in the parties' letters concerning the status of consultation. Among other things, the Advisory Council stated that it remained unconvinced that there are no viable alternatives to replacing the flashboards with a crest gate system across the entire dam. The Council requested that the Commission work with the applicant to consider alternatives or modifications that would minimize adverse effects to historic properties.

38. On January 8, 2013, Commission staff determined that despite numerous attempts to resolve differences among the consulting parties, including renewed efforts to consider alternatives during the past year, participants had failed to identify any viable alternatives or mitigation for the proposal that would be acceptable to all parties. As a result, staff found that further consultation would not be productive and provided notice to the Advisory Council that it was terminating consultation.[13] Staff requested that the Advisory Council provide its comments within 45 days, as provided in the Council's regulations.

39. By letter dated February 4, 2013, Boott provided comments in response to the Advisory Council's December 28, 2012 letter, explaining areas of disagreement with the Park Service and outlining limitations of the various alternatives considered. Boott stated that it supported Commission staff's decision to terminate consultation.

[13] This is the appropriate procedure under the Advisory Council's regulations. *See* 36 C.F.R. Part 800 (2012).

40. On February 5, 2013, the Advisory Council held a site visit and public meeting in Lowell and received comments from consulting parties, public officials, organizations, and members of the public. Commission staff and Boott provided comments for the record dated February 4 and 5, respectively.

41. On February 15, 2013, the National Trust for Historic Preservation (National Trust) filed comments in response to Commission staff's January 8, 2013 letter terminating consultation. On February 26, 2013, the Advisory Council filed its final comments on the proposed amendment. That same day, Interior also filed comments.

42. Since then, participants have continued to file comments regarding the proposed amendment. On March 4, 2013, Professor Patrick Malone of Brown University filed a copy of a letter he wrote to the Advisory Council, expressing his objections to the proposal. On March 11, 2013, John Kurland, Chairman of the Chelmsford Board of Selectmen, filed a letter in support of the Advisory Council's comments and expressing concerns about the effects of flooding on the Williamsburg Condominiums upstream, in the Town of Chelmsford. On March 15, 2013, Jean Whiting, a resident of the Condominiums, expressed similar concerns. That same day, Interior's Office of the Secretary reiterated the department's concerns about adverse effects on the Historic District, Lowell Park, and the Preservation District, and attached a May 2012 article about the history of Pawtucket Dam published in Industrial Archaeology Review, written by Professor Malone.

43. We have carefully considered all of the comments filed in this proceeding. We address the Advisory Council's comments in detail below, together with related comments of the National Trust and Interior, in the section of this order on historic resources. We also address the flooding issue, as well as the effects of the amendment on other resources, such as fisheries, dam and worker safety, and recreation.

Water Quality Certification

44. Under section 401(a)(1) of the Clean Water Act (CWA), the Commission may not authorize a license amendment for an activity that may result in a discharge at a hydroelectric project unless the state water quality certifying agency either has issued water quality certification for the proposed amendment or has waived certification by failing to act on a request for certification within a reasonable period of time, not to exceed one year. Section 401(d) of the CWA provides that the certification shall become a condition of any federal license that authorizes construction or operation of the project.

45. By letter dated September 30, 2011, staff requested that Boott submit documentation that it had applied for water quality certification from the Massachusetts Department of Environmental Protection (Massachusetts DEP), or documentation that the Massachusetts DEP had waived certification for this amendment. On October 6, 2011, Boott filed documentation indicating that the Massachusetts DEP waived water quality certification.

Threatened and Endangered Species

46. Section 7 of the Endangered Species Act requires federal agencies to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of their critical habitat. There are no known federally listed threatened or endangered species or critical habitat for listed species in the project area.

Project Economics

47. The licensees' proposal to install an inflatable crest gate system has an estimated capital cost of $5,980,000. This capital cost results in an average, annualized cost of $956,000.[14] We estimate that the annual cost to operate the system would be minimal.

48. Operation of an inflatable crest gate system instead of flashboards could enable the project to generate more power, because the gates could be reinflated relatively soon after high flows. In contrast, the flashboards would be washed out for an estimated three months. The licensees estimate that project operation with the inflatable crest gates would result in an increase in annual generation of approximately 8,000 megwatt hours (MWh). Using a regional estimated alternative energy value of $38.74/MWh, as determined from the Energy Information Administration, Annual Energy Outlook for 2012, this additional generation would be valued at $310,000 annually. Therefore, the net cost of the licensee's proposed action, including total capital costs and generation benefits, would be approximately $646,000 annually.

49. Although our analysis shows that the cost of installing the crest gates would exceed the value of the increased generation, it is the applicant who must decide whether to accept this license amendment and any financial risk that entails.

Design and Operation of the Proposed Crest Gate System

A. Crest Gate Design

50. The purpose of flashboards is to increase the height of the dam, thus increasing head to allow more generation than what would be possible without flashboards. However, if flashboards are too rigid they can aggravate flooding during high river flows. Therefore, they are designed to fail when overtopped by a sufficient amount of water. If the flashboards fail prematurely, valuable generation is lost, but if they remain up when the pool rises above the specified failure elevation, they can exacerbate flooding. Although flashboards can be designed to fail at a specified elevation, their actual

[14] Capital cost was annualized over a 10-year period, which is the remaining term of the project license, using an interest rate of 6 percent.

performance during high flows is uncertain. An inflatable crest gate system is mechanically controlled, can be programmed to deflate when a particular flow is reached, and can quickly be raised or lowered, as conditions dictate. For this reason, a crest gate system provides the most reliable and complete attenuation of the backwater effect that results from high flows. It is the preferred technology where there is a need for precise control of reservoir elevations and the licensee can afford the cost.

51. In addition, in order to replace flashboards, the licensee must draw down the reservoir or wait for water levels to recede sufficiently. Workers must approach the dam in boats, often during high flow periods, a relatively dangerous operation. An inflatable crest gate can be controlled remotely, with no worker risk.

52. The pneumatic crest control system that Boott proposes to install on the Pawtucket Dam consists of four independently-controllable zones. Each zone would contain multiple 20-ft-long hinged steel panel sections supported on the downstream side by tubular rubber air bladders. Restraining straps attached to each gate panel would prevent the panels from being raised more than 5 feet above the dam crest, thereby ensuring that the pool elevation would be maintained at the authorized elevation of 92.2 feet when the gates are fully raised.

53. The crest gate system that Boott originally proposed in the amendment application would require several modifications to the Pawtucket Dam. They consist of: (a) placing a concrete cap on top of the sloping granite capstones on the upstream face of the dam to provide a smooth and level surface for mounting and anchoring the crest gate system; (b) constructing three 5-foot-high piers at each major angle in dam alignment to provide a flat perpendicular bearing surface for adjoining panels; and (c) constructing end blocks at the dam's abutments to connect the crest gate with the curved wall of the Northern Canal gatehouse and fish ladder. Additionally, Boott would construct a new structure to house the air compressors that inflate and deflate the crest gate bladder system.

54. To address the Park Service's concerns that the proposed crest gate system would alter the historic character and appearance of the Pawtucket Dam, Boott proposed in a March 21, 2011 filing to modify the crest gate system by: (a) eliminating the intermediate piers and thereby preserving the unobstructed alignment of the dam crest and also achieving the same spillway discharge capacity as the wooden flashboard system; (b) painting the downstream side of the crest gate panels brown instead of black; and (c) installing black retaining straps on the panels at 20-inch centers.

55. To further address Park Service concerns, in a February 2, 2012 filing Boott proposed an alternative process for installing the crest gate system that would not require large volumes of concrete or other materials to be irreversibly installed on the Pawtucket Dam. The crest gate system would be attached to a steel crest anchorage assembly, which in turn would be attached by rock anchors through the dam and into the underlying

bedrock. This installation method would avoid pouring a concrete slab on top of the uneven dam capstones.

B. Crest Gate Operation and Effects on Impoundment Levels and Flooding

56. Under the proposed pneumatic crest gate system, the objectives for operating the project would remain the same as they have been under the wooden flashboard system. The pneumatic crest gate system would operate with a Programmable Logic Controller that would work in conjunction with the powerhouse automatic pond level control system to maintain a consistent impoundment elevation, which cannot be achieved with flashboards. The position of the crest gate system could vary with varying river flows, as shown in Figure 1 below.

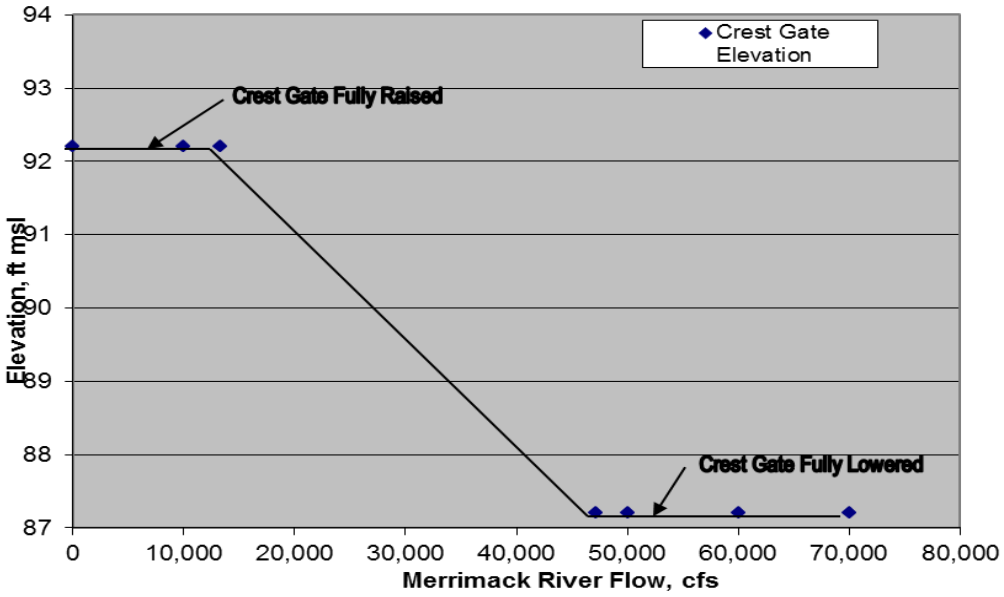

Figure 1. Lowell Hydroelectric Project Operation of Pneumatic Crest Gate System

57. Under the proposed crest gate system, for river flows up to 10,000 cfs (the maximum hydraulic capacity of the project units), the crest gate system elevation and the impoundment elevation would be at 92.2 feet msl. As the river flow increases from 10,000 cfs to 13,250 cfs, the crest gate would remain at elevation 92.2 ft msl, while the pond elevation would gradually rise to elevation 93.2 ft msl. As the river flow continues to rise above 13,250 cfs, the pond elevation would be maintained at 93.2 ft msl by lowering the crest gate and when the river flow reaches 47,200 cfs, the crest gates would be completely deflated down to elevation 87.7 ft msl, which is the top of Pawtucket Dam. As noted, the position of the crest gate system could vary with varying river flows. In

order to determine the exact position of the crest gate with varying river flows, ordering paragraph (G) requires the licensee to file a detailed plan for the operation of the crest gate system with specific details on the position of the crest gate system with varying river flows.

58. Many local residents have opposed the crest gate system, in part because of historic preservation concerns but primarily because of concerns about the dam's backwater effects and flooding. Many of these residents believe that the crest gate system will allow the licensees to maintain consistently higher reservoir levels that will exacerbate flooding.

59. Based on the backwater analysis, at river flows of about 50,000 cfs the projected impoundment levels with the proposed crest gate system would be about one-half foot lower than the levels that would occur with the wooden flashboard system in place. However, during major flood events such as those that occurred in 2006 and 2007, when river flows were in the range of about 86,000 to 93,000 cfs, there would be no significant difference in flood levels along the Clay Pit Brook area between the two systems. This is due to spillway submergence (i.e., where tailwater elevation and headwater elevation are equal) caused by backwater from the rocky bed below the dam, channel restrictions, and the School Street bridge piers, which are located in the river.

60. By letter dated September 9, 2010, staff requested that Boott provide an updated backwater analysis based on the proposed design change and operation, to show the potential impacts on flooding along the Clay Pit Brook neighborhood under different flow conditions. Boott examined the effect of various combinations of unbent flashboard configurations and the proposed crest gate system and river flows on flooding along the Clay Pit Brook neighborhood. The study used unbent flashboards as a worst case, as partially bent flashboards would reduce the backwater effect by allowing more water to pass over and through the partially bent boards. The study showed that the Pawtucket Dam impoundment elevation has only a minor effect on flooding in the Clay Pit Brook neighborhood, and flooding is caused primarily by flows in Clay Pit Brook and limitations on flow through the culverts.

61. As shown in the table below, water levels (msl) along the Clay Pit Brook neighborhood during 100-year flows in the brook would be considerably lower with the proposed crest gate system in place as compared to unbent 5-foot high flashboards.

Table 1. Comparison of water levels at various locations with flashboards and with proposed crest gate system.

Location	Water Surface Control Method	Merrimack River Flow, cfs				
		20,000	30,000	40,000	50,000	60,000
Pawtucket Dam Spillway	Unbent 5-ft High Flash Boards	94.3	95.5	96.5	97.3	98.0
	Proposed Crest Gate System	93.2	93.2	93.2	93.4	94.2
	Difference	**-1.1**	**-2.3**	**-3.3**	**-3.9**	**-3.8**
Confluence of Merrimack River & Clay Pit Brook	Unbent 5-ft High Flash Boards	94.3	95.6	96.6	97.5	98.3
	Proposed Crest Gate System	93.2	93.3	93.4	93.7	94.6
	Difference	**-1.1**	**-2.3**	**-3.2**	**-3.8**	**-3.7**
Upstream of Magnolia Avenue	Unbent 5-ft High Flash Boards	94.5	95.8	96.8	97.6	98.4
	Proposed Crest Gate System	93.7	93.6	93.7	93.9	94.8
	Difference	**-0.8**	**-2.2**	**-3.1**	**-3.7**	**-3.6**
Upstream of Dunbar Avenue	Unbent 5-ft High Flash Boards	94.7	95.9	96.9	97.7	98.4
	Proposed Crest Gate System	93.7	93.7	93.8	94.1	94.9
	Difference	**-1.0**	**-2.2**	**-3.1**	**-3.6**	**-3.5**
Upstream of Lexington Avenue	Unbent 5-ft High Flash Boards	95.0	96.1	97.1	97.9	98.5
	Proposed Crest Gate System	94.3	94.3	94.4	94.5	95.2
	Difference	**-0.7**	**-1.8**	**-2.7**	**-3.4**	**-3.3**
Upstream of Townsend Avenue	Unbent 5-ft High Flash Boards	95.4	96.4	97.3	98.0	98.6
	Proposed Crest Gate System	95.0	95.0	95.1	95.1	95.6
	Difference	**-0.4**	**-1.4**	**-2.2**	**-2.9**	**-3**

62. The proposed pneumatic crest gate system would reduce impoundment levels during high flow events but would allow the level to remain at the authorized normal pool elevation of 92.2 feet msl during normal flow conditions; it would avoid the drawdowns needed for replacing wooden flashboards. Maintaining a consistent impoundment level would benefit two utilities that use the impoundment as a source for water supply, the Pennichuck Water Works and Lowell Regional Water Utility.

63. Operation of the pneumatic crest gates would likely attenuate flooding as compared to the wooden flashboard system. Even if they are designed to fail under specific criteria, flashboard systems under actual conditions are uncontrollable, react unpredictably under water pressure, and may not fail as designed. It is difficult to design and construct an uncontrolled flashboard system that will collapse at once. More than likely, flashboard systems will fail locally at a weaker section. This relieves some of the pressure across the dam and can require a greater load or higher reservoir elevation before the remainder of the system fails.

64. In contrast, a pneumatic crest gate system can be controlled by a human operator or a computer. Sensors can be installed in the reservoir and when the water reaches a pre-defined level, air can be released from the bladders to lower the gates and keep the water level from going any higher, within a specific flood band. Once the flood event has passed, the bladders can be re-inflated to bring the water levels back to what they were before the flood event. This can be accomplished safely, and soon after the flood. The hydro operator does not need to draw down the reservoir or wait until flows in the river are low enough to allow workers to safely replace the flashboards. Because the water level returns to normal more quickly, this benefits the reservoir's use for water supply, recreation, and fish passage.

65. The Williamsburg Condominium Association (Association) has also expressed concerns about increased flood zones and associated insurance costs, erosion of the river bank that occurred during the 2006 and 2007 floods, and the increase in erosion that they believe will occur as a result of heightened water levels with the proposed crest gate system.[15] The Association states that, since its inception in 1984, its community has never experienced flooding until the 2006 and 2007 floods. The Association adds that, after the floods in June 2010, the Federal Emergency Management Agency (FEMA) issued new flood maps, resulting in increased costs for flood insurance.

66. The two floods that occurred in 2006 and 2007 were 100-year magnitude floods; that is, they had a one per cent chance of occurring each year. Any erosion that occurred was not due to operation of the Pawtucket Dam with flashboards. Rather, it occurred because of the magnitude of the flows.

67. Under the proposed crest gate system, for river flows up to 10,000 cfs, both the crest gate system elevation and the impoundment elevation would be at 92.2 feet msl, which is the same as under the flashboard system. As the river flow increases from 10,000 cfs to 13,250 cfs, the crest gate would remain at elevation 92.2 ft msl, while the water surface elevation would gradually rise to elevation 93.2 ft msl, the elevation at which the flashboards were designed to fail. As the river flow continues to rise above 13,250 cfs, the pond elevation would not rise above 93.2 ft msl, because the licensees would be required to begin to lower the crest. When the river flow reaches 47,200 cfs, the crest gates would be required to be completely deflated down to elevation 87.7 ft msl, at the crest of Pawtucket Dam. Accordingly, the licensee would not be permitted to raise the water levels with the proposed crest gate system, as the Association alleges.

68. FEMA administers the National Flood Insurance Program. FEMA periodically reviews flood zones, especially after large floods, and revises them as needed. Based on

[15] *See* Letter from Williamsburg Condominium Association I to Kimberly Bose, Commission Secretary (filed July 10, 2011).

the 2006 and 2007 floods, FEMA revised the flood zone maps for the area. Any increases in flood insurance premiums were thus caused by the magnitude of the 2006 and 2007 floods, and are not attributable to the Lowell Hydroelectric Project or the licensees' operation of Pawtucket Dam.

C. Interim Operation and the Wang Agreement

69. The City of Lowell and some area residents have raised concerns in this proceeding about the licensees' compliance with a 1980 agreement between Proprietors of Locks and Canals on Merrimack River (the original owner of the Pawtucket Dam) and Wang Laboratories, which formerly owned land and facilities upstream of the dam. This is commonly referred to as the Wang Agreement.[16] The agreement provides that flashboards on the dam will not be maintained above a height of 4 feet from March through June of each year and will be no higher than 5 feet for the rest of the year.

70. The Wang Agreement is not a part of the license and Boott is not a party to it.[17] Boott has asserted, however, that the historically used variable height 4+1 flashboard system with 4.5-foot high pins "materially complies" with the intent of the Wang Agreement.[18] Boott's technical assessment indicates that the historical system typically required that the reservoir be drawn down to replace the flashboards 2-3 times annually, as compared to the currently installed flashboard system with 5-foot pins, which typically requires a drawdown for flashboard replacement 4-5 times annually. Boott's assessment also found that the historic system allowed the project to generate more power, because the flashboards failed less frequently than the existing flashboards.[19] Boott states that although the crest gate system is the only option that could literally meet the terms of the Wang agreement, many participants questioned its reliability and preferred the historical 4+1 flashboards, at least for the near term.[20]

[16] *See* Attachment A to Opposition of the City of Lowell (filed Sept. 10, 2010).

[17] The City of Lowell was unsuccessful in its attempt to enforce the agreement against Boott. In response to the city's complaint, the U.S. District Court for the District of Massachusetts issued an order on March 8, 2011, dismissing the complaint and holding that the Wang Agreement is preempted by the FERC license and the FPA. *See* attachment to letter from Kevin Webb, Boott, to Commission Secretary (filed May 4, 2011).

[18] *See* Boott's Technical Assessment of Spillway Crest Control Alternatives for the Pawtucket Dam at 11 (filed Sept. 18, 2008).

[19] *Id.* at 5.

[20] *Id.* at 5, 12.

71. For these reasons, the licensees request that the Commission allow them to temporarily reinstall the historic 4+1 flashboards with 4.5 feet high pins during the interim period between approval of the amendment and completion of the pneumatic crest gate system. The licensees state that this temporary change will minimize impacts to upstream land owners and the Park Service's summer boat tours, while optimally maintaining a normal head pond elevation to benefit natural river resources and water safety during construction.

72. When staff found that the historically used flashboard system did not fail during the months of March and April 2008 with river flows in the range of 20,000 cfs to 37,000 cfs, staff ordered the licensees to submit a revised design that would allow the flashboards to fail as designed. In 2009, after the licensees changed the flashboard design, the flashboards failed five times during the period from May through October. Therefore, we now know the failure frequency of the post-2008 flashboards with support pins of 5 feet exposed. We do not know the failure frequency of the pre-2008 flashboards with support pins of 4.5 feet exposed. Given this uncertainty, we deny the licensees' request to modify the flashboards on an interim basis while the crest gate system is constructed. Accordingly, ordering paragraph (J) requires that the licensees maintain the flashboard configuration that has been in place since July 2008.

Historic Preservation

A. Historic Properties and Applicable Statutes

73. Pawtucket Dam is a masonry dam that was built in sections in 1847 and 1875 and replaced the earlier masonry and wood dams of 1826 and 1833. The foundation of the dam consists of granite blocks laid in a trench. The face of the dam is constructed of quarry-faced granite blocks, and the interior is granite rubble set in hydraulic cement. A fishway was built adjacent to the dam in 1921; this fishway was later reconstructed in 1985-1986 and expanded to include a fish ladder. According to Lowell Park, the dam was fitted with 2-foot flashboards in 1838; these were extended to 3 feet in 1883 and to 5 feet in 1896.[21]

74. Pawtucket Dam is listed as a contributing element of the Lowell Locks and Canals Historic District (Historic District). The Historic District was listed in the National Register of Historic Places on August 13, 1976. The Historic District was listed as a National Historic Landmark on December 22, 1977. The dam is also located within the boundaries of the Lowell National Historical Park (Lowell Park) and the adjacent Lowell Historic Preservation District (Preservation District). Lowell Park was authorized by

[21] *See* Letter from Michael Creasy, Lowell Park, to Ian Bowles, Massachusetts Executive Office of Energy and Environmental Affairs (filed June 16, 2010).

Congress on June 5, 1978. Lowell Park was listed in the National Register on October 18, 1985, and the Preservation District was listed in the National Register on January 19, 2001.[22]

75. There are two historic preservation statutes that apply to this proposed action. One is the National Historic Preservation Act of 1966 (NHPA).[23] The other is the Lowell Act, which established the Lowell Park and Preservation District in 1978.[24]

76. Under section 106 of the NHPA, the Commission must take into account the effects of its actions on historic properties and must afford the Advisory Council a reasonable opportunity to comment on the proposal.[25] Under section 110(f) of the NHPA, the Commission must to the maximum extent possible undertake such actions as may be necessary to minimize harm to a National Historic Landmark.[26] Under the Lowell Act, the Commission may not issue a license or permit to conduct an activity within the park or preservation district unless it determines that the proposed activity will be conducted in a manner consistent with the standards and criteria established pursuant to that act and will not have an adverse effect on the resources of the park or preservation district.

B. The Advisory Council's Comments and Our Response

77. The Advisory Council's regulations implementing section 106 of the NHPA generally require a federal agency to consult with the SHPO to determine the area of potential effect for a proposed action and to apply the criteria of effect. The Advisory Council may elect to participate in the consultation and has done so in this case. If the federal agency determines that the proposed action will have an adverse effect on historic properties, the parties should consult to seek ways to avoid, minimize, or mitigate the adverse effect and enter into a Memorandum of Agreement if possible. The goal is to seek agreement on how to resolve adverse effects. However, agreement is not always possible, and the NHPA does not require that all adverse effects be avoided or mitigated. If the parties are unable to reach an agreement on how to resolve adverse effects, the federal agency may find that further consultation would not be productive and may

[22] *See* Determination of Eligibility Notification, Park Service, at 1 (filed Oct. 26, 2011).

[23] 16 U.S.C. § 470 (2006).

[24] 16 U.S.C.§ 410cc (2006).

[25] 16 U.S.C. § 470f (2006).

[26] 16 U.S.C. § 470h-2(f) (2006).

terminate consultation. The agency must then request the Advisory Council's comments and must take them into account in reaching a final decision on the proposed action.[27]

78. Under section 110(l) of the NHPA, if an undertaking will adversely affect a historic property and the federal agency has not entered into an agreement, the head of the agency must document the agency's decision and may not delegate this responsibility.[28] Under section 800.7(c)(4) of the Advisory Council's regulations, the agency head must prepare a summary of the decision that contains the rationale and evidence that the agency considered the Advisory Council's comments, and must provide it to the Advisory Council before approving the proposal.[29] We are unable to comply with this latter requirement to provide our rationale and response to the Advisory Council before issuing our decision. Under section 3c.2 of our regulations, the nature and timing of any proposed Commission action are confidential and may not be disclosed to anyone outside the Commission. For this reason, we provide in this order the rationale for our decision and evidence that we have considered the Advisory Council's comments. We also address Interior's and the National Trust's comments as they relate to those of the Advisory Council.

79. The Advisory Council's comments set forth a number of findings, as well as project specific recommendations and agency recommendations. The Advisory Council recommends that the Commission not approve the proposal to replace the existing flashboard system with a crest gate system. Interior and the National Trust concur in that recommendation. Although the Advisory Council, Interior, and the National Trust find fault with some aspects of the section 106 consultation process, they do not argue that the Commission has violated section 106 of the NHPA. They argue that the Commission has failed to minimize harm to a National Historic Landmark to the maximum extent possible, as required by section 110(f) of the NHPA. They also argue that the Lowell Act precludes the Commission from approving the proposed license amendment. We address these arguments in turn.

1. Importance of the Historic Properties Affected

80. The Advisory Council finds that the historic properties affected by the proposed action are extremely significant and unique. The Council states that Pawtucket Dam is a nationally significant historic engineering resource listed on the National Register and designated as a National Historic Landmark within the Historic District. The Historic District is nationally significant as it represents one of America's first great industrial

[27] *See* 36 C.F.R. Part 800 (2012).

[28] 16 U.S.C. § 470h-2(l) (2006).

[29] 36 C.F.R. § 800.7(c)(4) (2012).

cities and encompasses the most historically significant extant aggregation of early 19th century industrial structures and artifacts in the United States. The Advisory Council adds that Pawtucket Dam is included as a nationally significant structure in the Lowell Preservation District and the Park Service's list of classified structures for Lowell Park, both of which are listed on the National Register. The Advisory Council states that Pawtucket Dam is accordingly an element of Lowell Park. The Advisory Council also points out that the Keeper of the National Register found that the dam is eligible for and listed in the National Register for its historic and engineering significance under Criteria A and C as a contributing structure in the nationally significant Historic District and that no distinction is made between properties determined individually eligible for the National Register and those determined eligible as contributing to a historic district. The Council quotes the Keeper's admonition that the dam should not be evaluated individually apart from its functioning as a highly significant and integral component of a larger nationally important historic district.

81. We acknowledge and appreciate the national significance of the historic properties at issue. However, Pawtucket Dam is an essential part of a licensed, operating hydroelectric project. Because the Lowell Hydroelectric Project is located on the navigable Merrimack River, the FPA requires that Boott may not continue to operate the project to generate hydroelectric power except in accordance with its Commission-issued license.[30]

82. When the Commission licensed the project in 1983, the adverse effect of adding a modern fishway structure could not be avoided but was adequately mitigated by recording the dam's historic and engineering characteristics, together with other measures that allowed the Commission to conclude that the proposed project would result in no adverse effect on the Historic District.[31] The same approach is warranted here, particularly in light of the fact that the dam has been modified to accommodate a modern fishway and its historic and engineering characteristics have been fully documented. The obligation to operate and maintain the project in compliance with a Commission license necessarily requires recognition of the Commission's authority to specify the terms of the project's continued operation.

83. We appreciate the value of historic preservation. This is one of the public interest factors that we are required to consider under the FPA. However, we cannot elevate historic preservation above all other considerations, but must strike an appropriate balance among competing resource needs. While the dam is currently safe, continued use of a flashboard system presents a risk of increased damage to the granite capstones over

[30] *See* section 23(b)(1) of the FPA, 16 U.S.C. § 817(1) (2006).

[31] *See Boott Mills*, 23 FERC at 63,063.

time, and replacing all or a major portion of the capstones is prohibitively expensive. In addition, flooding is a concern, and only the crest gate system can fully attenuate higher spring flows that typically occur in the Merrimack River. The leaking flashboards and extended drawdowns of the reservoir can present problems for fish passage, and both NMFS and the Massachusetts DFW support the crest gate system because it will improve fish passage. Eliminating the need to replace the flashboards multiple times each year after they have failed will result in more safe conditions for workers. Maintaining a more consistent reservoir elevation will allow the project to generate more clean energy. It will also benefit recreation, fish and wildlife resources, and those who use the reservoir as a source of water supply. In short, the crest gate system represents the best balance of resources in the public interest under the FPA, and we do not believe that historic preservation concerns should prevent us from authorizing it in this case.

2. Effects on Pawtucket Dam and the Historic Districts

84. The Advisory Council finds that the proposed action will have an adverse effect on Pawtucket Dam and the historic districts to which it is a contributing element. The Advisory Council states that the proposed permanent removal of the flashboard system, installation of a pneumatic crest gate, and alteration of the granite dam to accommodate the crest gate system will substantially and irreversibly change the historical appearance, historic fabric, physical form, and functionality of Pawtucket Dam.

85. The Advisory Council notes that under its regulations, an adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify it for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association.[32] The Council adds that adverse effects can include: (1) physical destruction of or damage to all or part of the property; (2) alteration of a property, including restoration, rehabilitation, repair, maintenance, or stabilization, that is not consistent with the Secretary's standards for treatment of historic properties and applicable guidelines; (3) change of the character of the property's use or physical features within the property's setting that contribute to its historic significance; and (4) introduction of visual, atmospheric, or audible elements that diminish the integrity of the property's significant historic features. The Council states that the proposed alteration of the dam from installing the crest gate system would result in direct adverse effects in all of the cited examples.

86. Flashboards are not an integral part of a dam. Rather, they are a temporary crest control structure placed on the top of a dam to increase the reservoir level and thus allow increased generation. They are designed to fail under the pressure of high flows to allow

[32] 36 C.F.R. § 800.5(a)(1) (2012).

the flows to safely pass over the crest of the dam. Replacing the flashboards on Pawtucket Dam with a pneumatic crest control system would not alter or destroy all or part of the dam, would not change the character of the dam's use, and would not introduce visual or audible elements that would diminish the integrity of the dam's significant historic features. For this reason, Commission staff initially found that replacing the flashboards on Pawtucket Dam with a pneumatic crest control system would not adversely affect the dam.

87. In response to the SHPO's objection to staff's finding, as well as the Keeper's determination that the dam was individually eligible for listing in the National Register because of its historic and engineering significance, staff changed its determination and found that installing the pneumatic crest gate system would adversely affect the dam because it would alter the dam's architecture. Staff nevertheless found that the proposed measures were adequate to mitigate this adverse effect. We agree that these mitigation measures are adequate.

88. The Advisory Council argues that the historic design of Pawtucket Dam includes the flashboard system and that the adverse effect of installing a pneumatic crest gate system cannot be adequately mitigated. The Council states that the historic flashboard system encourages passive and informal water control, whereas the crest gate system would significantly change the character of the dam by establishing it as a mechanically controlled structure, drastically altering the dam's view corridors, destroying its historic functionality, eliminating ambient water sounds, and diminishing the unique engineering design association with its designer.

89. This might be true if the flashboards were considered an integral part of the dam. In our view, however, this is not the case. Flashboards are a temporary and removable structure that is placed on top of a dam. In any event, staff found that the measures that Boott proposed were adequate to mitigate the adverse effect, and we agree. As noted, the historic and engineering features of the dam have already been documented. Although the ambient sounds and visual effects of water leaking through the partially-failed flashboards will be removed with a crest gate system, the sound and sight of water overtopping the dam will still be present during times of high flows. The dam's historic and engineering significance stems not from its particular means of crest control but from its association with the locks, canals, and mills that developed in Lowell between 1796 and 1848, making it one of America's first industrial cities. Moreover, there is nothing in the NHPA that requires a federal agency to avoid or mitigate all adverse effects on historic properties. If the consulting parties are unable to agree on proposed mitigation measures, the Advisory Council's regulations permit a federal agency to terminate consultation and request the Council's comments, as Commission staff has done here. Nothing further is required in this case.

90. The Advisory Council states that the undertaking as currently proposed will adversely affect the Historic District, Lowell Park, and Lowell Preservation District, in

which Pawtucket Dam is a contributing element. The Council asserts that when there is an adverse effect on a contributing element, a federal agency must consider the historic district in its assessment of effects, and argues that the Historic District, Lowell Park, and the Preservation District are more than just collections of related structures and buildings; they recognize an urban industrial historical landscape that developed around water power provided by the Pawtucket Dam and its associated canals.

91. The 1976 nomination form for the Historic District lists commerce, engineering, industry, and transportation as the district's areas of significance. Commerce, industry, and transportation are associated with National Register Criterion A. According to the Keeper, Criterion B also applies for the district's association with the lives of individuals significant in the development of Lowell. The 1977 nomination form for the Historic District as a National Historic Landmark lists the district's areas of significance as engineering and industry. Engineering is associated with National Register Criterion C, which encompasses both architecture and engineering significance. Architecture is not listed on either form.[33]

92. The descriptions included in the 1976 nomination form are primarily concerned with the locks, canals, and mill buildings. Regarding Pawtucket Dam, the form includes only two sentences. These simply state that the dam was built between 1826 and 1830 at Pawtucket Falls and created a mill pond on the Merrimack River eighteen miles long, and that the dam has been continually modified throughout the nineteenth century.

93. Like the 1976 form, the 1977 nomination form is primarily concerned with the locks, canals, mill yards, and work shops, but it also provides more detail about these structures. It includes only one paragraph about Pawtucket Dam. It briefly describes the dam's construction in 1847 and 1875, replacing the earlier masonry and wood dams of 1826 and 1833. It states that the dam follows the outline of the natural ledge of the Falls, and includes a few sentences about its composition and method of construction. It states that with its flashboards in place, the dam is capable of ponding the river for a distance of about 18 miles. It also states that the dam is 1,093.5 feet in length and that the fishway was built in 1921.

94. Neither form discusses the historic significance of Pawtucket Dam in relation to the other components of the district. The 1978 form includes a statement of significance and a history of the district. Together, these two sections of the nomination form comprise over eight pages. Pawtucket Dam is not specifically discussed in either the statement of significance or the history of the district.

[33] *See* Attachments 12 and 13 to letter from Robert Fletcher, FERC, to Carol Shull, Keeper of the National Register (Sept. 19, 2011).

95. The 1985 nomination form for Lowell Park states that the Park includes within its boundaries the 5.6 mile power canal system. It states that there are 895 properties within the Park and Preservation District and lists them by their classification as various types of structures. The list does not include any dams. It states that the Park and the Preservation District's most important historical resources are the canal system, the remaining major mill complexes, and the central business district's nineteenth century commercial buildings. The statement of significance does not mention Pawtucket Dam. Similarly, the 2001 nomination form for the Lowell Preservation District does not mention the dam.[34]

96. In light of the limited discussion of Pawtucket Dam in the 1976 and 1977 nomination forms for the Historic District, as well as the complete absence of any mention of the dam in the 1985 and 2001 nomination forms for the Lowell Park and Preservation District, we question whether installing a pneumatic crest gate system on the dam could have any effect at all on the Historic District, the district as a National Historic Landmark, or the Lowell Park and Preservation District. The dam's significance stems from its association with the power system and canals that drove the waterwheels of the mill buildings. This association would continue, and changing the dam's crest control system would have no effect on this historic association. Nor would there be any effect on the dam's engineering. In short, the proposed action would not affect the characteristics that qualify the Historic District, Lowell Park, and the Preservation District for listing on the National Register.

97. The Advisory Council states that the proposed project is inconsistent with the Secretary of the Interior's standards for historic preservation in 36 C.F.R. Part 68, and thus will constitute an adverse effect on Pawtucket Dam, the Historic District, and Lowell Park and the Preservation District. The Advisory Council asserts that conformance with these standards would preclude the major alterations of the dam and removal of the flashboard system that would be required for installing a crest gate system. Specifically, the Advisory Council states that the proposed work violates the standards because the distinctive materials and physical appearance of the flashboard system will not be retained; the essential historic characteristics of the often bent, leaking line of flashboards will be lost, allowing no random passage of water over its top or through its face, and eliminating the character-defining passage of some water through or over the system and over the rocky rapids below the dam during the summer and early fall.

98. This is simply a description of the appearance of the flashboard system. As we have acknowledged, the crest gate system will change the appearance of the dam crest. Although it will eliminate the sight and sound of water passing through gaps in the flashboards, it will still allow water to flow over the dam crest onto the rocks below the

[34] *Id.* at Attachments 14 and 15.

dam during times of high flows. The distinctive materials and physical appearance of the dam itself will not be altered. Only the crest control structure will be changed.

99. The Advisory Council states that the Secretary's standards will be violated because removing the entire flashboard system eliminates an essential engineering feature characterizing the historic dam. Similarly, the Advisory Council states that the distinctive materials and features of the flashboard system and the top of the angled and hand-finished sloping granite capstones will be lost.

100. As we have stated, the engineering of the dam will not change. Only the crest control system will be altered. The flashboards are not an essential engineering feature of the dam. Rather, they are a separate system for crest control that is placed on top of the dam and can be removed without affecting the dam's engineering. The distinctive materials and features of the flashboard system are not an integral part of the dam. The granite capstones will not be lost. Rather, they will remain on the dam. The angled slope of the capstones is below the ordinary low water level of the reservoir, and thus is not currently visible upstream of the dam with the flashboards in place. This will not change; the slope of the capstones will likewise not be visible from upstream with the crest gate system in place. The capstones will still be visible from downstream of the dam, except when flows are high enough to spill over the lowered crest gates.

101. The Advisory Council states that the crest gate system will violate the Secretary's standards because it will alter the historic character of the dam; the new concrete, steel crest gates, and inflatable bladders are inconsistent with the historic fabric; and any intermediate piers that may have to be used are not visually compatible with the historic dam.

102. As described in the National Register nomination forms, the dam's historic character results from its historic association with the locks, canals, buildings, and mills of the Historic District and the Lowell Park and Preservation District. Similarly, the dam's historic fabric will not be altered. Adding a modern crest control structure to this historic dam is no different from adding a modern fish passage structure, which all participants agreed would not adversely affect the dam when the Commission licensed the project in 1983. Boott's modified design for the crest gate system has eliminated the need for intermediate concrete piers.

103. The Advisory Council states that Boott's proposed measures to minimize and mitigate potential adverse effects are insufficient, given the significance and importance of the numerous resources that will be affected. The Advisory Council lists these measures as eliminating the intermediate piers, reducing the amount of concrete used as a base, placement of the gate on the capstones, anchoring systems, painting the bladders to reduce their visibility, designing the compressor building to resemble 19th century buildings in Lowell, and constructing two exhibits with examples of the historic flashboard system and the new crest gate system for display near the dam. The Advisory

Council states that these measures "would appear cosmetic and are totally inadequate given the impacts of the proposed project." [35]

104. We disagree. These measures are adequate to minimize and mitigate the potential adverse effects of replacing the flashboards with a crest control system on Pawtucket Dam. Moreover, because the proposed action will not affect the dam's historic association with other significant historic properties, the proposed changes to the dam's crest control structure will not adversely affect the Historic District, Lowell Park, or the Preservation District. In any event, the NHPA does not require that all adverse effects be avoided or fully mitigated.

3. Compliance with the Advisory Council's Regulations

105. The Advisory Council finds that there have been flaws in the Commission's compliance with the section 106 regulations for this undertaking. The Council states that the consulting parties have had ongoing concerns about identifying the area of potential effect, identifying historic properties and their significance, determining the nature and scope of effects, considering alternatives, and resolving adverse effects.

106. The Advisory Council states that Boott's use of a consultant to study effects on historic resources "caused concern among stakeholders because they were unclear about the status of the Section 106 review." [36] The Council acknowledges that the regulations allow a federal agency to delegate an applicant to begin a section 106 review but require prior notification to the SHPO, as specified in section 800.2(c)(5) of the Advisory Council's regulations. The Council states that, because Commission staff had not yet formally initiated consultation with the SHPO at that point, the SHPO was not consulted in determining the area of potential effect before historic properties were identified, as required by section 800.4(a)(1).

107. As the Advisory Council acknowledges, applicants often begin the section 106 review process. Indeed, Commission regulations require applicants to consult with federal and state resource agencies on a wide range of resource concerns, including historic preservation, before filing an application with the Commission. The Advisory Council and SHPOs are familiar with this aspect of our regulations and it does not typically cause uncertainty or concern. In many cases, Commission staff provides notice to the SHPO in the form of a letter designating the applicant as the Commission's non-federal representative to begin the section 106 review. However, the Commission remains responsible for initiating consultation under section 106 and making the required findings, which Commission staff did in this case.

[35] Advisory Council's Comments at 4 (filed Feb. 26, 2013).

[36] *Id*.

108. The Advisory Council maintains that when Commission staff issued its April 26, 2011 letter initiating section 106 consultation, it addressed multiple steps at once without first obtaining the SHPO's agreement. The Council acknowledges that its regulations allow a federal agency to address multiple steps at one time. Commission staff uses this approach in nearly all of its consultations under section 106 of the NHPA. In this case, the SHPO noted its disagreement with staff's letter not by complaining about multiple steps, but rather by declining to concur in staff's finding of no adverse effect to historic properties. In response, staff continued to consult for nearly two years with Lowell Park, the SHPO, the City of Lowell, and the Advisory Council on ways to avoid, minimize, or mitigate any adverse effects to historic properties. In these circumstances, staff's initial attempt to address multiple steps of the consultation process in a single letter was superseded by the subsequent consultation and had no bearing on the outcome.

109. The Advisory Council contends that the consultation was characterized by limited interaction with consulting parties and the public. The Council also notes that a number of individuals and entities that might have been appropriately recognized as consulting parties were not invited into the consultation, and that their absence "undermined the effectiveness of the consultation." [37]

110. As the Advisory Council recognizes, its regulations allow a federal agency to determine which entities and individuals should participate as consulting parties for purposes of section 106. The Commission allows many opportunities for public participation in its review process for hydroelectric licenses and amendments. In this case, the Commission received and considered comments on multiple occasions from numerous local residents, associations, representatives of historic preservation organizations, and representatives of local governments with jurisdiction over residential areas affected by backwater effects and flooding. In these circumstances, including these individuals and entities as consulting parties would not have materially affected the consultation. Moreover, staff must follow our regulations governing ex parte communications, and therefore may not engage in informal interactions with anyone outside the Commission who has an interest in the issues and outcome of a contested proceeding.

111. The Advisory Council avers that staff's delineation of the area of potential effect for the proposed action does not follow the definition in the section 106 regulations. The Council points out that, in its April 26, 2011 letter, Commission staff identified the area of potential effect as the Pawtucket Dam and areas where construction would take place, but did not include the Historic District, Lowell Park, or the Preservation District. The Advisory Council argues that, under guidance provided by the Park Service and the Keeper of the National Register, an adverse effect to a contributing element of a historic

[37] *Id.* at 5.

district is an adverse effect to the district as a whole, and that the area of potential effect for the proposed action should therefore include the areas encompassed by the Historic District, Lowell Park, and the Preservation District.

112. The area of potential effect is defined as "the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties."[38] Commission staff was aware of the guidance that the Park Service and the Keeper provided regarding the need to consider the historic districts and the park, and took this guidance into account during the subsequent consultation. Therefore, staff's initial description of a more limited area of potential effect than was later suggested did not affect the consultation.

113. The Advisory Council argues that staff's assessment of effects in its April 26, 2011 letter was compromised by its failure to recognize that under section 106, contributing elements in eligible or listed historic districts are treated the same as individual properties. The Advisory Council points out that both the SHPO and Lowell Park objected to staff's finding of no adverse effect and requested that it submit to the Keeper a request for clarification of the Dam's eligibility and integrity.

114. As noted, Commission staff followed this advice and requested a determination of eligibility for Pawtucket Dam from the Keeper of the National Register. Staff then took the Keeper's determination into account and found that the proposed action would have an adverse effect on Pawtucket Dam.

115. The Advisory Council states that, in light of its initial finding of no adverse effect, staff should not have proposed the development of an MOA to address the effects of the proposed action. The Council admonishes that, under the regulations, an MOA is only developed when there is a need to resolve adverse effects.

116. This ignores the fact that staff was aware of the views of other consulting parties that modifying the flashboards would constitute an adverse effect. In an effort to be responsive to those concerns and to foster consultation on proposed measures to avoid or mitigate the effects of the proposed action, staff reasonably offered a draft MOA for the consulting parties' consideration.

117. The Advisory Council contends that, after receiving the Keeper's determination, staff "misinterpreted [it] to mean that Pawtucket Dam was individually eligible for inclusion on the National Register because of its historic and engineering significance." Staff then changed its effect finding and offered a draft MOA with the same proposed measures to address the adverse effects, without considering the effects of the proposed action on the Historic District, Lowell Park, and the Preservation District.

[38] 36 C.F.R. § 800.16(d) (2012).

118. As the Advisory Council recognizes, the Keeper's letter states that under federal law and regulations, "no distinction is made between properties determined individually eligible for the national Register and those determined eligible as contributing to a historic district."[39] In light of that statement, we fail to understand why or how staff's finding "misinterpreted" the Keeper's determination. Staff reasonably found that replacing the flashboards would adversely affect the dam. The Advisory Council seems to suggest that, as a result, staff was necessarily compelled to find an adverse effect on the Historic District, Lowell Park, and the Preservation District. As we have seen, however, this proposition, while strongly argued by the consulting parties, is by no means self evident.

119. We agree with staff that any minor adverse effect of replacing the flashboards on Pawtucket Dam with a crest control system can be adequately minimized and mitigated by the measures proposed in the draft MOA. Moreover, because the Dam's historic and engineering significance stems from its association with other historic resources in the districts and the park, and replacing the flashboards will not affect that association, the proposed action will not adversely affect the Historic District, Lowell Park, or the Preservation District.

4. Compliance with Section 110(f) of the NHPA

120. The Advisory Council finds that the Commission has failed to address the effects of the undertaking on a National Historic Landmark and the requirements of section 110(f) of the NHPA. Interior and the National Trust make similar arguments. The Council reiterates that Pawtucket Dam is a contributing element of the Historic District, which has been designated a Landmark. The Council adds that Landmarks are nationally significant historic places designated by the Secretary of the Interior because they possess exceptional value or quality in illustrating or interpreting the heritage of the United States.

121. The Advisory Council states that there is "no question" that the effects to Pawtucket Dam are "direct and adverse," and that the Commission "has refused to acknowledge the status of Pawtucket Dam as a contributing element" of a Landmark Historic District, or "to seriously consider the nature and extent of the adverse effects" to the Dam, the Landmark Historic District, Lowell Park, and the Preservation District. The Council maintains that there is "no evidence in the administrative record" of the section 106 consultation that the Commission "seriously considered alternatives" that might minimize harm to the Landmark. The Council concludes that the Commission has failed to meet the statutory standard.

[39] Park Service, Determination of Eligibility Notification at 2 (filed Oct. 26, 2012).

122. We disagree. Consulting parties pointed out the Historic District's Landmark status even before the amendment application was filed.[40] Commission staff acknowledged and discussed the Historic District's Landmark status in its draft and final EA[41] and engaged in nearly two years of consultation on ways to avoid, minimize, or mitigate any adverse effects. Under section 110(f) of the NHPA, federal agencies are required "to the maximum extent possible" to "undertake such planning and actions as may be necessary to minimize harm" to Landmarks that may result from their proposed actions. Because the only identified adverse effect is that of replacing the flashboards, and the consulting parties argue that an adverse effect on the dam is, by definition, an adverse effect on the Landmark district, staff's consultation on ways to avoid, minimize, or mitigate adverse effects to the dam must, by extension, be recognized as applying to the Landmark district as well. Therefore, there is no basis for the Advisory Council's assertion that the Commission has failed to meet the statutory standard.[42]

123. The Advisory Council also asserts, without elaboration, that the Commission has failed to comply with the requirements of section 800.10 of the Council's regulations.[43] A brief review of the requirements of that section reveals that staff met them in this case.

124. Section 800.10(a) simply reiterates the statutory requirement discussed above. Section 800.10(b) provides that the agency official shall request the Advisory Council's participation in any consultation to resolve adverse effects on Landmarks conducted under the Council's regulations. As noted, the Advisory Council requested to participate in the consultation by letter dated August 19, 2011. Therefore, staff was not required to request the Advisory Council's participation. Section 800.10(c) provides that the agency official shall notify the Secretary of the Interior of any consultation involving a Landmark and invite the Secretary to participate if there may be an adverse effect. As noted, Interior has participated in this consultation from the outset, even before the application was filed, through its Lowell Park, Park Service, and Office of the Solicitor.

[40] *See, e.g.*, Lowell Park's letter of June 11, 2010 at 3 (commenting on Boott's draft application).

[41] *See* draft EA at 9, 13-15, 65 (June 10, 2011); final EA at 8, 15-16, 68 (Dec. 19, 2011).

[42] The National Trust maintains that the Commission failed to meet section 110(f) of the NHPA by not considering the alternative of restoring the flashboard pins to their historic strength and spacing. This is not correct. Commission staff required Boott to redesign the flashboard pins and spacing to ensure that they would fail as designed, thus approximating the historic configuration of the flashboard system. Staff examined this option as the no-action alternative in the EA.

[43] 36 C.F.R. § 800.10 (2012).

Therefore, there was no need for staff to inform the Secretary of the consultation and request the Secretary's participation. Finally, section 800.10(d) does not impose any obligations on the federal agency that is considering a proposed action. Rather, it requires the Advisory Council to report the outcome of the section 106 process to the federal agency and the Secretary. We assume that the Council's comments filed with the Commission on February 26, 2013, satisfy this requirement.

5. Compliance with the Lowell Act

125. The Advisory Council finds that the Commission has not adequately addressed the ramifications of the Lowell Act, which established Lowell Park. The Advisory Council notes that the purpose of the Lowell Act was "to preserve and interpret the nationally significant historical and cultural sites, structures, and districts in Lowell, Massachusetts, for the benefit and inspiration of present and future generations."[44] The Council adds that, among other things, Congress found that "certain sites and structures in Lowell, Massachusetts, historically and culturally the most significant planned industrial city in the United States, symbolize in physical form the Industrial Revolution."[45]

126. The Council maintains that the Lowell Act specifically prevents federal entities from issuing "any license or permit to any person to conduct an activity within the park or preservation district unless such entity determines that the proposed activity will be conducted in a manner consistent with the standards and criteria established pursuant to Section 302(e) of this Act and will not have an adverse effect on the resources of the park or preservation district." [46] The Advisory Council acknowledges that the Lowell Act does not define the term "adverse effect" but states that "Section 106 of the NHPA, the preeminent federal statute in pari materia, supplies its intended definition."[47] However, section 106 of the NHPA does not use the term "adverse effect," and it is not included among the terms that are defined for purposes of that act in section 301 of the NHPA.[48] Thus, it is not clear that we should look to the regulations implementing section 106 for purposes of defining an "adverse effect" under the Lowell Act.

127. The NHPA was enacted in 1966. Advisory Council states that the term "adverse effect" had a well-established meaning in federal historic preservation practice and law

[44] 16 U.S.C. § 410cc-12(b) (2006).

[45] *Id.* at § 410cc-11(a)(1).

[46] *Id.* at § 410cc-12(b).

[47] Advisory Council's comments at 7 (filed Feb. 26, 2013).

[48] *See* section 301 of the NHPA, 16 U.S.C. § 470w (2006).

by the time Congress passed the Lowell Act in 1978. The Advisory Council points out that the procedures for implementing section 106 published in the Federal Register in 1969 and 1970, and then in the Code of Federal Regulations in 1975, defined an "adverse effect" to include "(a) destruction or alteration of all or part of a property; . . .[and] (c) introduction of visual, audible, or atmospheric elements that are out of character with the property and its setting."[49] The Advisory Council states that the proposed action would result in such adverse effects to Pawtucket Dam, the Historic District, Lowell Park, and the Preservation District. As a result, the Council states that it is unclear how the Commission could issue a license for the proposed action consistent with the Lowell Act.

128. The Advisory Council asserts that the crest gate proposal is "a fundamental change in the character, appearance, and mode of functioning of a central feature" of Lowell Park, the Preservation District, and the Landmark Historic District.[50] In the Council's view, it is "not just a modern addition to the vicinity of the Park and associated historic districts, but rather a direct adverse effect to the resource itself."[51] The Advisory Council states that it concurs in the opinion of Lowell Park and Interior that the Commission will not be able to make a finding that the proposed action will not have an adverse effect on the resources of Lowell Park and the Preservation District.

129. Interior makes a similar argument, maintaining that a finding of "no adverse effect" under the Lowell Act would be inconsistent with Commission staff's finding of adverse effect under the NHPA. Interior states that it is "indisputable" that the dam is a resource of the park and preservation district and that, given staff's finding under the NHPA, the Department cannot see how the Commission can make the findings required of it under the Lowell Act.

130. While both Interior and the Advisory Council state that Pawtucket Dam is a resource of not only Lowell Park but also the Preservation District, it is not clear that this is true. By its terms, the Lowell Act requires a finding that the proposed action "will not have an adverse effect on the resources of the park *or* the preservation district."[52] Pawtucket Dam is listed as a contributing element to Lowell Park and is located within the park's external boundaries (although it is not located on federal land within the park). However, the Preservation District is an adjacent area that is distinct from the park, and

[49] 36 C.F.R. § 800.9 (1975).

[50] Advisory Council's comments at 7.

[51] *Id.*

[52] Section 102(b) of the Lowell Act, 16 U.S.C. § 410cc-12(b) (2006) (emphasis added).

the statute's use of the word "or" suggests that our finding need only pertain to the resources of Lowell Park.

131. Nor is it clear that Pawtucket Dam is a "resource" of Lowell Park. As noted earlier, the dam is not mentioned at all in the 1985 National Register nomination form for the park.[53] Moreover, the dam is not mentioned anywhere in the Lowell Act. Under section 202 of the Act, the Secretary of the Interior is authorized to acquire certain designated properties, as well as other properties that meet certain standards.[54] We find it significant that Pawtucket Dam is not among the listed properties that the Secretary was authorized to acquire. Similarly, we find it significant that the Secretary made no effort to acquire the dam between 1978, when Lowell Park was established, and 1983, when the Commission issued a license for the Lowell Hydroelectric Project that included Pawtucket Dam.

132. As Interior acknowledges, the NHPA is procedural rather than substantive; that is, a federal agency may authorize a proposed action despite its having an adverse effect on historic properties. Under the NHPA, an action that might have an adverse effect can be avoided, minimized, or mitigated through appropriate treatment measures to the point that the effect is no longer considered adverse. If the term "adverse effect" is to have the same meaning in the Lowell Act as it is understood to have in the NHPA, presumably an initial finding of an adverse effect under the NHPA would not stand as an absolute bar to a proposed action under the Lowell Act. With appropriate measures to avoid, minimize, or mitigate the adverse effect, the proposed action would not be considered adverse and could proceed as planned.

133. This is exactly what happened when the Lowell Hydroelectric Project was licensed in 1983. The adverse effect of introducing a modern fishway on Pawtucket Dam was mitigated through recording the historic and engineering features of the dam and other appropriate measures, thus permitting a finding of no adverse effect on the resources of the Landmark Historic District. The Park Service and the Massachusetts SHPO concurred in the mitigation measures and the finding of no adverse effect. The only difference in this case is the lack of concurrence on the part of the Park Service and the SHPO.

134. We find nothing in the Lowell Act that requires us to obtain that concurrence. Rather, under the Lowell Act it is the federal entity that must make a finding of no adverse effect before authorizing an activity within the park or preservation district. To hold otherwise would, in effect, amend the statute. We find that the measures that we

[53] Similarly, as discussed earlier in this order, there is no mention of the dam in the 2001 National Register nomination form for the Preservation District.

[54] Section 202 of the Lowell Act, 16 U.S.C. §410cc-22 (2006).

require in this order to mitigate the adverse effect of replacing the flashboards on Pawtucket Dam with a crest control system are adequate, and we need not obtain any other agency's concurrence in that finding. We therefore find that the proposed action, with those mitigation measures, will not have an adverse effect on Pawtucket Dam or the resources of Lowell Park.

135. The Advisory Council also questions whether the Commission can approve the amendment request under the Lowell Act because the proposed action may not be consistent with the standards and criteria established pursuant to section 302(e) of that Act. The Council notes that the Lowell Historic Board has been informally involved with Boott's proposal and has advised that it may not meet the Board's design guidelines issued under section 302(e) of the Lowell Act. The Council adds that, without an application and plans submitted as part of the review process, the Board cannot make any formal determination regarding appropriateness and effect.

136. We question whether the proposed action, which requires our approval under the FPA and is subject to the requirements of the NHPA and the Lowell Act, would also need to be submitted to the Lowell Historic Board for approval. In any event, the Lowell Act requires us to determine whether the proposed activity will be conducted in a manner consistent with the standards and criteria established pursuant to that Act.

137. Interior argues that we cannot make that finding, because the proposed action is inconsistent with the preservation standards for the park.[55] Interior asserts that the Commission must analyze consistency with all of the standards, and not restrict itself to only those that Interior has discussed in its comments. We disagree, as most of the standards would appear to be inapplicable to the dam.

138. Interior published preservation standards for Lowell Park and the Preservation District under section 302(e) of the Lowell Act on April 29, 1981.[56] They are specific to the park and preservation district, and apply to the construction, preservation, restoration, alteration, and use of properties within the park and the district. They do not contain any specific references to dams in general or to Pawtucket Dam in particular. Many of these standards concern mill buildings and thus would not apply to the dam. Others concern features of buildings that are not present on the dam, such as windows, roofs, interior spaces, and doors. We need not analyze the proposed action's consistency with standards that are clearly inapplicable.

[55] 16 U.S.C. § 410cc-32(e) (2006).

[56] 46 Fed. Reg. 24,000 (1981).

139. Interior argues that the proposed action violates Preservation Standard E-2. This standard concerns historic architectural features, and states that historic buildings "owe their character to the particular blend of their architectural features: scale, rhythm, form, massing, and proportion." [57] It provides that "original building features should whenever feasible be preserved rather than replaced.[58] Interior maintains that the flashboards constitute an original feature of the dam and the power system, despite the fact that individual pins and boards are continually replaced, as this replacement is part of the historic pattern of use. Interior argues that it is feasible to preserve this feature because the licensees have continued to use the flashboard system for years and make no showing that they cannot continue to do so. Because preservation is feasible, Interior concludes that the flashboards should be preserved. Interior adds that it is feasible to accomplish the Commission's flood control purpose with a flashboard system.

140. The architecture of the masonry dam would not be altered, thus preserving the dam's scale, rhythm, form, massing, and proportion. Only the flashboards, which are an original crest control feature of the dam, would be replaced. As we have seen, because of flooding concerns there is a need for a crest control system that would collapse completely during high flows. Although Interior asserts that flashboards could be designed to meet this purpose, the record suggests otherwise. By their very nature, flashboard systems fail incompletely and unpredictably in response to high flows. For this reason, it is not feasible to preserve the existing flashboards. Only an inflatable crest gate system can attenuate the backwater effect of the dam during high flows to the maximum extent practicable.

141. The existing granite capstones would not be altered, and would still be visible from the downstream side of the dam. To mimic the appearance of the existing flashboards, Boott would use a brown-colored bladder, paint the downstream side of the crest gate panels brown, and install black retaining straps an average of 20 inches on center. This will help ensure that the crest gate system is similar in appearance to the existing wooden flashboards. Upstream of the dam, the anchoring assembly for the new crest control structure would be below the ordinary low water elevation and would not be visible. With the crest gate down and water going over the dam, the crest control structure would not be visible. Boott would also develop two interpretive exhibits, one featuring a replica of a portion of the original flashboard system and one featuring the new crest gate system, to be located at the project to enhance visitors' understanding of the history of Pawtucket Dam and the Lowell Hydroelectric Project. In light of all of these measures, as well as the fact that preserving the existing flashboard system is not

[57] *Id.* at 24,001.

[58] *Id.*

feasible given the need to provide maximum flood attenuation, we find that the proposed action is consistent with this standard.

142. Interior argues that the proposed action is inconsistent with Preservation Standard E-3. This standard concerns historic materials, and states that "historic character also comes from the use and design of construction materials." [59] Interior argues that the proposed action would completely remove the wood and metal flashboard system and replace it with a pneumatic crest gate supported by a steel frame anchored in bedrock through the dam. Interior asserts that the capstones would be lost to view, and the view would be dominated by the steel crest gates. Interior concludes that the materials used would be very different from those used historically and would radically change the historic character of the dam.

143. We disagree. The original materials, design, and use of the masonry dam would not be altered. Although the wood and metal flashboard system would be replaced, these materials have been continually replaced and are not original. In light of the need for a crest control system that is completely down during high flows, this is a limited but necessary change in the materials used for crest control. We find that the proposed action is consistent with this standard.

144. Interior argues that the proposed action is inconsistent with Preservation Standard E-16. This standard states that "hardware relating to the original industrial power system and manufacturing processes may be historically significant and should be preserved."[60] It further states: "Determine significance of hardware by its role in original manufacturing, its completeness, and its potential for interpreting the history of Lowell. Retain elements with such significance."[61] Interior argues that the flashboard system has been in use since 1834, continuously since 1838, and on the dam in its current configuration since 1875. Interior maintains that the flashboard system is an essential part of the original industrial power system and remains essentially complete, and that the Park Service uses it as part of its interpretation of the history of Lowell. Interior therefore concludes that the flashboard system should be retained.

145. Standard E-16 concerns the industrial hardware of mill buildings, so we question whether it is applicable to the dam. We agree that the dam is part of the original system of dams, locks, and canals that powered the mills. This historic aspect and association of the dam will not change. To the extent that the flashboard system would be considered "hardware" relating to the original industrial power system, its role in original

[59] *Id.*

[60] *Id.* at 24,006.

[61] *Id.*

manufacturing would be the same as that of the dam itself, to provide head for the system that powered the mills. Only the dam's crest control structure will be altered, to address a present-day need for a more effective means of alleviating backwater effects during high flows. In addition, Boott will provide interpretive exhibits to assist visitors and the Park Service in interpreting the role of the dam as part of the history of Lowell. We find that the proposed action is consistent with this standard.

146. Although Interior addresses only those three standards in its comments, we note that Preservation Standard N-1, which concerns new construction, would presumably apply to the new compressor building. This standard states that "new buildings and activities are important for economic revitalization."[62] It adds that new buildings should be designed "using a contemporary vocabulary that adds to the richness and compactness of existing 19th century buildings."[63] In previous comments submitted with its motion to intervene, Interior stated that, without any design details, there is no information sufficient to permit the Commission to determine whether the new compressor building will be consistent with this standard.

147. This standard clearly encourages new construction, and does not require that historical elements be copied. Rather, it suggests using "naturally textured materials and subdued colors related to the historic materials of the District," and interpreting into contemporary architecture the "scale, rhythms, proportions, and level of animation found in the historic buildings of Lowell."[64] In this order, we require Boott to design and construct the compressor house with materials that are compatible with the historic fabric of the adjacent architecture, to ensure that the building will resemble 19th century buildings in Lowell, specifically the nearby Northern Canal Gatehouse. We therefore find that the proposed action is consistent with this standard.

148. In short, we find that the proposed action will be conducted in a manner consistent with the preservation standards established pursuant to the Lowell Act, and will not have an adverse effect on the resources of the park or preservation district. We therefore may authorize the proposed amendment consistent with the Lowell Act.

6. Consideration of Alternatives and the Public Interest

149. The Advisory Council finds that the Commission's consideration of alternatives and specification of requirements for the project fail to take into account the need to balance the agency's mission, the purpose and need for the undertaking, effects on

[62] *Id.* at 24,008.

[63] *Id.*

[64] *Id.*

significant historic properties, and the public interest. The Advisory Council points out that the Commission's mission, as summarized in its Strategic Plan for Fiscal Years 2009 – 2014, is to assist consumers in obtaining reliable, efficient and sustainable energy services at a reasonable cost through appropriate regulatory and market means. The Council notes that one of the major ways the Commission does this is by promoting the development of safe, reliable, and efficient energy infrastructure that serves the public interest. The Council then cites the goals of an interagency memorandum of understanding (MOU) among Interior, the Army Corps of Engineers, and the Department of Energy (March 24, 2010) that expresses the Administration's interest in maintaining and optimizing hydropower generation in a sustainable manner that recognizes the need to preserve biological diversity, ecosystem function, our natural and cultural heritage, and recreational opportunities, and recognizes that some geographic locations are not appropriate for new hydropower development.

150. The Advisory Council states that the environmentally responsible approach promoted in the MOU is not demonstrated in the administrative record for the section 106 consultation in this case. The Council adds that it does not appear that the Commission "engaged in a forthright consideration of alternatives" in light of the goals of the proposed action, balanced by "consideration of the real significance of the dam as a central component in multiple overlapping historic districts," including a Landmark Historic District and a National Historical Park.

151. We disagree. The Commission is not a party to the MOU. However, the MOU recognizes that hydropower can be developed in a sustainable manner that recognizes the importance of a broad range of public interest factors, including fish and wildlife resources and their habitat, endangered species, historic preservation, and recreation. These are the same public interest factors that we are required to balance, along with developmental interests, under the comprehensive development standard of the FPA. What the Advisory Council would have us do in this case is to give more weight to historic preservation than to all other aspects of the public interest, including fish passage benefits, improvements to recreation, attenuation of backwater flooding during high flows, dam and worker safety, water supply, and increased hydropower generation. In our view, this would not represent the best balance of developmental and environmental resources in the public interest.

152. The Advisory Council states that the justification for the project has varied over the decade or more that it has been in development. The Advisory Council notes that correspondence from Boott and the Commission references benefits to fisheries, minimizing backwater flooding effects, maintaining the project, continual failure of the flashboards, addressing concerns about workers' safety, and preservation of Pawtucket Dam. The Council adds, however, that in Boott's 2010 amendment and earlier discussions of the project, there seems to be at least an equal emphasis on increasing the average annual elevation of the head pond and the increased efficiency and productivity of the hydro facility that would result. The Advisory Council maintains that, following

significant floods in 2006 and 2007 and throughout the section 106 consultation process, there has been an emphasis on justifying the proposed action primarily as an effort to address local residents' flooding concerns related to Pawtucket Dam operations. The Council states that this is in contrast with Boott's backwater analysis and technical assessment of crest control alternatives that suggest Boott believes that the dam's flashboards have little or no impact on upstream flooding conditions.

153. We disagree with this assessment. Throughout this proceeding, there has been a focus on multiple interests and concerns and the justification for the project has not varied. Flooding has been a concern of local residents at least since 2003, when the Commission first received a local resident's complaint about the dam's operation and requested the licensee's response. However, the Commission was also aware of complaints about the adverse effects of flashboard failure and repair on fish passage as a result of high water events in 2005 and 2006.[65] Complaints about flooding increased and flooding concerns received increased attention after the significant floods that occurred in 2006 and 2007. This prompted Commission staff to require Boott to consider flashboard and other crest control options with the objective of designing a system that could be fully down during high flow events. However, Boott and Commission staff acknowledged from the outset that the proposed crest gate system would allow increased generation. It would also benefit recreation and fish and wildlife resources by providing a more stable reservoir elevation.

154. Boott's statements regarding the impact of the dam's flashboards on flooding simply reflect the fact that, while a crest gate system provides the maximum attenuation of the dam's backwater effect during high flows, no system, whether flashboards or a crest gate, can provide any meaningful flood relief during major flood events such as those that occurred in 2006 and 2007, when river flows were in the range of about 86,000 to 93,000 cfs. During such major flood events, there would be no significant difference in flood levels along the Clay Pit Brook area between the two systems. In the EA, staff analyzed the environmental impacts of the proposed crest gate system and alternatives on the full range of developmental and non-developmental resources and recommended the crest gate system as providing the best balance of costs and benefits for these resources. The justification for the proposed action has not varied, but has always reflected consideration of all of the relevant factors.

155. The Advisory Council states that the record lacks data on the benefits of the crest gate system in reducing flood damage, and that therefore, a more rigorous analysis of costs and benefits appears warranted. The Advisory Council adds that such an analysis should include adverse effects to historic properties as well as impacts to other cultural

[65] *See, e.g.*, letter from Paul Diodati, Massachusetts Division of Marine Fisheries, to Skip Medford, Boott (filed Dec. 28, 2006).

and natural resources and recreational and educational opportunities. The Council concludes that, without such an analysis, the consideration of alternatives does not provide a realistic appraisal of costs and benefits for options which preserve historic resources.

156. The Advisory Council overlooks the fact that staff presented a full evaluation of costs and benefits on all relevant resources in the EA. Among other things, staff analyzed the no-action alternative, defined as retaining the existing flashboard system without changing it. This is the only option in the EA that would fully preserve historic resources without affecting them in any way. However, staff did not recommend it because it would not provide all of the benefits of the crest gate system; that is, it would not attenuate the dam's backwater effect to the maximum extent possible, it would not provide fish passage benefits, it would not benefit fish and wildlife and recreation by providing a more constant reservoir elevation, it would not provide benefits to dam and workers safety, and it would not allow increased power generation. There is no requirement in the FPA, the NHPA, or the Lowell Act to consider only those alternatives that would have no impact on historic resources.

157. The Advisory Council states that the Commission must actively consider and balance the goals of the project and needs of the licensees with the effects of the project on the general environment, the significance of affected historic properties, their preservation value for the community and the nation, and concerns of the local community. The Advisory Council maintains that all of these factors should inform a decision about the project in the public interest.

158. This is precisely what the FPA requires, and what we have done in this case. The Advisory Council disagrees with our balancing and would have us give greater weight to historic resources. However, we fully considered the costs and benefits of the proposed action and its effects on all relevant resources, and believe the crest gate system represents the best balance of effects on all of those resources.

159. The Advisory Council states that staff's requirement that the licensee must ensure that any flashboard system be completely down during high flows appears to be related to addressing concerns about backwater flooding, but does not appear to take into account all associated costs of a crest gate system, and suggests an apparent lack of sensitivity to the significance of the dam, its associated historic districts, and the park. The Advisory Council concludes that the tradeoffs inherent in implementing the proposed project have not been adequately explored or represented to the public, and that impacts on historic properties have been understated or dismissed.

160. We disagree. Staff imposed this requirement for the flashboard system because of numerous complaints about backwater flooding. We agree with staff's assessment that, in actual conditions, flashboards fail incompletely and unpredictably and thus cannot attenuate backwater flooding to the maximum extent possible. This does not mean,

however, that impacts to historic properties have been understated or dismissed. Rather staff fully considered them in the EA, and we have fully considered them in this order. We approve the crest gate system because it is the option that would provide the best means of attenuating backwater flooding while also benefiting project generation, fish passage, fish and wildlife resources, recreation, and dam and worker safety, with minor effects on historic properties that are adequately mitigated. This does not mean that we have failed to consider effects to historic properties, or have understated or dismissed those effects.

7. Appropriateness of Modifying this Historic Dam

161. The Advisory Council reiterates and specifically finds that replacement of the flashboard system is not an appropriate treatment for this historic dam. The Advisory Council recognizes that traditional flashboards have been replaced at other locations to provide operational benefits. However, the Council maintains that Pawtucket Dam with its flashboards should be maintained, because it is a central component of a Landmark Historic District and a unit of Lowell Park, which is focused in part on the history of American waterpower development. In essence, the Advisory Council maintains that the dam with its flashboards should be preserved as "an elegant, functioning artifact." [66]

162. We do not share this view. As we have seen, it elevates historic preservation above all other resources, and does not represent the best balance among competing resources for the Lowell Hydroelectric Project.

8. Purpose and Need for the Proposed Action

163. The Advisory Council finds that the purpose and need for the project are questionable to consulting parties and members of the public, including residents who have suffered from the effects of backwater flooding. The Advisory Council notes that consulting parties and members of the local community have suggested that the main purpose of the project is to increase the average annual elevation of the head pond, thus increasing the efficiency and productivity of the hydro facility that relies on the dam by up to 10 percent. The Advisory Council concurs with Lowell Park's view that the historic and visual value of the traditional flashboard system on Pawtucket Dam outweighs any marginal increase in the licensee's generating capacity or ease of operations.

164. This ignores the fact that, under the FPA, we are not engaged in a simple balance between historic preservation and increased generation. Rather, as we have seen, the crest gate system offers numerous benefits, not only to increased generation and operational efficiency, but also to attenuating backwater flooding to the maximum extent

[66] Advisory Council's Comments at 9.

possible, as well as benefits to fish and wildlife resources, fish passage, recreation, and dam and worker safety. That being the case, it represents the best balance of all relevant resources.

9. The Dam's Importance to Lowell's Historical and Cultural Landscape

165. The Advisory Council finds that, as the source of waterpower control that allowed the growth of the textile industry at this bend in the Merrimack River in the 19th century, the physical form of Lowell's intact historical and cultural landscape begins with Pawtucket Dam. The Advisory Council states that the historic design of Pawtucket Dam encourages passive and informal water control to provide hydropower to the canals and help to prevent flooding upstream, as suggested by the naturalistic edges and open areas in the originally designed 1875 flashboards. The Council contends that the proposed action would significantly change the character of Pawtucket Dam by establishing it as a crest gate mechanically controlled waterway, would affect its historic presence, alter the dam's view corridors, destroy its historic functionality, eliminate water sound contributions, and diminish its engineering association with James B. Francis, its designer and chief engineer. The Council adds that the proposed action is out of character with the existing surroundings, and would significantly compromise historic visual and spatial relationships, both from the dam side and down river.

166. The flashboards are no longer present on the dam in their originally designed 1875 configuration. Nor was preservation of the flashboards made a condition of the license for the Lowell Project in 1983. The interpretive exhibits that Boott will be required to install will mitigate the effects of changing the crest control system from informal to mechanical, and will preserve information about the dam's historic functionality. The dam's engineering association with James B. Francis will be preserved, and its historic association with the locks, canals, and mills will not be altered. The design and color of the crest gate system will mimic the appearance of the flashboard system. The sight and sound of water falling over the crest of the dam will still be present during times of high flows. The Advisory Council's assessment does not recognize the mitigation measures that will be required.

10. The Advisory Council's Project-Specific Recommendations

167. The Advisory Council makes five project-specific recommendations. Most of these have already been addressed in our response to the Advisory Council's comments. We discuss them briefly below.

168. First, the Advisory Council strongly recommends that the Commission not approve the proposed amendment. We believe it represents the best balance of all affected resources.

169. Second, the Advisory Council recommends that, before considering any modifications to the dam, the Commission should re-examine the purpose and need used to justify the project and any resulting requirements, and fully consider the significance of the historic properties affected. We have done this, and do not believe that any further analysis is warranted.

170. Third, the Advisory Council recommends that the Commission require Boott to focus on an alternative that relies on rehabilitating the historic flashboard system as originally designed across the entire length of the dam. The Advisory Council notes that the Massachusetts SHPO made a similar recommendation early in the section 106 process. The Advisory Council recommends that the Commission evaluate claims that the historical flashboard system worked appropriately as designed in response to high water events and also facilitated drain-down and dry out of the river system soils during the time required to refurbish flashboards after failure. The Advisory Council further recommends that the Commission should take into account the damage to the dam and compromise of the original functionality of the flashboard system that resulted from Boott's changes to the flashboards since receiving its license in order to increase the average elevation of the head pond. According to the Council, these changes include increasing pin diameter and strength, reducing the spacing between pins, using plywood instead of flashboards, and increasing the height of flashboards to five feet above the capstones.

171. We disagree with this recommendation. The no-action alternative that staff considered in the EA is essentially the same as the historic flashboard system. Moreover, the license does not specify the type of flashboards that can be used. Rather, it only specifies the height of the boards and the strength, diameter, and height of the pins. We could not require Boott to reinstall a replica of the historic flashboard system without reopening and amending the license. Nor do we find any basis for doing so. In 2008, Commission staff required Boott to make changes to the pin strength and height to ensure that the flashboards would fail as designed. Since that time, the flashboads have operated in essentially the same manner as they did historically. The information in the record about the functionality of the historic flashboard system is anecdotal. Even if Boot were to attempt to re-create the historic flashboard system, it would not necessarily function in the same manner. Moreover, the increased frequency of major flood events such as those that occurred in 2006 and 2007 would override any benefits that might otherwise be thought possible. We find no basis for requiring any further analysis of the historic flashboard system.

172. Fourth, the Advisory Council recommends that the Commission evaluate Pawtucket Dam, the Historic District, Lowell Park, and the Preservation District as encompassing a historic landmark and traditional cultural landscape. The Advisory Council further recommends that the Commission should select only alternatives that are consistent with the Secretary of the Interior's Standards for the Treatment of Historic Properties, the Park Service's Preservation Brief 36: Protecting Cultural Landscapes

(1994), and the Park Service's Guidelines for the Treatment of Cultural Landscapes (1996).

173. We disagree with this recommendation, as it would elevate historic preservation concerns above all other resource considerations. Pawtucket Dam is a licensed project work of an operating hydroelectric project, and the FPA requires us to consider all aspects of the public interest in determining whether and under what conditions to amend the project's license.

174. Fifth, the Advisory Council recommends that, given the significance of the resources affected, the Commission should require Boott to prepare a master plan for that portion of the Merrimack River system affected by operation of the Lowell Project. The Council recommends that this plan should be developed in collaboration with Lowell Park, the City of Lowell, and municipalities with jurisdiction over the river and riverbanks, and should identify opportunities and alternatives for restoration, rehabilitation, repair, maintenance, stabilization, hazardous material remediation, and handicapped access required for continuous use. The Council adds that the plan should address appropriate measures to modify aspects of the hydro facility operation that affect significant visual, atmospheric, or audible elements associated with significant features of Pawtucket Dam, the Historic District, Lowell Park, and the Preservation District.

175. We disagree with this recommendation. It reaches far beyond the effects of the Lowell Hydroelectric Project and is not needed.

11. The Advisory Council's General Agency Recommendations

176. The Advisory Council makes six general agency recommendations based on its review of this project, which it states has highlighted the need for the Commission to review and update its protocols for compliance with section 106 to better reflect the consultative nature of the process and the responsibility to explore a full range of alternatives. We address these general agency recommendations briefly below.

177. First, the Advisory Council recommends that the Commission should follow the section 106 regulations and formally notify the SHPO regarding delegating the applicant to initiate the section 106 process. The Council states that informal delegation or the applicant's efforts to identify historic properties and assess effects before the federal agency is formally involved can often create confusion.

178. We already do this. We designate the applicant as our non-federal representative to gather information and initiate the section 106 process, but retain the responsibility to make all of the necessary findings under section 106.

179. Second, the Advisory Council recommends that, in accordance with its regulations, the Commission should be more expansive in identifying and inviting potential consulting parties into the section 106 consultation. Specifically, the Council

recommends that individuals and organizations with a demonstrated interest in an undertaking may participate as consulting parties due to the nature of their legal or economic relation to the undertaking or affected properties, or their concern with effects to historic properties. The Advisory Council states that it interprets these characteristics broadly and encourages agencies to do likewise.

180. The Commission involves interested individuals and organizations in its proceedings though opportunities for public comment and involvement in its environmental review process, as well as its section 106 review process. However, because of the quasi-judicial nature of its licensing and amendment proceedings, the Commission is limited in its ability to invite numerous individuals and organizations to participate as consulting parties for purposes of its section 106 review. Our practice reflects the nature of our licensing and amendment proceedings and the many opportunities for public involvement that they provide.

181. Third, the Advisory Council states that the Commission's rules regarding ex parte communications can create an impediment to open and inclusive consultation. The Council recommends that we review them to determine if there are ways to make our compliance procedures more compatible with section 106 policies and goals.

182. We recognize that our ex parte rules can make consultation more formal than might otherwise be possible. However, these rules protect the integrity of our quasi-judicial decision making. Over the years, the Commission has considered numerous requests to change these rules but has concluded that it would not be appropriate to do so. We do not believe that it is unduly burdensome to ensure that consultation occurs on the record, with an opportunity for all interested persons to be present to observe the consultation.

183. Fourth, the Advisory Council states that the Commission must give serious consideration to the impact of its actions on historic properties and cultural heritage as it considers the technical aspects and program goals of its undertakings.

184. We agree. The Commission is required to do this in all of its licensing and amendment proceedings for which historic preservation is an issue, and we did so in this case.

185. Fifth, the Advisory Council states that the Commission has an obligation under section 106 to actively explore a full range of alternatives that can avoid, minimize, or mitigate the adverse effects of its proposed actions. The Advisory Council adds that the development of alternatives should not be left exclusively to the applicant, or imposed on consulting parties.

186. We agree that the Commission is required to explore a full range of alternatives to the proposed action, and that, to the extent possible, alternatives should include those that will also avoid, minimize, or mitigate adverse effects to historic properties. Commission

staff and the consulting parties made every effort to identify and develop such alternatives in this case. The fact that they were unable to agree on mitigation measures does not mean that the Commission did not explore a full range of alternatives.

187. Sixth, the Advisory Council recommends that the Commission develop procedures to comply with section 110(f) of the NHPA when an undertaking may affect a National Historic Landmark.

188. We disagree that specific procedures for Landmark properties are needed. The statutory requirement that federal agencies "to the maximum extent possible" must undertake such planning and actions as may be necessary to minimize harm to Landmark properties can be addressed through the section 106 process. The Advisory Council already has specific regulations regarding Landmark properties, which the Commission followed in this case. There is no need for the Commission to develop specific regulations that would duplicate those of the Advisory Council.

12. Structural and Dam Safety Concerns

189. As noted earlier, Boott's original design required capping the dam with concrete and placing piers at the ends of the dam and at each angle in its crest. Boott proposed an alternative design on February 2, 2012, that would place the crest gate on a steel frame anchored through the dam into bedrock, to avoid capping the dam with concrete and eliminating the piers. The drawings include cross section and profile views of the general design for the pneumatic gate system. The conceptual design relies on a steel crest gate anchorage assembly which would be attached by rock anchors through the dam and into the underlying bedrock. Boott explained that this installation method would avoid placing a concrete slab on top of the uneven dam capstones to provide a level surface for the crest gate system. Boott did not specify materials or dimensions, and did not include supporting design calculations. During consultation, Boott further refined the design with concept drawings on July 18, 2012, combining structural steel and rock anchors with reinforced concrete infill in order to address some technical comments raised by staff of Interior's Bureau of Reclamation (Reclamation).[67]

190. The Advisory Council states, without elaboration, that the proposed action may diminish the long term physical integrity of the dam. The Council states that this may occur as a result of potential changes in the flow and fall of water as it impacts the capstones, as well as the methods of anchoring the crest gates that may damage the

[67] *See* letter from Celeste Bernardo, Lowell Park, to Victor Engel, Boott (filed Oct. 18, 2012), with July 18, 2012 concept drawings attached.

capstones or compromise the dam's ability to achieve natural movement in response to changing flows. Interior raises similar concerns and attaches Reclamation's analysis.[68]

191. Reclamation states that, regardless of the final technical details, attaching the proposed crest gate system to the historic masonry dam would cause stress-related deformation and thermally-induced differential movement within the granite stonework, resulting from the stronger, rigidly anchored longitudinal reinforced concrete and steel structure. The highly localized differential movement would cause excessive joint opening and mortar cracking, well beyond what the dam has experienced historically. This differential movement and joint opening would lead to a substantial decrease of the dam's water penetration resistance and lead to greater freeze-thaw and erosion damage to the masonry joints. The gates would allow overtopping water to impinge on the cap stone's open mortared joints, which could induce higher than normal hydrostatic pressures within the joints/structure creating overall instability. Reclamation concludes that these factors would structurally compromise and reduce the longevity of the structure.

192. Based on a review of the February 2, 2012 and July 18, 2012 designs by the Commission's Division of Dam Safety and Inspections (D2SI), we find that further analysis and design refinement are needed for the anchoring system. The licensee must provide calculations to show the anchoring system is integrated to the reinforced concrete infill in order to distribute the load over the structure. Also, additional details are needed to ensure that water overtopping the gate would not impinge and degrade mortar joints or seep into the joint between the concrete infill and existing dam causing freeze thaw/damage. Although more information and refinement are needed on the design, we find no reason why a pneumatic crest gate system cannot be designed to adequately address the above technical comments.

193. Before the Commission authorizes construction for any project, D2SI performs a detailed review of the design calculations and plans and specifications. The licensee typically submits its plans and specifications and supporting design report after the Commission has authorized the proposed modifications and at least 60 days before the proposed start of construction. As part of its pre-construction review, D2SI will consider issues concerning the distribution of anchor load over the structure and prevention of flows impinging and collecting on the dam crest, as well as any other issues that might arise from the division's review, before authorizing the licensee to start construction.

[68] *See* letter from John Trojanowski, Interior, to Wayne Donaldson, Advisory Council (dated Feb. 15, 2013), attached to Interior's February 26, 2013 letter to the Commission Secretary.

13. Consideration of Alternatives under NEPA

194. Interior argues that the Commission has failed to consider a reasonable range of alternatives under the National Environmental Policy Act (NEPA). Interior maintains that the EA defined the purpose of the proposed action as "to address concerns expressed by residents about flooding caused by Pawtucket Dam operations." [69] Interior concludes that the alternatives analyzed in the EA were intended to serve this purpose, but the Commission failed to consider and develop other alternatives that could also serve this purpose. Although Interior contends that the range of alternatives considered in the EA was inadequate, the only alternative that Interior mentions as warranting further consideration is re-installation of the historic flashboard system.

195. Interior misunderstands the purpose of the proposed action. The EA states that the applicant filed its amendment request in an effort to address residents' concerns about flooding. However, that was not the only purpose of the proposed amendment. The proposed crest gate system affects multiple resources and can serve a number of different purposes, including increased generation, attenuation of upstream flooding, improved dam and worker safety, and benefits to recreation, fish and wildlife resources, and fish passage. The purpose of this proposed action is to determine whether or under what conditions to approve Boott's request to install a pneumatic crest gate system.

196. In Commission practice, a proposed action results from a specific license or amendment application. This requires the Commission to determine whether to approve the request, and if so, under what conditions. Thus, an appropriate range of alternatives typically includes the applicant's proposal, the applicant's proposal with additional or different mitigation measures, and denial of the application (the no-action alternative).

197. The EA examined the effects of Boott's proposal and two alternatives: Boott's proposal with additional staff-recommended measures, and the no-action alternative of retaining the existing flashboards. As we have seen, the existing flashboards approximate the historic flashboard system. This is a reasonable range of alternatives for an EA.[70]

14. The Need for a Supplemental EA

198. Interior argues that, because the applicant's proposed design changes to the crest gate system were not analyzed in the EA, the Commission's finding of no significant impact is inapplicable and there is a need to supplement the EA.

[69] EA at 3.

[70] *See Richard Balagur*, 57 FERC ¶ 61,315, at 62,018 (1991), *aff'd sub nom. Friends of the Ompompanoosuc v. FERC*, 968 F.2d 1549, 1556-56 (2nd Cir. 1992).

199. This is incorrect. The EA analyzed the environmental effects of installing the crest gate system on the full range of affected resources. Boott's subsequent design changes are minor adjustments that do not require a supplemental EA

200. Under the Council of Environmental Quality's regulations, a supplement to an environmental impact statement is required if an agency makes substantial changes in the proposed action that are relevant to environmental concerns, or there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts.[71] There are no regulations concerning supplements to an EA. In any event, Boott's proposed design changes to the pneumatic crest system are not substantial, and would not constitute significant new circumstances or information within the meaning of the rule. Rather, they are minor design changes made in response to comments from interested resource agencies. Applicants, agencies, and Commission staff frequently suggest these types of changes in response to comments made during consultation under section 106 of the NHPA. There is no need to supplement the EA to consider them.

Aquatic and Fish Resources

A. Anadromous Fish and Fish Passage

201. The Merrimack River supports an anadromous fish community including Atlantic salmon, American shad, alewife, and blueback herring.[72] The Lowell Project is the second hydroelectric dam encountered by anadromous fish during their upstream migration, and has a fish lift and a modified Ice Harbor fish ladder to provide upstream passage. Though surveys indicate that the habitat upstream of the Pawtucket Dam could support a run of one million shad annually, a 2002 study concluded that few shad are able to access this habitat even if they enter the project's tailrace area.

202. The preferred method for upstream passage at the Lowell Project is the fish lift at the powerhouse. Despite adjustments made to improve the performance of the fish lift during the 2010 season (including increasing the attraction flow to 125 cfs), recent counts indicate that only 8 percent of the river herring and 5 percent of the American shad that successfully pass the Essex dam (the first dam on the Merrimack River) are also able to successfully pass the Lowell project. These data suggest that further modifications to the facility may be warranted. Additionally, the Pawtucket Dam fish ladder is normally operated only when excess water is spilled at Pawtucket Dam. Flows through the fish ladder during operation are 200 cfs, including attraction flows; the ladder is designed to

[71] *See* 40 C.F.R. §1502.9(c)(1) (2012).

[72] Alewife and blueback herring are collectively referred to as "river herring."

operate at river flows up to 25,000 cfs. Because fish counts are not performed at the ladder, the passage efficiency of the Pawtucket Dam ladder has not been established.

203. As designed and in actual operation, the existing flashboard system that the Commission approved in 2008 has a higher frequency of failure compared to the pre-June 2008 system. During the migratory season, flashboard failures require impoundment drawdowns to facilitate repairs, which can delay the start of or interrupt ongoing fish passage measures by reducing the net head (and thus flow) in passage structures. In addition, flashboard system leaks or failure may introduce uncontrollable spillage at the dam, creating a false attraction for migrating fish and resulting in a greater period of time during which fish ladder operations are required. If the leakage or failure occurs at the eastern end of the dam, flows on the opposite side of the bypassed reach channel could exceed the fish ladder's 200-cfs attraction flow releases, creating a false attraction which may draw migrating fish away from the fish ladder approach channel. Fish attracted to the bypassed reach instead of the fish lift would be subject to passage delays if the fish ladder is not operating or subject to passage with an unknown efficiency if the fish ladder is operating.

204. In the EA, staff concluded that the proposed pneumatic crest gate system would minimize upstream passage delay or inefficiency at both the fish lift and the fish ladder, by eliminating false attraction flows that originate from wooden flashboard leaks or failures. This could result in greater use of upstream habitat for spawning and rearing by American shad and river herring, a beneficial cumulative effect. Federal and state fishery agencies on the Technical Committee from both New Hampshire and Massachusetts strongly support the proposed pneumatic crest gate to enhance upstream anadromous fish passage at the Lowell Project. As river herring are currently under review to determine if they warrant a "threatened" listing on the endangered species list,[73] ensuring expedient upstream migration to spawning grounds would benefit both species. Additionally, improved upstream passage would help with the establishment of a viable American shad fishery upstream of Lowell, thus enhancing fishing opportunities, increasing fishing license sales, and benefiting the local economy.

205. In order to protect upstream and downstream migrating fish during crest gate construction, staff recommended in the EA that the licensees follow time-of-year in-water restrictions. Therefore, the licensees should not perform in-water silt-producing work or work that would obstruct the waterway from April 1 to July 15 to protect upstream migrating fish, and the licensees' construction plans should allow for passage of downstream migrating fish from September 1 to November 15.

[73] "Listing Endangered and Threatened Wildlife and Plants; 90-Day Finding on a Petition to List Alewife and Blueback herring as Threatened Under the Endangered Species Act," 76 Fed. Reg. 67,652-67,656 (Nov. 2, 2011).

B. Resident Fish

206. The Merrimack River main stem supports a warm water resident fish community including smallmouth bass, largemouth bass, yellow perch, brown bullhead, chain pickerel, and various species of sunfish, minnows, and suckers. Most resident fish in the project impoundment are likely to spawn during June and July. Depending on the species, fish may either deposit eggs in nests built in shallow water habitats, or deposit eggs in habitats with appropriate submerged aquatic vegetation. Upon hatching, the young fry often remain closely associated with those habitats.

207. The current wooden flashboard system can cause both high impoundment levels, as the flashboards may not fail predictably, and low impoundment levels, because flashboard repair may require lowering the impoundment for work to occur. Fluctuations in the impoundment may have a detrimental impact on resident fish during spawning and early life stages, as habitats used during those life stages could be dewatered during drawdowns.

208. In the EA, staff concluded that the proposed pneumatic crest gate system would reduce the frequency of impoundment drawdowns from June through July, thus reducing the potential for shoreline-spawning, nest-building fish to have their nests dewatered during egg incubation. Additionally, staff found that reducing the number of drawdowns during August and September could also minimize stranding of fish fry that may either still be in shoreline nests or using shoreline submerged vegetation for cover. Consequently, up to 46 miles of near shore aquatic habitat could benefit from installing the proposed pneumatic crest gate system (the effect of drawdowns would attenuate with distance upstream from the dam). Resident fish upstream of the project would benefit from the reduced frequency of sudden and extended drawdowns, because the river would behave more like an unregulated river and nearshore spawning and nursery habitat would remain submerged.

C. Erosion and Sediment Control

209. The licensee's revised method for installing the proposed pneumatic gate crest system, filed with the Commission on February 2, 2012, is expected to result in little need for impoundment fluctuations during construction. However, it will still be necessary to draw down the impoundment to facilitate installing the cofferdam upstream of the dam, which could lead to release of silt and other sediment to the Merrimack River. If upstream migrating anadromous fish encounter substantial suspended sediment plumes, there may be delays in upstream passage until more natural conditions return. To ensure that construction activities have a minimal and temporary effect on sediment transport, and to minimize the potential for sedimentation to impact migratory fish passage, staff recommended in the EA and we agree that the licensee should develop an erosion and sediment control plan in consultation with the appropriate agencies and for Commission

approval. The plan should specify the best management practices it would implement to control erosion during construction, including details as to how work would be sequenced, how work areas would be dewatered, and how fines in the work area would be managed.

Administrative Conditions

210. The licensees included in their amendment application an Exhibit A project description and Exhibit F drawings reflecting the proposed project modifications. They did not file any Exhibit G drawings, because there would be no change in the project boundary. Ordering paragraph (E) approves the submitted Exhibit A. Ordering paragraph (C) approves the revised Exhibit F drawings as described in that paragraph. Ordering paragraph (D) requires filing of the approved exhibit drawings in specific aperture card and electronic formats.

211. Additionally, Article 304 requires the licensees to file as-built exhibit drawings within 90 days of the completion of construction authorized by this order.

Conclusion

212. As discussed above, we find that the proposed amendment will provide substantial benefits in the form of improved flood control, recreation, fish passage, dam and worker safety and renewable generation, without unacceptably altering or affecting historical properties. We therefore approve it.

The Commission orders:

(A) Boott Hydropower, Inc.'s and Eldred L. Field Hydroelectric Facility Trust's (licensees') application for amendment of license for the Lowell Hydroelectric Project filed on July 6, 2010, and supplemented on March 21, 2011, and February 2, 2012, is approved as provided in this order, effective the day this order is issued.

(B) The project description in ordering paragraph (B)(2) of the April 13, 1983 order issuing a license for the Lowell Project is revised to read in part:

> (2) Project works consisting of: (1) the 1,093-foot-long and 15-foot-high Pawtucket Dam with a 5-foot-high pneumatic crest gate system; (2) a reservoir with a storage capacity of 3,960 acre-feet; (3) the 5.5-mile-long Northern and Pawtucket Canal System; (4) four power stations with a total installed capacity of 7,515 kilowatts (kW) housed in nineteenth century mill buildings along the canal system; and (5) a new power station with an installed capacity of 17,308 kW drawing water from the Northern Canal.

(C) The following exhibit F drawings filed on March 21, 2011, conform to Commission's rules and regulations are approved and are approved and made part of the

license, as labeled and numbered below:

Exhibit	FERC Drawing No.	Title	Superseding
F-6	2790-51	Pawtucket Dam Pan, Elevation and Sections	2790-10
F-51	2790-52	Pawtucket Dam Proposed Crest Gate System	-
F-52	2790-53	Pawtucket Dam Proposed Crest Gate System	-
F-53	2790-54	Pawtucket Dam Proposed Crest Gate System	-
F-54	2790-54	Pawtucket Dam Proposed Crest Gate System	-
F-55	2790-55	Pawtucket Dam Proposed Crest Gate System	-

Superseded Drawing 2790-10 is eliminated from the license.

(D) Within 45 days of the date of issuance of this order, the licensee shall file the exhibit drawings approved in ordering paragraph (C) in aperture card and electronic file formats. (a) Three sets of the approved exhibit drawings shall be reproduced on silver or gelatin 35mm microfilm. All microfilm shall be mounted on type D (3-1/4" X 7-3/8") aperture cards. Prior to microfilming, the FERC Project-Drawing Number (i.e., P- 2790-51) shall be shown in the margin below the title block of the approved drawing. After mounting, the FERC Drawing Number shall be typed on the upper right corner of each aperture card. Additionally, the Project Number, FERC Exhibit (i.e., F-6), Drawing Title, and date of this order shall be typed on the upper left corner of each aperture card. See Figure 2.

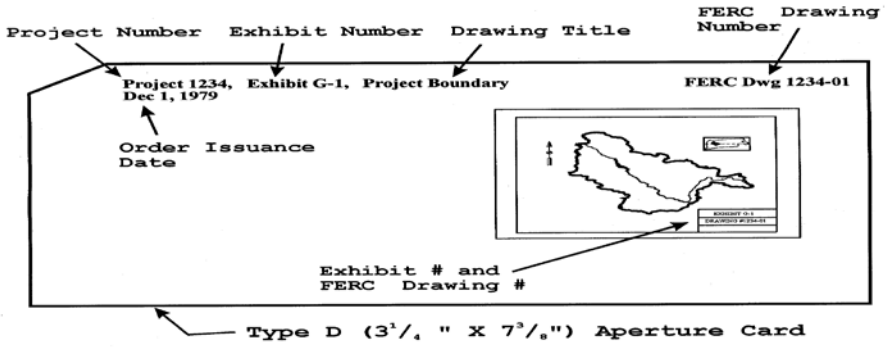

Figure 2.

Two of the sets of aperture cards shall be filed with the Secretary of the Commission, ATTN: OEP/DHAC. The third set shall be filed with the Commission's Division of Dam Safety and Inspections New York Regional Office.

(b) The licensee shall file two separate sets of exhibit drawings in electronic raster format with the Secretary of the Commission, ATTN: OEP/DHAC. A third set shall be filed with the Commission's Division of Dam Safety and Inspections New York Regional Office. Exhibit F drawings must be identified as (CEII) material under 18 CFR §388.113(c). Each drawing must be a separate electronic file, and the file name shall include: FERC Project-Drawing Number, FERC Exhibit, Drawing Title, date of this order, and file extension in the following format [P-2790-51, F-6, Pawtucket Dam Pan, Elevation and Sections, MM-DD-YYYY.TIF]. Electronic drawings shall meet the following format specification:

IMAGERY - black & white raster file
FILE TYPE – Tagged Image File Format, (TIFF) CCITT Group 4
RESOLUTION – 300 dpi desired, (200 dpi min)
DRAWING SIZE FORMAT – 24” X 36” (min), 28” X 40” (max)
FILE SIZE – less than 1 MB desired

(E) Pages A-1 through A-9 of the Exhibit A filed with the amendment application are approved.

(F) The licensees shall follow time-of-year in-water restrictions for the protection upstream and downstream migrating fish. The licensees shall not perform in-water silt-producing work or work that would obstruct the waterway from April 1 to July 15, and the licensee’s construction plans shall allow for passage of downstream migrating fish from September 1 to November 15.

(G) Within 90 days from the order of this order, the licensees shall submit for Commission approval a detailed plan for the operation of the crest gate system with specific details on the position of the system with corresponding pool elevations at varying river flows.

(H) To mitigate any adverse effects on historic properties of installing the pneumatic crest gate system, the licensees shall consult with the Massachusetts State Historic Preservation Officer and the Lowell National Historical Park to the extent possible, and shall implement the following measures:

(a) The licensees shall design and install two interpretive exhibits, one featuring a replica of the original flashboard system and one featuring the new crest gate system, to be located at the Project to enhance visitor understanding of the history of Pawtucket Dam and the Lowell

Hydroelectric Project. To the extent possible, the licensees will develop the interpretive displays and determine their location in consultation with the National Park Service.

(b) The licensees shall design the compressor house with materials and colors that are compatible with the historic fabric of the adjacent architecture, to ensure that the compressor house resembles nineteenth century buildings in Lowell, particularly the nearby Northern Canal Gatehouse.

(c) To mimic the existing dam's appearance, the licensees shall use a brown-colored bladder, paint the downstream side of the crest gate panels brown, and install black retaining straps an average of 20 inches on center, to ensure that the crest gate system is similar in appearance to the existing wooden flashboards.

(d) These activities shall be carried out under the authority of the Commission by or under the direct supervision of a person or persons meeting at a minimum the Secretary of Interior's Professional Qualifications Standards (48 Fed. Reg. 44738-39) in the appropriate discipline. However, nothing in this requirement may be interpreted to preclude the Commission or any agent or contractor thereof from using the properly supervised services of persons who do not meet the Professional Qualifications Standards.

(I) The licensee is also subject to the following additional articles:

Article 301. Start of Construction. The licensees shall commence construction of the project works authorized by this order within 2 years from the issuance date of this order and shall complete construction within 4 years from the issuance date of this order.

Article 302. Commission's Review of Contract Plans and Specifications. At least 60 days prior to the start of any construction, the licensees shall submit one copy of its plans and specifications and a supporting design document to the Commission's Division of Dam Safety and Inspections (D2SI) – New York Regional Engineer, and two copies to the Commission (one of these shall be a courtesy copy to the Director, D2SI). The submittal to the D2SI-New York Regional Engineer must also include as part of pre-construction requirements: a Quality Control and Inspection Program, Temporary Construction Emergency Action Plan, and Soil Erosion and Sediment Control Plan. The licensees may not begin any land-disturbing activities until the D2SI – New York Regional Engineer has reviewed and commented on the plans and specifications, determined that all preconstruction requirements have been satisfied, and authorized the start of construction.

The Soil Erosion and Sediment Control Plan shall specify the best management practices the licensee will implement to control erosion during construction, including, at

a minimum, details as to how work would be sequenced, how work areas would be dewatered, and how fines in the work area would be managed. The plan shall be developed in consultation with the National Marine Fisheries Service, U.S. Fish and Wildlife Service, National Park Service, Massachusetts Division of Fisheries and Wildlife, Massachusetts Division of Marine Fisheries, Massachusetts Department of Environmental Protection, and New Hampshire Department of Fish and Game, and the plan shall be provided to the agencies for a minimum 30 day comment period. The plan must include agency comments and the licensee's response to agency comments.

Article 303. *Cofferdam Construction*. The licensees shall review and approve the design of contractor-designed cofferdams and deep excavations prior to the start of construction and shall ensure that construction of cofferdams and deep excavations are consistent with the approved design. At least 30 days before starting construction of any cofferdams or deep excavations, the licensees shall submit one copy to the Commission's Division of Dam Safety and Inspections (D2SI) – New York Regional Engineer and two copies to the Commission (one of these copies shall be a courtesy copy to the Commission's Director, D2SI), of the approved cofferdam and deep excavation construction drawings and specifications, and the letters of approval.

Article 304. *As-built Exhibits*. Within 90 days of completion of construction of the facilities authorized by this order, the licensees shall file for Commission approval, revised Exhibits A, F, and G, as applicable, to describe and show those project facilities as built. A courtesy copy shall be filed with the Commission's Division of Dam Safety and Inspections (D2SI) – New York Regional Engineer; the Director, D2SI; and the Director, Division of Hydropower Administration and Compliance.

(J) The licensees' request to modify the flashboard design during interim period between the approval of the amendment and completion of construction of the crest gate system is denied. The flashboard configuration shall remain the same as it has been in place since July 2008.

(K) The licensee shall serve copies of any Commission filing required by this order on any entity specified in the order to be consulted on matters related to that filing. Proof of service on these entities must accompany the filing with the Commission.

(L) This order constitutes final agency action. Any party may file a request for rehearing of this order within 30 days from the date of its issuance, as provided in section 313(a) of the FPA, 16 U.S.C. § 825*l* (2006), and section 385.713 of the

Commission's regulations, 18 C.F.R. § 385.713 (2012). The filing of a request for rehearing does not operate as a stay of the effective date of this amendment or of any other date specified in this order. The licensee's failure to file a request for rehearing shall constitute acceptance of this order.

By the Commission.

(S E A L)

Nathaniel J. Davis, Sr.,
Deputy Secretary.

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Boott Hydropower, Inc., and
Eldred L. Field Hydroelectric Facility Trust

Project No. 2790-055

ERRATA NOTICE

(Issued May 2, 2013)

On April 18, 2013, the Commission issued an *Order Amending License*, 143 FERC ¶ 61,048, in this proceeding. Ordering paragraph (C) contained duplicative words, an incorrect drawing title, and incorrect drawing numbers. This errata notice revises ordering paragraph (C) to renumber the drawing numbers, correct the drawing title of Exhibit F-6, and delete the duplicative words "are approved" after the word "regulations" in the first sentence. Ordering paragraph (C) is revised to read as follows:

(C) The following exhibit F drawings filed on March 21, 2011, conform to the Commission's rules and regulations and are approved and made part of the license, as labeled and numbered below:

Exhibit	FERC Drawing No.	Title	Superseding
F-6	2790-51	Pawtucket Dam Plan, Elevation and Sections	2790-10
F-51	2790-52	Pawtucket Dam Proposed Crest Gate System	-
F-52	2790-53	Pawtucket Dam Proposed Crest Gate System	-
F-53	2790-54	Pawtucket Dam Proposed Crest Gate System	-
F-54	2790-55	Pawtucket Dam Proposed Crest Gate System	-
F-55	2790-56	Pawtucket Dam Proposed Crest Gate System	-

Superseded Drawing 2790-10 is eliminated from the license.

Charles K. Cover, P.E.
Acting Chief, Engineering Resources Branch
Division of Hydropower Administration
and Compliance

Appendix F - USDA Soil Series Descriptions

LOCATION AGAWAM MA+CT NH NY RI VT

Established Series
REV. WHT-CAW-SMF
01/2013

AGAWAM SERIES

The Agawam series consists of very deep, well drained soils formed in sandy, water deposited materials. They are level to steep soils on outwash plains and high stream terraces. Slope ranges from 0 to 15 percent. Saturated hydraulic conductivity is moderately high or high in the upper solum and high or very high in the lower solum and substratum. Mean annual temperature is about 48 degrees F. and mean annual precipitation is about 47 inches.

TAXONOMIC CLASS: Coarse-loamy over sandy or sandy-skeletal, mixed, active, mesic Typic Dystrudepts

TYPICAL PEDON: Agawam fine sandy loam in a nearly level cultivated field at an elevation of about 124 feet. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 11 inches; dark grayish brown (10YR 4/2) fine sandy loam; light brownish gray (10YR 6/2) dry; weak medium and coarse subangular blocky structure; very friable; common fine and medium roots; strongly acid; abrupt smooth boundary. (5 to 14 inches thick)

Bw1--11 to 16 inches; dark yellowish brown (10YR 4/4) fine sandy loam; weak medium and coarse subangular blocky structure; very friable; common fine and medium roots; strongly acid; abrupt smooth boundary.

Bw2--16 to 26 inches; light olive brown (2.5Y 5/4) fine sandy loam; weak medium subangular blocky structure; very friable; common fine and medium roots; strongly acid; clear smooth boundary. (Combined thickness of the Bw horizons is 10 to 30 inches)

2C1--26 to 45 inches; olive(5Y 5/3) loamy fine sand; massive; very friable; few fine roots; strongly acid; clear smooth boundary.

2C2--45 to 55 inches; olive brown (2.5Y 4/4) loamy fine sand; massive; very friable; strongly acid; abrupt smooth boundary.

2C3--55 to 65 inches; olive (5Y 5/3) loamy sand; single grain; loose; strongly acid.

TYPE LOCATION: Hampshire County, Massachusetts; Town of Hatfield; 700 feet north of Elm Street at a point 1,600 feet west of its intersection with Prospect Street. USGS Mt. Holyoke quadrangle; Lat. 42 degrees 22 minutes 00 seconds N. and 72 degrees 36 minutes 42 seconds W., NAD 27.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 15 to 35 inches. Coarse fragments range from 0 to 10 percent by volume in the surface, 0 to 30 percent in the B and C horizons above a depth of 40 inches and 0 to 60 percent below. The soil ranges from very strongly acid to slightly acid, unless limed.

The Ap horizon has hue of 7.5YR to 2.5Y, value of 3 or 4, and chroma of 2 to 4. Dry value is 6 or more. It is fine sandy loam, very fine sandy loam, or loam. Undisturbed pedons have an A horizon that has hue of 7.5YR to 2.5Y, value of 2 to 3, and chroma of 1 to 3. It is 1 to 4 inches thick. Some pedons have a thin E horizon directly below the A.

The upper part of the Bw horizon has hue of 5YR to 10YR, value of 4 to 7, and chroma of 3 to 8. The lower part has hue of 10YR to 5Y with value and chroma ranges the same as the upper part. Texture is fine sandy loam, very fine sandy loam, or loam in the upper part and fine sandy loam or very fine sandy loam in the lower part. Structure is very weak, weak or moderate granular or subangular blocky or the horizon is massive.

A BC horizon of sandy loam or loamy sand is present in some pedons. Color and texture ranges are the same as the lower part of the Bw. Structure is very weak, weak or moderate granular or the horizon is massive. It is up to 5 inches thick.

The C horizon has hue of 10YR to 5Y, value of 3 to 7, and chroma of 1 to 4. It is stratified loamy fine sand, loamy sand, fine sand, sand, or their gravelly analogues and is very gravelly below a depth of 40 inches in some pedons. Consistence is very friable or loose.

COMPETING SERIES: These are the Barnstable, Branford, Haven, and Narragansett series. Barnstable soils formed in till over outwash and have rock fragments in the solum that are dominantly angular. Branford soils have hue of 5YR or redder throughout the B and C horizons. Narragansett soils lack stratified layers and have coarse fragments that are dominantly angular. Haven soils typically have more than 40 percent silt in the lower part of the Bw horizon.

GEOGRAPHIC SETTING: Agawam soils are level to steep soils on outwash plains and high stream terraces. Most areas are on slopes that are less than 15 percent. Steeper slopes are on terrace escarpments and steep sides of gullies in dissected outwash plains. The soils formed in sandy water deposited material derived principally from schist, granite, gneiss, and phyllite. Mean annual precipitation ranges from 28 to 55 inches and mean annual air temperature from 45 degrees to 50 degrees F. The mean growing season ranges from 120 to 200 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Enfield, Hadley, Hartland, Hinckley, Merrimac, Ninigret, Occum, Walpole, and Windsor soils on nearby landscapes. The excessively drained Hinckley and Windsor, somewhat excessively drained Merrimac, and well drained Enfield and Hartland soils are on associated outwash terraces and glacial lake plains. Well drained Hadley and Occum soils are on nearby floodplains. The moderately well drained Ninigret and poorly drained Walpole soils are associated in a drainage sequence with Agawam soils.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. Runoff and internal drainage are negligible to low. Saturated hydraulic conductivity is moderately high or high in the upper solum and high or very high in the lower solum and substratum.

USE AND VEGETATION: Most areas are used for growing cultivated hay, silage corn, tobacco, potatoes, and truck crops. Some areas are used for growing pasture. Native vegetation is forest composed mainly of white pine, gray birch, red maple, red, white, black, and scarlet oaks.

DISTRIBUTION AND EXTENT: Connecticut, Massachusetts, New Hampshire, eastern New York, and Rhode Island; MLRA's 101, 142, 144A, and 145. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Hampden and Hampshire Counties, Massachusetts, 1928.

REMARKS: It should be noted that as a competing series, Haven soils typically have soil temperatures that may be slightly warmer but a precise difference could not be quantified based on available data and historical use.

Diagnostic horizons and other features recognized in this pedon are:

1. Ochric epipedon - the zone from 0 to 11 inches (Ap horizon).
2. Cambic horizon - the zone from 11 to 26 inches (Bw horizons).
3. Contrasting particle-size - the coarse-loamy material contains less than 50 percent fine or coarser sand and the transition zone is less than 12.5 cm thick.

ADDITIONAL DATA: Reference samples from pedons S54MA023006, S58MA011002, S57NH013003, S70CT003001, S85VT027017, S85VT027018, S91MA011008, S93MA011003, S93MA011003, S93MA011004 from numerous counties and states, by NSSL, Lincoln, NE, various years. Pedon S70 CT-3-1 sampled in Hartford, Connecticut. Analysis by Beltsville soil survey laboratory.

National Cooperative Soil Survey
U.S.A.

LOCATION BELGRADE MA+CT NH NY VT
Established Series
Rev. WHT-CAW-MFF
06/2007

BELGRADE SERIES

The Belgrade series consists of very deep, moderately well drained soils formed in glaciolacustrine material. They are nearly level to moderately steep soils on terraces. Slope ranges from 0 to 25 percent. Saturated hydraulic conductivity is moderately high or high in the solum and moderately low to high in the substratum. Mean annual precipitation is about 44 inches, and the mean annual temperature is about 49 degrees F.

TAXONOMIC CLASS: Coarse-silty, mixed, active, mesic Aquic Dystric Eutrudepts

TYPICAL PEDON: Belgrade silt loam - on a 1 percent slope in a cultivated field at an elevation of about 8 meters. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 9 inches; very dark grayish brown (10YR 3/2) very fine sandy loam, light brownish gray (10YR 6/2) dry; very weak fine and medium granular structure; very friable; many fine roots; slightly acid; abrupt smooth boundary. (5 to 10 inches thick)

Bw1--9 to 20 inches; yellowish brown (10YR 5/6) very fine sandy loam; weak fine granular structure; very friable; common fine roots; slightly acid; clear wavy boundary. (6 to 32 inches thick)

BC--20 to 30 inches; light olive brown (2.5Y 5/4) very fine sandy loam; massive; very friable; few very fine roots; common prominent distinct strong brown (7.5YR 5/6) masses of iron accumulation and gray (5Y 5/1) iron depletions; slightly acid; clear wavy boundary. (0 to 12 inches thick)

C1--30 to 42 inches; light olive brown (2.5Y 5/4) very fine sandy loam; massive; very friable; many medium and coarse prominent yellowish red (5YR 4/6) and strong brown (7.5YR 5/6) masses of iron accumulation, and gray (5Y 6/1) iron depletions; slightly acid; abrupt wavy boundary.

C2--42 to 65 inches; gray (5Y 6/1) loamy very fine sand; massive; very friable; common lenses of fine sand; many coarse prominent yellowish red (5YR 4/6) and strong brown (7.5YR 5/6) masses of iron accumulation; neutral.

TYPE LOCATION: Essex County, Massachusetts; Town of Amesbury, 3.2 miles southwest of Amesbury Village, 550 feet north of Pleasant Valley Road and 700 feet east of Amesbury-Merrimac town line. Lat. 42 degrees 49 minutes 30 seconds N., and long. 70 degrees 58 minutes 04 seconds W., NAD 27.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 20 to 44 inches. Reaction ranges from very strongly acid to neutral in the solum and from moderately acid to slightly alkaline in the C horizon; however, some subhorizon between depths of 10 and 30 inches is moderately acid to neutral. Redox depletions with a chroma of 2 or less are within a depth of 24 inches (60 cm). Gravel content ranges from 0 to 5 percent to a depth of 40 inches and 0 to 30 percent below 40 inches.

The Ap horizon has hue of 10YR, value of 3 or 4, and chroma of 2 to 4. Dry value is 6 or more. It is silt loam or very fine sandy loam. Undisturbed areas have an A horizon with colors and textures similar to the Ap.

The Bw horizon has hue of 10YR to 5Y, value of 4 or 5, and chroma of 3 to 6. Some pedons have lower Bw horizons with hue of 10YR to 5Y, value of 4 to 6, and chroma of 2 to 6, with common or many redoximorphic features. The Bw horizon is typically silt loam or very fine sandy loam but includes loamy very fine sand. Structure is weak coarse prismatic, weak fine subangular blocky or weak or moderate, fine or medium granular, or the horizon is massive. Consistence ranges from firm to very friable.

The BC horizon, where present, has characteristics similar to those of the lower Bw horizons.

The C horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 to 4. It is silt loam, very fine sandy loam, or loamy very fine sand in the fine-earth fraction. Some pedons have thin strata of loamy fine sand, fine sand, or silt. Below a depth of 40 inches some pedons have unconforming strata of sand or sand and gravel, or very thin strata or varves of contrasting material. The C horizon has common to many redoximorphic features. It is usually massive, but some pedons have platy structure. Consistence ranges from firm to loose.

COMPETING SERIES: There are no other series in this family. The Bridgehampton, Boxford, Dartmouth, Enfield, Georgia, Hartland, Raynham, Scio, Suffield, Tisbury, Unadilla, and Wapping are similar soils in related families. Boxford soils are fine. Georgia soils are coarse-loamy. Suffield soils are coarse-silty over clayey. Bridgehampton, Dartmouth, Enfield, Scio, Tisbury, Unadilla, and Wapping soils have base saturation of less than 60 percent in the upper 30 inches. In addition, Enfield and Tisbury soils have sand and gravel within a depth of 40 inches. Hartland soils do not have redox depletions within a depth of 24 inches. Raynham soils have dominant chroma of 2 or less within a depth of 20 inches.

GEOGRAPHIC SETTING: Belgrade soils are nearly level to moderately steep soils on glaciolacustrine terraces. Slope ranges from 0 to 25 percent. The upper part of the soil formed in water or wind deposited material high in silt and very fine sand. The material below 40 inches is variable and ranges from gravelly sand to silt. Mean annual temperature ranges from 45 to 52 degrees F. and mean annual precipitation ranges from 40 to 47 inches. The frost free season ranges from 135 to 195 days.

GEOGRAPHICALLY ASSOCIATED SOILS: Belgrade soils are in a drainage sequence with the well drained Hartland, poorly drained Raynham, and very poorly drained Birdsall soils. Agawam, Deerfield, Enfield, Haven, Merrimac, Ninigret, Sudbury, Tisbury, and Windsor soils

are on nearby glacial outwash landforms. Hadley, Limerick, Occum, Pootatuck, Rippowam, and Winooski soils are on nearby flood plains.

DRAINAGE AND PERMEABILITY: Moderately well drained. Runoff is negligible to high. Saturated hydraulic conductivity is moderately high or high in the solum and moderately low to high in the substratum.

USE AND VEGETATION: Most areas are cleared and are used mainly for growing grasses, and legumes for hay or pasture, and for silage. Some areas are used for growing potatoes, sweet corn, vegetables, and other crops and some areas are used as urban land. Common trees in woodlots are white, red and black oak, hickory, sugar maple, red maple, ash, tulip, black birch, yellow birch, beech, white pine, and hemlock.

DISTRIBUTION AND EXTENT: Massachusetts, New Hampshire, New York, and Vermont (MLRAs 142, 144A, 144B, 145, and 149B). The soil is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Hartford County, Connecticut, 1959.

REMARKS: Diagnostic horizons and features recognized in this pedon are:

1. Ochric epipedon - the zone from the soil surface to a depth of 9 inches (Ap horizon).
2. Cambic horizon - the zone from 9 to 30 inches (Bw and BC horizon).
3. Coarse-silty feature - the zone from 10 to 40 inches contains less than 15 percent sand that is coarser than very fine sand, including gravel, and about 5 to 10 percent clay (Bw, BC and Cl horizons).

National Cooperative Soil Survey
U.S.A.

LOCATION CANTON MA+CT NH NY RI

Established Series
Rev. DAS-DCP-MCT-DHZ
05/2016

CANTON SERIES

The Canton series consists of very deep, well drained soils formed in a loamy mantle underlain by sandy till. They are on nearly level to very steep moraines, hills, and ridges. Slope ranges from 0 to 45 percent. Saturated hydraulic conductivity is moderately high or high in the solum and high or very high in the substratum. The mean annual temperature is about 9 degrees C and the annual precipitation is about 1205 mm.

TAXONOMIC CLASS: Coarse-loamy over sandy or sandy-skeletal, mixed, superactive, mesic Typic Dystrudepts

TYPICAL PEDON: Canton fine sandy loam on a west-facing, convex, 8 percent slope in an extremely stony forested area at an elevation of about 210 meters. (Colors are for moist soil unless otherwise noted.)

Oi-- 0 to 5 cm; slightly decomposed plant material; (0 to 13 cm thick.)

A-- 5 to 13 cm; very dark grayish brown (10YR 3/2) fine sandy loam; weak fine granular structure; friable; common fine roots; 5 percent gravel; very strongly acid (pH 4.6); abrupt smooth boundary. (3 to 10 cm thick.)

Bw1-- 13 to 30 cm; yellowish brown (10YR 5/6) fine sandy loam; weak medium subangular blocky structure; friable; common fine and medium roots; 5 percent gravel; very strongly acid (pH 4.6); clear smooth boundary.

Bw2-- 30 to 41 cm; yellowish brown (10YR 5/4) fine sandy loam; weak medium subangular blocky structure; friable; common fine and medium roots; 5 percent gravel; strongly acid (pH 5.1); clear smooth boundary.

Bw3-- 41 to 56 cm; yellowish brown (10YR 5/4) gravelly fine sandy loam; weak medium subangular blocky; friable; common fine and medium roots; 15 percent gravel; strongly acid (pH 5.1); abrupt smooth boundary. (Combined thickness of the Bw horizons is 43 to 84 cm.)

2C-- 56 to 170 cm; grayish brown (2.5Y 5/2) gravelly loamy sand; massive; friable; 25 percent gravel; moderately acid (pH 5.6).

TYPE LOCATION: Worcester County, Massachusetts; Town of Douglas; 150 feet south on Wallum Lake Road from the junction of Cedar and South West Main Streets, and 165 feet

southwest of Wallum Lake Road. USGS Oxford, MA quadrangle; Latitude 42 degrees, 2 minutes, 43.2 seconds N., and Longitude 71 degrees, 45 minutes, 44.8 seconds W., NAD 83.

RANGE IN CHARACTERISTICS: Solum thickness is commonly 46 to 91 cm, but ranges to 36 cm. It corresponds closely to the depth to the sandy till. Rock fragment content consists of 0 to 20 percent gravel and 0 to 5 percent cobbles in the solum. Stones and boulders are 0 to 15 percent of the surface and solum. Gravel content is 10 to 30 percent, cobbles 5 to 10 percent, and stones 0 to 10 percent in the substratum. Rock fragments are dominantly granite, gneiss, and quartzite. The soil ranges from extremely acid to moderately acid.

The O horizons, where present, consist of slightly, moderately, and/or highly decomposed organic material.

The A horizon has hue of 7.5YR or 10YR, value of 2 to 4, and chroma of 1 to 3. Texture is sandy loam, fine sandy loam, loam, or very fine sandy loam in the fine-earth fraction. Some pedons have an Ap horizon with properties similar to the A horizon. It is up to 20 cm thick.

Some pedons have a thin E or AE horizon that has hue of 7.5YR or 10YR, value of 3 to 5 and chroma of 1 or 2 with similar textures to the A horizon. It is up to 8cm thick.

The upper Bw horizons commonly have hue of 10YR, and includes 7.5YR when a high ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron (greater than 0.15) exists, value of 4 or 5, and chroma of 4 to 8. The lower Bw horizons have hue of 10YR or 2.5Y, value of 4 to 7, and chroma of 4 to 8. Texture of the fine-earth fraction of the Bw horizons is commonly fine sandy loam and less commonly sandy loam, loam, and very fine sandy loam. Structure of the Bw horizons is granular or subangular blocky.

Some pedons have a Bs, Bh, or BC horizon with texture similar to the Bw horizons.

The 2C horizon typically has hue of 2.5Y or 5Y, value of 5 to 7, and chroma of 2 or 3. In some pedons hue is 10YR with chroma of 4 to 6. The texture of the fine-earth fraction is loamy fine sand or coarser. It is single grain or massive. Consistence is friable, very friable or loose. Thin lenses or small pockets of firm or very firm finer textured material are common below 91 cm.

COMPETING SERIES: There are no other soils currently in the same family.

The Agawam, Barnstable, Branford, Brookfield, Charlton, Haven, and Narragansett series are in closely related families. The Agawam, Branford, and Haven soils have stratified sand or sand and gravel in the series control section. In addition, the Branford soils have hues redder than 7.5YR throughout the B horizon. Barnstable soils formed in till over outwash and have less than 30 percent fine sand in the lower part of the Bw horizon. Brookfield soils formed in sulfur bearing parent materials and have a ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron less than 0.15 and have pedogenic iron contents greater than 1 percent throughout the pedon. Charlton soils lack a lithologic discontinuity of abrupt change in sand distribution. Narragansett soils have more than 55 percent silt and very fine sand in the solum.

GEOGRAPHIC SETTING: Canton soils are on moraines and glaciated upland hills and ridges. Slope ranges from 0 to 45 percent. The soils formed in an acid coarse loamy supraglacial melt out till over loose sandy till of Wisconsin age derived from gneiss, granite and schist along with some fine-grained sandstone in some pedons. The loamy mantle in some pedons is influenced or derived from eolian sources. The climate is humid temperate. The mean annual air temperature is 7 to 11 degrees C, and the mean annual precipitation ranges from 1016 to 1295 mm.

GEOGRAPHICALLY ASSOCIATED SOILS: The Newfields series is the moderately well drained member of the same toposequence. The Agawam, Haven, Merrimac, and Warwick soils are on nearby glacial outwash kames and plains. The Barnstable, Brookfield, Charlton, Cheshire, Dutchess, Gloucester, Hollis, Montauk, Narragansett, and Paxton soils are on nearby glaciated uplands. Brookfield, Charlton, Cheshire, Dutchess, Gloucester, Hollis, Montauk, and Paxton soils do not have a contrasting particle size in the control section.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. Runoff is negligible to medium. Internal drainage is medium. Saturated hydraulic conductivity is moderately high or high in the solum and high or very high in the substratum.

USE AND VEGETATION: Mostly forested. Some areas have been cleared of surface stones and are used for crops and pasture. Native vegetation is forest composed of eastern white pine, northern red, white, and black oaks, hickory, red maple, sugar maple, gray birch, yellow birch, beech, eastern hemlock, and white ash.

DISTRIBUTION AND EXTENT: Glaciated uplands in Connecticut, Massachusetts, New Hampshire, eastern New York, and Rhode Island, also in the Massachusetts Coastal Islands; MLRAs 144A, 145, and 149B. The series is of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Herkimer County, New York, 1969.

REMARKS:

Diagnostic horizons and features recognized in this pedon are:
1) Ochric epipedon - the zone from 0 to 13 cm (Oi and A horizons).
2) Cambic horizon - the zone from 13 to 56 cm (Bw1, Bw2, and Bw3 horizons).
3) Contrasting particle size - the coarse-loamy material contains less than 50 percent fine sand or coarser, and the transition zone between the two parts of the particle-size control section is less than 12 cm thick. (Coarse-loamy over sandy or sandy skeletal).
4) Lithologic discontinuity - abrupt change in sand distribution at 56 cm (2C horizon).
6) Particle-size control section - the zone from 30 to 105 cm (Bw1, Bw2, Bw3, and 2C horizons).

ADDITIONAL DATA: M.S. Thesis work by Shawn McVey, University of Connecticut, 2006. Full characterization data for sample no. S1982CT007001, S1999CT013001, S1999CT013004, S2000CT007003, S2004CT011003, and pedons of similar soils is available through the National

Cooperative Soil Survey Soil Characterization Database:
http://ncsslabdatamart.sc.egov.usda.gov/

National Cooperative Soil Survey
U.S.A.

LOCATION CHARLTON CT+MA NH NY RI

Established Series
Rev. SJM-DCP-SMF
05/2016

CHARLTON SERIES

The Charlton series consists of very deep, well drained soils formed in loamy melt-out till. They are nearly level to very steep soils on moraines, hills, and ridges. Slope ranges from 0 to 60 percent. Saturated hydraulic conductivity is moderately high or high. Mean annual temperature is about 9 degrees C and mean annual precipitation is about 1205 mm.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, mesic Typic Dystrudepts

TYPICAL PEDON: Charlton fine sandy loam - forested, very stony, at an elevation of about 170 meters. (Colors are for moist soil unless otherwise noted.)

Oe -- 0 to 4 cm; black (10YR 2/1) moderately decomposed forest plant material. (0 to 5 cm thick.)

A -- 4 to 10 cm; dark brown (10YR 3/3) fine sandy loam; weak fine granular structure; very friable; many fine roots; 5 percent gravel; very strongly acid; abrupt smooth boundary. (2 to 15 cm thick.)

Bw1 -- 10 to 18 cm; brown (7.5YR 4/4) fine sandy loam; weak coarse granular structure; very friable; many fine and medium roots; 5 percent gravel; very strongly acid; clear wavy boundary.

Bw2 -- 18 to 48 cm; yellowish brown (10YR 5/6) fine sandy loam; weak medium subangular blocky structure; very friable; common fine and medium roots; 10 percent gravel and cobbles; very strongly acid; clear wavy boundary.

Bw3 -- 48 to 69 cm; light olive brown (2.5Y 5/4) gravelly fine sandy loam; massive; very friable; few medium roots; 15 percent gravel and cobbles; very strongly acid; abrupt wavy boundary. (Combined thickness of the Bw horizons is 35 to 91 cm.)

C -- 69 to 165 cm; grayish brown (2.5Y 5/2) gravelly fine sandy loam with thin lenses of loamy sand; massive; friable, some lenses firm; few medium roots; 25 percent gravel and cobbles; strongly acid.

TYPE LOCATION: New Haven County, Connecticut; town of Middlebury, 3800 feet along Long Meadow Road from the intersection with South Street, 450 feet southeast along a gravel road and 50 feet west of the gravel road, 400 feet northeast of Long Meadow Pond, in a wooded area. USGS Naugatuck topographic quadrangle, Latitude 41 degrees 29 minutes 48.40 seconds

N., Longitude 73 degrees 7 minutes 04.59 seconds W., NAD 1983.

RANGE IN CHARACTERISTICS: Thickness of the solum ranges from 31 to 109 cm. Depth to bedrock is commonly more than 180 cm. Rock fragments range from 5 to 35 percent by volume to a depth of 100 cm and up to 50 percent below 100 cm. Except where the surface layer is stony, the fragments are mostly subrounded gravel and typically make up 60 percent or more of the total rock fragments. Unless limed, reaction ranges from extremely acid to moderately acid.

The O horizon, where present, ranges from slightly decomposed to highly decomposed plant material.

The A horizon has hue of 7.5YR or 10YR, value of 2 or 3, and chroma of 1 to 3. Disturbed pedons have an Ap horizon with value of 3 or 4 and chroma of 2 to 4. The A or Ap horizon is sandy loam, fine sandy loam, or loam in the fine-earth fraction. It has weak or moderate granular structure and is friable or very friable.

Some pedons have a thin AE or E horizon below the O horizon or a thin E horizon below the A horizon. It has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 to 3. Texture, structure, and consistence are like the A horizon.

The upper part of the Bw horizon has commonly hue of 7.5YR or 10YR, and includes 7.5YR when a high ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron (greater than 0.15) exists, and value and chroma of 4 to 6. The lower part of the Bw horizon has hue of 10YR or 2.5Y and value and chroma of 4 to 6. Texture of the Bw horizon is loam, fine sandy loam, or sandy loam with less than 65 percent silt plus very fine sand in the fine earth fraction. It has weak granular or subangular blocky structure. Consistence is friable or very friable.

Some pedons have a BC horizon with value and chroma like the lower part of the Bw horizon, but includes hue of 5Y. The BC horizon commonly has texture, structure, and consistence like the Bw horizon but the range includes geologically derived structure appearing in the form of thin plates.

The C horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 2 to 6. Texture is loam, fine sandy loam, or sandy loam in the fine-earth fraction, with pockets or thin lenses of loamy sand. The horizon is massive or has plates of geogenic origin. Consistence commonly is very friable or friable but in some pedons includes firm.

COMPETING SERIES: These are Chadakoin, Chatfield, Maplecrest, Riverhead, Stinger and Valois. Chadakoin and Valois soils formed in till derived primary from sedimentary rock parent materials. Chatfield soils have a lithic contact at 50 to 100 cm below the mineral soil surface. Maplecrest soils formed in till derived from red sedimentary rock parent materials. Riverhead soils formed in glacial outwash deposits and have sandy textures in the substratum. Stinger soils are moderately deep to a paralithic contact and formed in colluvium on mountain side slopes in Oregon.

GEOGRAPHIC SETTING: Charlton soils are nearly level to very steep soils on moraines and glaciated upland hills and ridges. Slope ranges from 0 to 60 percent. The soils formed in acid melt-out till derived mainly from schist, gneiss, or granite. Mean annual temperature ranges from 7 to 11 degrees C and mean annual precipitation commonly ranges from 940 to 1245 cm, but the range includes as low as 660 cm in some places east of the Adirondack Mountains in the Champlain Valley of New York. The growing season ranges from 115 to 185 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Acton, Brookfield, Chatfield, Essex, Hollis, Leicester, Rainbow, Ridgebury, Sutton, Wapping, Whitman, and Woodbridge soils on nearby landscapes. The moderately well drained Sutton and the poorly drained Leicester soils are associated in a drainage sequence. Acton and Wapping soils are moderately well drained. Brookfield soils formed in iron sulfide bearing parent materials and have a ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron less than 0.15 and have pedogenic iron contents greater than 1 percent throughout the pedon. Chatfield soils have bedrock within a depth of 50 to 100 cm. Essex soils have a sandy particle-size control section and a dense substratum. Hollis soils have bedrock within a depth of 25 to 50 cm. Rainbow and Woodbridge soils are moderately well drained with a dense substratum. Ridgebury soils are poorly drained and have a dense substratum. Whitman soils are very poorly drained with a dense substratum.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. Runoff is negligible to medium. Saturated hydraulic conductivity is moderately high or high in the mineral soil.

USE AND VEGETATION: Areas cleared of stones are used for cultivated crops, specialty crops, hay, and pasture. Many scattered areas are used for community development. Stony areas are mostly wooded. Common trees are northern red, white, and black oak, hickory, sugar maple, red maple, black and gray birch, white ash, beech, white pine, and hemlock.

DISTRIBUTION AND EXTENT: Glaciated uplands in Connecticut, Massachusetts, New Hampshire, New York, and Rhode Island. MLRAs 142,144A, and 145. The series is of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts

SERIES ESTABLISHED: Worcester County, Massachusetts, 1922.

REMARKS: Diagnostic horizons and features recognized in this pedon include:
1. Ochric epipedon - the zone from 0 to 10 cm (Oe and A horizons).
2. Cambic horizon - the zone from 10 to 69 cm (Bw1, Bw2, and Bw3 horizons).
3. Particle-size class - coarse-loamy in the control section from 29 to 109 cm.

ADDITIONAL DATA: M.S. Thesis work by Shawn McVey, University of Connecticut, 2006.

Full characterization data for sample numbers S1999NY005001 and S1999CT013003. Pedons analyzed by the KSSL, Lincoln, NE.

National Cooperative Soil Survey
U.S.A.

LOCATION CHATFIELD NH+CT MA NJ NY

Established Series
Rev. LWK-ERS-JTI
04/2017

CHATFIELD SERIES

The Chatfield series consists of well drained soils formed in loamy melt-out till. They are moderately deep to bedrock. They are nearly level to very steep soils on bedrock-controlled hills and ridges. Slope ranges from 0 to 70 percent. Crystalline bedrock is at depths of 50 to 100 cm. Saturated hydraulic conductivity is moderately high or high in the mineral soil. Mean annual temperature is about 9 degrees C, and mean annual precipitation is about 1205 mm.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, mesic Typic Dystrudepts

TYPICAL PEDON: Chatfield fine sandy loam, on a 13 percent slope in a wooded area. (Colors are for moist soil unless otherwise noted).

Oi -- 0 to 3 cm, slightly decomposed leaf, needle, and twig litter; extremely acid, pH 4.2. (0 to 15 cm thick.)

A -- 3 to 5 cm, very dark gray (10YR 3/1) fine sandy loam, gray (10YR 5/1), dry; weak fine subangular blocky structure; friable; many fine and medium roots throughout; 5 percent mixed gravel and cobbles; very strongly acid, pH 4.5; abrupt smooth boundary. (1 to 25 cm thick.)

Bw1-- 5 to 33 cm, strong brown (7.5YR 5/6) gravelly fine sandy loam; weak fine subangular blocky structure; friable; common fine roots throughout and common medium roots throughout; 15 percent mixed gravel and cobbles; very strongly acid, pH 4.5; abrupt wavy boundary.

Bw2 -- 33 to 76 cm, strong brown (7.5YR 5/6) gravelly fine sandy loam; moderate medium subangular blocky structure; friable; few fine roots throughout; 20 percent mixed rock fragments; very strongly acid, pH 4.5; abrupt irregular boundary. (Combined thickness of the Bw horizons is 10 to 80 cm.)

2R -- 76 cm; fractured slightly-weathered schist bedrock.

TYPE LOCATION: Merrimack County, New Hampshire; Town of Epsom, 450 feet north-northwest from point 3,550 feet southwest along Old Mountain Road from intersection of Mountain Road and Tarlton Road. USGS Gossville, NH topographic quadrangle; Latitude 43 degrees, 11 minutes, 55.79 seconds N. and Longitude 71 degrees, 19 minutes, 22.31 seconds W., WGS 1984.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 40 to 97 cm. Depth to

bedrock ranges from 50 to 100 cm from the mineral soil surface. Rock fragments range from 5 to 50 percent by volume in the A horizon and from 5 to 35 percent in the B and C horizons. Rock fragments are typically gravel or channers, but include cobbles, stones, boulders and flagstones, particularly just above the bedrock.

The O horizon has hue of 5YR to 2.5Y, value of 2 or 3, and chroma of 0 to 2. It is slightly, intermediately, and/or highly decomposed plant material. Reaction ranges from extremely acid to moderately acid.

The A, or Ap horizon where present, has hue of 7.5YR to 2.5Y, value of 2 to 4, and chroma of 1 to 4. Dry value is 6 or higher. Texture is sandy loam, fine sandy loam, very fine sandy loam, loam, or silt loam in the fine-earth fraction. Structure is granular. Consistence is friable or very friable. Reaction ranges from extremely acid to moderately acid, unless limed.

The AB or BA horizon, where present, has hue of 7.5YR to 2.5Y, value of 3 or 4, and chroma of 2 to 4. Texture is similar to the A horizon.

The Bw horizon commonly has hue of 10YR or 2.5Y, and includes 7.5YR when a high ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron (greater than 0.15) exists, value of 3 to 6, and chroma of 4 to 6. Texture is similar to the A horizon. The Bw horizon has subangular blocky or granular structure and is friable or very friable. Reaction ranges from very strongly acid to moderately acid.

Some pedons have a BC horizon with color and texture similar to the C horizon.

The C horizon, where present, has hue of 7.5YR to 5Y, value of 4 or 5, and chroma of 2 to 4, and the 7.5YR hue is limited to horizons having a high ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron (> 0.15). Texture is sandy loam, fine sandy loam, very fine sandy loam, loam, or silt loam in the fine-earth fraction and may have lenses or pockets of loamy sand. It is massive and may have plate-like divisions. It is friable or firm. Reaction ranges from very strongly through moderately acid.

The 2R horizon is dominantly schist, granite, or gneiss bedrock. In places it is massive, but it dominantly has vertical and horizontal fractures in the upper 30 to 76 cm.

COMPETING SERIES: These are the Chadakoin, Charlton, Maplecrest, Riverhead, Stinger, and Valois series. Chadakoin, Maplecrest, and Valois soils formed in till derived primary from sedimentary rock parent materials and are greater than 100 cm to bedrock. Charlton soils formed in similar parent material to that of Chatfield but are greater than 150 cm to bedrock. Riverhead soils formed in glacial outwash deposits and are greater than 100 cm to bedrock. Stinger soils are not from Region R and have a paralithic contact.

GEOGRAPHIC SETTING: Chatfield soils are nearly level through very steep, and are on bedrock-controlled glaciated upland landscapes. The soils formed in a moderately thick mantle of melt-out till overlying granite, gneiss, or schist bedrock. Slope ranges from 0 to 70 percent. Mean annual precipitation ranges from 660 to 1270 mm, mean annual temperature ranges from 7

to 13 degrees C, and the frost free season ranges from 130 to 180 days. Elevation ranges from 0 to 305 meters above sea level.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Brimfield, Brookfield, Cardigan, Charlton, Hollis, Narragansett, Nipmuck, and Paxton soils and their wetter associates on nearby landscapes where the soil mantle is deeper than 100 cm. Brimfield, Brookfield and Nipmuck soils formed in sulfur bearing parent materials and have a ratio of ammonium oxalate extractable iron to dithionite-citrate extractable iron less than 0.15 and have pedogenic iron contents greater than 1 percent throughout the pedon. Brookfield, Charlton, Narragansett, and Paxton soils are very deep soils. Cardigan soils are moderately deep soils that formed in till derived from phyllite, slate, shale, and schist. Hollis soils are shallow to bedrock and are on nearby ridge crests and areas adjacent to rock outcrops.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Well drained. Potential for surface runoff ranges from low to high. Saturated hydraulic conductivity is moderately high or high in the mineral soil.

USE AND VEGETATION: Most areas of Chatfield soils are in woodland. Major tree species include white and northern red oaks, sugar maple, beech, eastern hemlock, eastern white pine, eastern red cedar, and shagbark hickory. Some small cleared areas are used for pasture, are idle, or are sites for residential and recreational development.

DISTRIBUTION AND EXTENT: Connecticut, eastern New York, Massachusetts, New Jersey, and New Hampshire. MLRAs 142, 143, 144A and 145. The soils are of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts

SERIES ESTABLISHED: Orange County, New York, 1940.

REMARKS: Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon - the zone from 0 to 5 cm (Oi and A horizons).
Cambic horizon - the zone from 5 to 76 cm (Bw1 and Bw2 horizons).
Lithic contact - bedrock at 76 cm (2R horizon).
Particle-size control section - the zone from 28 to 76 cm (part of the Bw1 horizon and all of the Bw2 horizon).
Lithologic discontinuity - at a depth of 76 cm.

ADDITIONAL DATA: M.S. Thesis work by Shawn McVey, University of Connecticut, 2006. Full characterization data for pedons with User Pedon IDs of S1955NH015003, S1982CT007005, S1982CT007005, S1982NY061001, S1995NH013003, S1995NJ037003, S1998NY005001, S1999NY005004, S2000NY005002, S2000NY005004, S2000NY005008, S2000NY119002, S2000NY119003, S2002CT005007, and S2002CT005008. Pedons analyzed by the NSSL, Lincoln, NE. The laboratory characterization data for these pedons and similar soils is available through the National Cooperative Soil Survey Soil Characterization Database: http://ncsslabdatamart.sc.egov.usda.gov/

National Cooperative Soil Survey
U.S.A.

LOCATION DEERFIELD MA+CT NH NY RI VT

Established Series
Rev. CAW-MFF
01/2017

DEERFIELD SERIES

The Deerfield series consists of very deep, moderately well drained soils formed in glaciofluvial deposits. They are nearly level to strongly sloping soils on terraces, deltas, and outwash plains. Slope ranges from 0 to 15 percent. Saturated hydraulic conductivity is high or very high. Mean annual temperature is about 49 degrees F. and mean annual precipitation is about 47 inches.

TAXONOMIC CLASS: Mixed, mesic Aquic Udipsamments

TYPICAL PEDON: Deerfield loamy sand in a cultivated field at an elevation of about 114 meters. (Colors are for moist soil.)

Ap --0 to 9 inches; very dark grayish brown (10YR 3/2) loamy sand, light brownish gray (10YR 6/2) dry; weak fine granular structure; very friable; many fine roots; moderately acid; abrupt smooth boundary. (6 to 12 inches thick)

Bw1 --9 to 15 inches; yellowish brown (10YR 5/6) loamy sand; very weak fine granular structure; very friable; common fine roots; moderately acid; clear wavy boundary.

Bw2 --15 to 19 inches; yellowish brown (10YR 5/4) loamy sand; very weak fine and medium granular structure; very friable; common fine roots; common medium prominent strong brown (7.5YR 5/8) masses of iron accumulation; moderately acid; clear smooth boundary. (Combined thickness of the Bw horizons is 5 to 27 inches thick)

BC --19 to 27 inches; olive brown (2.5Y 4/4) sand; single grain; loose; few fine roots; common fine and medium prominent strong brown (7.5YR 5/8) and reddish brown (5YR 4/4) masses of iron accumulation, and common fine and medium distinct grayish brown (10YR 5/2) iron depletions; moderately acid; abrupt smooth boundary. (0 to 20 inches thick)

C --27 to 65 inches; olive gray (5Y 4/2) sand grading with depth to dark gray (5Y 4/1) fine sand; single grain; loose; common fine and medium prominent strong brown (7.5YR 5/8) and reddish brown (5YR 4/4) masses of iron accumulation, and common fine and medium distinct grayish brown (10YR 5/2) iron depletions; moderately acid.

TYPE LOCATION: Franklin County, Massachusetts; Town of Montague, 800 feet west of a point on West Mineral Road that is 4,000 feet from the intersection of West Mineral Road and Millers Falls Road, in a cultivated field. Lat. 42 degrees 35 minutes 36.4 seconds N. and long. 72 degrees 30 minutes 48.2 seconds W., NAD 83.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 15 to 40 inches. Gravel, generally fine pebbles, ranges from 0 to 15 percent in the solum and 0 to 20 percent in the substratum. Reaction ranges from very strongly acid through slightly acid unless limed. Iron depletions with chroma of two or less are between depths of 15 and 40 inches from the mineral soil surface.

The Ap horizon has hue of 10YR, value of 2 to 4, and chroma of 1 to 3. It is fine sandy loam, sandy loam, loamy fine sand, loamy sand, fine sand, or sand. Undisturbed pedons commonly have an O horizon, and a thin sequence of A, E, and Bs, Bhs or Bh horizons, or an AB horizon. The Ap or A horizon has weak or moderate very fine to medium granular structure.

The Bw horizon has hue of 7.5YR to 2.5Y, value of 4 to 6, and chroma of 3 to 6. Texture of the upper part of the Bw horizon, within a depth of 10 inches from the soil surface, has the same range as the A horizon. Below 10 inches texture is loamy fine sand, loamy sand, fine sand, sand or coarse sand. Structure is weak, very fine to medium granular or subangular blocky, or is single grain.

The BC horizon, where present, has hue of 7.5YR to 2.5Y, value of 3 to 6, and chroma of 2 to 4. Texture range is the same as the lower part of the Bw horizon. Structure is weak, very fine to medium granular, or is single grain.

The C horizon has hue of 7.5YR to 5Y, value of 4 to 6, and chroma of 1 to 4. Texture is loamy fine sand, loamy sand, fine sand, sand or coarse sand. It is commonly single grain but may be very weak or weak granular.

COMPETING SERIES: These are the Algansee, Altmar, Brems, Brockatonorton, Elnora, Fortress, Livonia, Morocco, Ottokee, Partridge, Tedrow, and Zaborowsky series. The Algansee, Brems, Brockatonorton, Meckling, Morocco, Ottokee, Partridge, Tedrow, and Zaborowsky soils are from outside of region R. Algansee soils have an irregular decrease of organic matter with depth. Altmar soils have rock fragments dominated by sandstone. Birchwood soils formed in sandy sediments over glacial till. Brems and Ottokee soils have sola more than 40 inches thick, and Ottokee soils have lamellae. Elnora soils contain more fine sand in the lower part of the series control section. Fortress soils formed in anthropotransported soil material from eolian sand, outwash, ordredging activities. Livonia soils formed in glaciolacustrine parent material with neutral to moderately alkaline reaction and average less than 960 mm of annual precipitation. Meckling soils are calcareous throughout. Morocco soils have redox features within a depth of 15 inches. Partridge soils have bedrock at depths of 20 to 40 inches. Tedrow and Zaborosky soils have carbonates.

GEOGRAPHIC SETTING: Deerfield soils are level to strongly sloping soils on terraces, deltas, and outwash plains. Slope gradients are commonly 0 to 3 percent, but range to 15 percent. The soils formed in thick deposits of sand derived mainly from granite, gneiss and quartzite, but in places containing materials from schist and sandstone. The sand is poorly graded; medium sand is generally dominant and typically contains little or no gravel. Mean annual temperature ranges from 45 to 52 degrees F. and the mean annual precipitation typically ranges from 38 to 55

inches but the range includes as low as 26 inches in some places east of Adirondack Mountains in the Champlain Valley of New York. The mean growing season ranges from 120 to 200 days.

GEOGRAPHICALLY ASSOCIATED SOILS: Deerfield soils are in a drainage sequence that includes the excessively drained Carver and Windsor soils, the somewhat poorly drained Pipestone and Wareham soils, and the very poorly drained Scarboro soils. The well drained Agawam, somewhat excessively drained Merrimac, and the excessively drained Hinckley and Penwood soils are on nearby glacial outwash landforms and have sandy and gravelly substrata. The excessively drained Plymouth, somewhat excessively drained Gloucester, well drained Canton, Charlton, Cheshire, Essex and Paxton, and moderately well drained Woodbridge soils are on nearby glacial till uplands.

DRAINAGE AND PERMEABILITY: Moderately well drained. Runoff is negligible to low. Saturated hydraulic conductivity is high or very high.

USE AND VEGETATION: Mainly cleared and used for truck crops, tobacco, potatoes, hay, pasture and silage corn. Forested areas have pitch pine, white pine, gray birch, red maple, oaks, and sugar maple. Some areas are in urban uses.

DISTRIBUTION AND EXTENT: New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut and New York. (MLRA's 101, 142, 144A, 144B, 145, and 149B) The soils of this series are moderately extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Franklin County, Massachusetts, 1964.

REMARKS: The use of very weak structure in the A horizon is no longer an approved choice for grade of structure and has been removed from this description. Some pedons may exist where this grade of structure has been described.

Diagnostic horizons and features recognized in this pedon include:
1. Ochric epipedon - the zone from 0 to 9 inches (Ap horizon).
2. Aquic feature - the zone from 19 to 40 inches has redox depletions with chroma of 2 or less. (BC and C horizons).

National Cooperative Soil Survey
U.S.A.

LOCATION HINCKLEY MA+CT ME NH NJ NY RI VT

Established Series
Rev. CAW-SMF-DCP
08/2017

HINCKLEY SERIES

The Hinckley series consists of very deep, excessively drained soils formed in glaciofluvial materials. They are nearly level through very steep soils on outwash terraces, outwash plains, outwash deltas, kames, kame terraces, and eskers. Saturated hydraulic conductivity is high or very high. Slope ranges from 0 to 60 percent. Mean annual temperature is about 7 degrees C, and mean annual precipitation is about 1143 mm.

TAXONOMIC CLASS: Sandy-skeletal, mixed, mesic Typic Udorthents

TYPICAL PEDON: Hinckley loamy sand in woodland at an elevation of about 240 meters. (All colors are for moist soil.)

Oe -- 0 to 3 cm; moderately decomposed plant material derived from red pine needles and twigs. (0 to 5 cm thick.)

Ap -- 3 to 20 cm; very dark grayish brown (10YR 3/2) loamy sand; weak fine and medium granular structure; very friable; many fine and medium roots; 5 percent fine gravel; very strongly acid; abrupt smooth boundary. (3 to 25 cm thick.)

Bw1 -- 20 to 28 cm; strong brown (7.5YR 5/6) gravelly loamy sand; weak fine and medium granular structure; very friable; common fine and medium roots; 20 percent gravel; very strongly acid; clear smooth boundary.

Bw2 -- 28 to 41 cm; yellowish brown (10YR 5/4) gravelly loamy sand; weak fine and medium granular structure; very friable; common fine and medium roots; 25 percent gravel; very strongly acid; clear irregular boundary. (Combined thickness of the Bw horizon is 8 to 41 cm.)

BC -- 41 to 48 cm; yellowish brown (10YR 5/4) very gravelly sand; single grain; loose; common fine and medium roots; 40 percent gravel; strongly acid; clear smooth boundary. (0 to 13 cm thick)

C -- 48 to 165 cm; light olive brown (2.5Y 5/4) extremely gravelly sand consisting of stratified sand, gravel and cobbles; single grain; loose; common fine and medium roots in the upper 20 cm and very few below; 60 percent gravel and cobbles; moderately acid.

TYPE LOCATION: Worcester County, Massachusetts; Town of Petersham, Harvard Forest, 240 feet north of Tom Swamp Road at a point 1.15 miles east of the intersection of Athol Road

and Tom Swamp Road. USGS Athol, MA topographic quadrangle, Latitude 42 degrees, 30 minutes, 41.8 seconds N., and Longitude 72 degrees, 12 minutes, 28.9 seconds W., NAD 1983.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 30 to 87 cm. Rock fragment content of the solum ranges from 5 through 50 percent gravel, 0 through 30 percent cobbles, and 0 through 3 percent stones. Rock fragment content of individual horizons of the substratum ranges from 10 through 55 percent gravel, 5 through 25 percent cobbles, and 0 through 5 percent stones. In some places gravel content throughout the soil ranges up through 75 percent. The soil ranges from extremely acid through moderately acid, except where limed.

The O horizons, where present, consist of slightly, moderately, and/or highly decomposed plant material. They have hue N or 2.5YR through 7.5YR, value of 2 or 3, and chroma of 0 through 3.

The Ap horizon has hue of 7.5YR or 10YR, value of 2 through 4, and chroma of 1 through 4. Texture of the fine-earth fraction is very fine sandy loam, fine sandy loam, sandy loam, coarse sandy loam, loamy fine sand, loamy sand, or loamy coarse sand. Structure is weak or moderate very fine through coarse granular or subangular blocky. Consistence is friable or very friable. Undisturbed areas have an A horizon that has hue of 10YR, value of 2 or 3, and chroma of 1 through 4.

Some pedons have thin E, Bhs, Bh, or Bs horizons below the A horizon.

The upper part of the Bw horizon has hue of 7.5YR or 10YR, value of 3 through 5, and chroma of 3 through 8. The lower part has hue of 7.5YR through 2.5Y, value of 3 through 6, and chroma of 3 through 8. Texture, to a depth of 25 cm from the surface, is fine sandy loam, sandy loam, coarse sandy loam, loamy fine sand, loamy sand, or loamy coarse sand in the fine-earth fraction. Below 25 cm it is loamy fine sand, loamy sand, loamy coarse sand, fine sand, sand, or coarse sand in the fine-earth fraction. Structure commonly is weak fine and/or medium granular or the horizon is structureless, but ranges through weak subangular blocky in some places. It is very friable, friable, or loose.

Some pedons have a BC horizon with characteristics similar to both the B and 2C horizons.

The C horizon has hue of 7.5YR through 5Y, value of 3 through 7, and chroma of 2 through 8. Texture is loamy fine sand, loamy sand, loamy coarse sand, fine sand, sand or coarse sand in the fine-earth fraction, and is stratified.

COMPETING SERIES: These are the Bonaparte, Manchester, Mecosta, Multorpor, Otisville, Quonset, and Rikers series. Mecosta and Multorpor soils are from outside Land Resource Region R. Bonaparte soils have carbonates within a depth of 100 cm. Manchester soils have 5YR or redder hue in the Bw and C horizons. Mecosta soils are calcareous and Multorpor soils do not have Bw horizons. Otisville soils have rock fragments dominated by sandstone, shale, and slate. Quonset soils have rock fragments dominated by phyllite, slate, and shale. Rikers soils have carboliths in the soil.

GEOGRAPHIC SETTING: Hinckley soils are nearly level through very steep soils on outwash

terraces, outwash plains, outwash deltas, kames, kame terraces, and eskers. Slope is generally 0 through 8 percent on tops of the terraces, outwash plains and deltas. Slope of 8 through 60 percent or more are on the kames, eskers and margins of the outwash plains, deltas, and terraces. The soils formed in glaciofluvial sand and gravel derived principally from granite, gneiss, and schist. Mean annual temperature ranges from 7 to 13 degrees C, and mean annual precipitation ranges from 1016 to 1270 mm. Length of the growing season ranges from 140 through 240 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Agawam, Canton, Charlton, Deerfield, Essex, Gloucester, Horseneck, Mashpee, Massasoit, Merrimac, Paxton, Pompton, Riverhead, Scarboro, Sudbury, Walpole, Wareham, and Windsor soils on nearby landscapes. Horseneck, Pompton, and Riverhead soils are commonly associates in the extreme southern portions of MLRA 144A. Agawam, Merrimac, and Riverhead soils are similar to Hinckley soils, but have cambic horizons. Canton, Charlton, Essex, Gloucester, and Paxton soils formed in till. Deerfield, Horseneck, and Sudbury soils are moderately well drained and Horseneck and Sudbury soils have Cambic horizons. Pompton soils have Cambic horizons and are moderately well and somewhat poorly drained. Scarboro soils are very poorly drained. Windsor soils have less than 15 percent rock fragments. Mashpee and Massasoit soils are poorly drained with spodic horizons. Walpole and Wareham soils are poorly drained.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Excessively drained. Surface runoff is negligible through low. Saturated hydraulic conductivity is high or very high.

USE AND VEGETATION: Cleared areas are used for hay, pasture, and silage corn. In the southern Connecticut River Valley, Hinckley soils are used for growing tobacco and truck crops and in eastern Massachusetts, truck crops. Most areas are forested, brush land or used as urban land. Northern red, black, white, scarlet and scrub oak, eastern white and pitch pine, eastern hemlock, and gray birch are the common trees. Unimproved pasture and idle land support hardhack, little bluestem, bracken fern, sweet fern, and low bush blueberry.

DISTRIBUTION AND EXTENT: Connecticut, southern Maine, Massachusetts, New Hampshire, northern New Jersey, New York, Rhode Island, and Vermont. MLRA's 101, 141, 142, 144A, 145, and 149B. The series is extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Oneida County, New York, 1913.

REMARKS: The use of the Hinckley series in frigid areas of Maine, and in MLRA 143 and 144B, is relict to before temperature classes. These have been removed from the SC file.

Diagnostic horizons and features recognized in this pedon are:
1. Ochric epipedon - the zone from 3 to 20 cm (Ap horizon).
2. Sandy-skeletal feature - the zone from 25 to 100 cm has a weighted average content of rock fragments of 51 percent and a particle size of the fine-earth fraction is sandy (Bw, BC, and C horizons).

ADDITIONAL DATA: Reference samples from pedons S55NH015002, S56MA011002, S56MA011003, S57MA023005, S58NH015002, S73MA009001, S73MA005002, S73MA009004, S73MA005005, S96NH013003 from Massachusetts and New Hampshire, samples by NSSL, Lincoln, NE, various dates.

National Cooperative Soil Survey
U.S.A.

LOCATION LIMERICK CT MA NH NY VT
Established Series
Rev. MHS-SHG-DCP
03/2010

LIMERICK SERIES

The Limerick series consists of very deep, poorly drained soils on flood plains. They formed in loamy alluvium. Saturated hydraulic conductivity is moderately high or high. Slope ranges from 0 through 3 percent. Mean annual precipitation is about 44 inches (1118 millimeters) and mean annual temperature is about 45 degrees F. (7 degrees C).

TAXONOMIC CLASS: Coarse-silty, mixed, superactive, nonacid, mesic Fluvaquentic Endoaquepts

TYPICAL PEDON: Limerick silt loam, on a nearly level slope in hay land at an elevation of about 10 feet. (Colors are for moist soil unless otherwise noted.)

Ap-- 0 to 8 inches (0 to 20 centimeters); dark grayish brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; moderate medium granular structure; friable; common very fine and fine and few medium roots; moderately acid; clear smooth boundary. (3 to 10 inches, 8 to 25 centimeters thick.)

BCg1-- 8 to 20 inches (20 to 50 centimeters); olive gray (5Y 4/2) silt loam; massive; friable; few very fine and fine roots; common medium prominent dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4 and 10YR 5/6) soft masses of iron accumulation; moderately acid; clear smooth boundary.

BCg2-- 20 to 36 inches (50 to 91 centimeters); olive gray (5Y 4/2) silt loam; massive; common medium prominent dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4 and 10YR 5/6) soft masses of iron accumulation; moderately acid; clear smooth boundary.

BCg3-- 36 to 54 inches; (91 to 137 centimeters) dark gray (5Y 4/1) silt loam; massive; common medium prominent dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4 and 10YR 5/6) soft masses of iron accumulation; moderately acid; clear smooth boundary. (Combined thickness of the BCg horizons ranges from 6 to more than 60 inches (15 to 152 centimeters.)

Cg-- 54 to 65 inches (137 to 165 centimeters); dark greenish gray (5GY 4/1) silt loam; massive; few, fine prominent dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4 and 10YR 5/6) soft masses of iron accumulation; neutral.

TYPE LOCATION: Hartford County, Connecticut; town of Wethersfield, 1200 feet east on Second Lane Road from Interstate 91 underpass, 50 feet south of Second Lane Road, on the Hartford South. USGS Hartford South topographic quadrangle, Latitude 41 degrees, 41 minutes,

52 seconds N., Longitude 72 degrees, 38 minutes, 22 seconds W., NAD 1983, on the floodplain of the Connecticut River.

RANGE IN CHARACTERISTICS: Thickness of the solum ranges from 17 through more than 60 inches (43 through 152 centimeters). Depth to bedrock is more than 60 inches (152 centimeters). Reaction ranges from strongly acid through neutral. The weighted average of fine and coarser sands, in the particle-size control section, is less than 15 percent.

The A or Ap horizon has hue of 10YR through 5Y, value of 3 or 4, and chroma of 1 or 2. Texture is commonly silt loam but includes very fine sandy loam. Structure is typically weak or moderate, fine or medium granular. Some A horizons have weak or moderate medium subangular blocky structure. Consistence is friable or very friable. Redoximorphic features, where present, are few through many, fine through coarse and faint through prominent.

Some pedons have one or more Ab horizons with hue of 10YR through 5Y, value of 3 or 4 and chroma of 1 or 2. Texture is commonly silt loam but includes very fine sandy loam. The horizons are massive and friable.

Some pedons have a Bg horizon, 6 through 8 inches (15 through 20 centimeters) thick, with hue of 10YR through 5Y, value of 4 through 6, and chroma of 1 or 2. Texture is commonly silt loam, but includes silt and very fine sandy loam. Structure is weak granular or subangular blocky, or the horizon is massive. Consistence is friable. Redoximorphic features are few through many, fine through coarse and distinct or prominent.

The BCg horizon, where present, has hue of 10YR through 5Y, value of 4 through 6 and chroma of 1 or 2. Texture is commonly silt loam, but includes silt and very fine sandy loam. Strata of loamy very fine sand, very fine sand, or fine sand .2 through .5 inches (.5 through 1.3 centimeters) thick are present in some horizons. The horizon is massive and friable or very friable. Redoximorphic features range from few through many, fine through coarse and faint through prominent.

The Cg horizon, where present, has hue of 10YR through 5GY, or is neutral, value of 4, and chroma of 0 through 2. Texture is commonly silt loam but includes silt and very fine sandy loam. Some pedons have thin strata (less than .2 inches) (.5 centimeters) that vary in color, texture, or reaction. Redoximorphic features, where present, are few through many and fine or medium prominent. The horizon is massive and friable.

Some pedons have a 2Cg horizon below a depth of 40 inches (100 centimeters). It has hue of 10YR through 5Y, value of 3 through 5, and chroma of 1 through 4. Texture is fine sandy loam through sand.

COMPETING SERIES: Oridia and Skokomish soils are currently the only other series in this family. Oridia and Skokomish series are from Land Reasource Region A in the Pacific Northwest.

The Lim, Rippowam, and Rumney series are in related families. They have a weighted average of fine sand or coarser in the particle-size control section of more than 15 percent. Rumney soils have a cooler mean annual soil temperature.

GEOGRAPHIC SETTING: Limerick soils are on the flood plains of major rivers and their larger tributaries. In some places they are on the flood plains of small streams. They may be on broad flat areas or in shallow depressions. The soils formed in recent alluvial deposits that are dominantly silt and very fine sand. Mean annual temperature ranges from about 45 through 52 degrees F. (7 through 11 degrees C.), and mean annual precipitation ranges from 30 through 50 inches (762 through 1270 millimeters). The frost-free season ranges from 105 through 180 days.

GEOGRAPHICALLY ASSOCIATED SOILS: Limerick soils are the poorly drained member of the drainage sequence that includes the well drained Hadley, the moderately well drained Winooski, and the very poorly drained Saco soils. Common associated soils on nearby terraces are the Agawam, Enfield, Hinckley, Merrimac, and Windsor series.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Poorly drained. Saturated hydraulic conductivity is moderately high or high. Most areas are flooded for periods of several days each year, usually in late winter or early spring.

USE AND VEGETATION: Most areas are used for long term hay and pasture. A few areas have been drained, and cultivated crops are grown. Common trees in wooded areas are red maple and eastern white pine. Additional woody species are alders, willows, black ash, green ash, swamp birch, river birch, silky willow, and pussy willow. Common herbaceous species include cinnamon fern, nettle, and skunk cabbage.

DISTRIBUTION AND EXTENT: Connecticut, Massachusetts, New Hampshire, New York, and Vermont; MLRAs 142, 144A, and 145. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Aroostook County, Maine, 1943.

REMARKS: 1. With this revision the classification is changed from Coarse-silty, mixed, active, nonacid, mesic Fluvaquentic Endoaquepts to Coarse-silty, mixed, superactive, nonacid, mesic Fluvaquentic Endoaquepts. This reflects a review of current lab data available for this series, S70MA015004, S70MA015005 and S06CT003-001 were some of the selected lab pedons used to make the determination.

2. The use of the Limerick series in Maine, and in MLRA 143 and 144B, is relict to before temperature classes. These have been removed from the SC file.

3. Diagnostic horizons and features recognized in this pedon include:

a. Ochric epipedon - the zone from 0 to 8 inches (0 to 20 centimeters) (Ap horizon).
b. Cambic horizon - the zone from 8 to 54 inches (20 to 137 centimeters) (BCg horizons).
c. Aquept feature - Within 20 inches (50 centimeters) of the soil surface the matrix has chroma of 2 or less with redox concentrations.
d. Fluvaquentic feature: The organic-carbon content is presumed to decrease irregularly with depth between 10 through 50 inches (25 through 125 centimeters).
e. Nonacid reaction class - the pH is presumed to be 5.0 or more in 0.01m CaCl2 in at least some part of the control section.
f. The material composing the Cg layer is presumed to change color upon exposure to air thereby not meeting the criteria for a Cambic horizon.

National Cooperative Soil Survey
U.S.A.

LOCATION MERRIMAC MA+CT NH NY RI VT

Established Series
Rev. DGG-WHT-MFF
01/2013

MERRIMAC SERIES

The Merrimac series consists of very deep, somewhat excessively drained soils formed in outwash. They are nearly level through very steep soils on outwash terraces and plains and other glaciofluvial landforms. Slope ranges from 0 through 35 percent. Saturated hydraulic conductivity is high or very high. Mean annual temperature is about 48 degrees F. (9 degrees C.) and mean annual precipitation is about 42 inches (1067 millimeters).

TAXONOMIC CLASS: Sandy, mixed, mesic Typic Dystrudepts

TYPICAL PEDON: Merrimac fine sandy loam cultivated, at an elevation of about 122 meters. (Colors are for moist soil.)

Ap -- 0 to 10 inches (0 to 25 centimeters); very dark grayish brown (10YR 3/2) fine sandy loam, light brownish gray (10YR 6/2) dry; weak fine and medium granular structure; very friable; many fine roots; 10 percent fine gravel; strongly acid; abrupt smooth boundary. (1 to 14 inches (3 to 36 centimeters) thick.)

Bwl -- 10 to 15 inches (25 to 38 centimeters); brown (7.5YR 4/4) fine sandy loam; weak fine and medium granular structure; very friable; common fine roots; 10 percent fine gravel; strongly acid; clear wavy boundary.

Bw2 -- 15 to 22 inches (38 to 56 centimeters); dark yellowish brown (10YR 4/4) gravelly sandy loam; weak fine and medium granular structure; very friable; few fine roots; 15 percent gravel; strongly acid; clear wavy boundary.

Bw3 -- 22 to 26 inches (56 to 66 centimeters); dark yellowish brown (10YR 4/4) gravelly loamy sand; very weak fine granular structure; very friable; few fine roots; 25 percent gravel; moderately acid; clear wavy boundary. (Combined thickness of the Bw horizons is 6 to 34 inches (15 to 86 centimeters).)

2C -- 26 to 65 inches (66 to 165 centimeters); 80 percent yellowish brown (10YR 5/4) and 20 percent dark grayish brown (10YR 4/2) very gravelly sand; single grain; loose; stratified; few fine roots in upper 4 inches; 40 percent gravel, 10 percent cobbles; moderately acid.

TYPE LOCATION: Franklin County, Massachusetts; Town of Leverett, 2.75 miles south-southeast of Montague Village, 0.13 miles southeast of Cranberry Pond, just west of Route 63. USGS Williamsburg, MA topographic quadrangle, Latitude 42 degrees, 29 minutes, 51 seconds

N. and Longitude 72 degrees, 31 minutes, 12 seconds W., NAD 1983.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 18 through 36 inches (46 through 91 centimeters). Rock fragments are commonly granite or gneiss or schist but up to 25 percent are flat, fine-grained slate, shale, or phyllite fragments. The upper part of the solum commonly has 2 through 20 percent gravel, but includes cobbles in some pedons, and the lower part 5 through 30 percent. The substratum contains 2 through 55 percent gravel and 5 through 15 percent cobbles. Total volume of rock fragments in the particle-size control section is less than 35 percent. Clay content is less than 18 percent. Reaction ranges from extremely acid through moderately acid, unless limed.

The O horizon, where present, ranges in thickness from 2 through 5 inches (4 through 13 centimeters). They have hue 2.5YR through 10YR, value 2 or 3, and chroma 1 through 3. They are fibric, hemic, or sapric material.

The Ap, A, or AE horizon has hue of 7.5YR or 10YR, value of 2 through 4, and chroma of 1 through 4. Texture is fine sandy loam, sandy loam, or very fine sandy loam in the fine-earth fraction.

The E horizon, where present, ranges in thickness from 1 through 3 inches (3 through 8 centimeters). They have hue 5YR through 10YR, value 4 through 6, and chroma 1 through 4. Texture is sandy loam or coarse sandy loam in the fine-earth fraction. Some pedons have thin Spodic horizons less than 2 inches (5 centimeters) thick with hue 7.5YR or 10YR, value 4, and chroma 3 through 6.

The Bw horizon has hue of 7.5YR or 10YR in the upper part and 7.5YR through 2.5Y in the lower part. Value ranges from 3 through 6 and chroma from 3 through 8. Texture of the upper part of the Bw horizon is fine sandy loam, sandy loam, coarse sandy loam, or very fine sandy loam in the fine-earth fraction. It has granular or subangular blocky structure or the horizon is massive. The lower part of the B horizon is sandy loam, coarse sandy loam, loamy coarse sand, loamy fine sand, or loamy sand in the fine-earth fraction. Sandy loam textures do not extend below a depth of 27 inches (69 centimeters), but a minimum thickness of 5 inches (13 centimeters) of sandy loam overlies any lower B or 2C horizon that is loamy fine sand or coarser. The B subhorizon that lies above the 2C horizon in many pedons is single grain. Some pedons have a BC horizon that is similar to the lower part of the Bw.

The 2C horizon has hue of 10YR through 5Y and ranges widely in value and chroma. It consists of stratified coarse sand, sand, gravel, and cobbles and has a weighted texture of gravelly or very gravelly sand or coarse sand. Some pedons have thin lenses of loamy fine sand or fine sand.

COMPETING SERIES: These are the Hartford and Knickerbocker series. Hartford soils have hues of 5YR or redder in the Bw horizon. Knickerbocker soils generally have less rock fragments in the substratum and the fragments are commonly slate and dark shale.

GEOGRAPHIC SETTING: Merrimac soils are level to very steep soils on outwash plains and valley trains, and associated kames, eskers, stream terraces and water deposited parts of

moraines. The steeper slopes are on the margin escarpments of terraces and plains, and on eskers and kames. Slope ranges from 0 through 35 percent. The soils formed in water sorted gravelly and sandy material derived mainly from granitic, gneissic, and some schistose rocks. Mean annual precipitation ranges from 28 through 55 inches (711 through 1397 millimeters); mean annual air temperature ranges from 45 through 50 degrees F. (7 through 10 degrees C.), mean growing season ranges from 120 through 200 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Agawam, Hinckley, Mashpee (T), Massasoit (T), Sudbury, Scarboro, Walpole, and Windsor soils on nearby landscapes. The well drained Agawam soils are coarse-loamy over sandy or sandy-skeletal. The excessively drained Hinckley soils are sandy-skeletal. The very poorly drained Scarboro soils are in depressions. The moderately drained Sudbury soils are on adjacent, slightly lower landforms. The poorly drained Mashpee (T), Massasoit (T), and Walpole soils are in drainageways and on low landforms. The excessively drained Windsor soils have loamy fine sand to sand textures in the Bw horizon and lack rock fragments.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Somewhat excessively drained. Runoff is negligible through medium. Saturated hydraulic conductivity is high or very high.

USE AND VEGETATION: Most areas are cultivated and used for growing hay, pasture, silage, corn, or truck crops. Some areas are used to grow tobacco in the Connecticut River Valley in Massachusetts and Connecticut. Some areas are forested with mostly white pine, gray birch, hemlock, red maple, and red, black, white, and scarlet oaks.

DISTRIBUTION AND EXTENT: Massachusetts, Connecticut, New Hampshire, New York, Vermont, and Rhode Island. MLRA's 142, 144A, 145, and 149B. The series is extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Merrimack County, New Hampshire, 1906.

REMARKS: The use of the Merrimac series in Maine, and in MLRA 143 and 144B, is relict to before temperature classes. These have been removed from the SC file.

Diagnostic horizons and other features recognized in this pedon are:

1. Ochric epipedon - the zone from 0 to 10 inches (0 to 25 centimeters) (Ap horizon).
2. Cambic horizon - the zone from 10 to 22 inches (25 to 56 centimeters) (Bw horizon).

National Cooperative Soil Survey
U.S.A.

LOCATION OCCUM CT +MA NH NY VT
Established Series
Rev. MFF-SMF
07/2006

OCCUM SERIES

The Occum series consists of very deep, well drained loamy soils formed in alluvial sediments. They are nearly level soils on flood plains, subject to common flooding. Slope ranges from 0 to 3 percent. Saturated hydraulic conductivity is moderately high or high in the loamy layers and high or very high in the sandy substratum. Mean annual temperature is about 50 degrees F., and mean annual precipitation is about 43 inches.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, mesic Fluventic Dystrudepts

TYPICAL PEDON: Occum fine sandy loam in a hayfield at an elevation of about 200 feet. (Colors are for moist soil unless otherwise noted.)

Ap--0 to 10 inches; dark brown (10YR 3/3) fine sandy loam, pale brown (10YR 6/3) dry; weak fine and medium granular structure; very friable; many very fine and fine roots; moderately acid; clear smooth boundary. (5 to 12 inches thick)

Bw1--10 to 17 inches; dark yellowish brown (10YR 4/4) fine sandy loam; weak medium subangular blocky structure; very friable; common very fine and fine roots; moderately acid; clear smooth boundary.

Bw2--17 to 28 inches; dark yellowish brown (10YR 4/6) sandy loam; weak medium subangular blocky structure; very friable; few very fine and fine roots; moderately acid; clear smooth boundary. (Combined thickness of the Bw horizons is 14 to 35 inches.)

C1--28 to 32 inches; yellowish brown (10YR 5/4) loamy sand; single grain; loose; moderately acid; clear smooth boundary.

C2--32 to 42 inches; brown (10YR 5/3) and light olive brown (2.5Y 5/4) sand; single grain; loose; 10 percent gravel; moderately acid; clear smooth boundary.

C3--42 to 65 inches; brown (10YR 5/3) and light olive brown (2.5Y 5/4) very gravelly coarse sand; single grain; loose; 35 percent gravel; moderately acid.

TYPE LOCATION: Hartford County, Connecticut; town of Granby, 50 feet north of Mechanicsville Road at a point 2,300 feet west of Route 10 and 50 feet east of East Branch Salmon Brook. USGS Tariffville topographic quadrangle, latitude 41 degrees 58 minutes 15 seconds N., longitude 72 degrees 48 minutes 11 seconds W., NAD 27.

RANGE IN CHARACTERISTICS: Thickness of the solum and depth to the coarse-textured substratum range from 20 to 40 inches. Gravel ranges from 0 to 15 percent by volume in the solum and from 0 to 60 percent in the substratum. Some pedons have up to 10 percent cobbles in the substratum. Unless limed, reaction ranges from very strongly acid to slightly acid.

The A or Ap horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 1 to 4. Texture is very fine sandy loam, fine sandy loam, or sandy loam. It has weak or moderate granular structure and is friable or very friable.

The Bw horizon has hue of 7.5YR to 2.5Y, value of 3 to 8, and chroma of 3 to 6. It is commonly fine sandy loam or sandy loam, but the range includes very fine sandy loam or loam in the upper part. Some pedons have thin strata of loam, very fine sandy loam, or silt loam. The Bw horizon has granular or subangular blocky structure, or it is massive. Consistence is friable or very friable. Some pedons have thin Ab horizons.

The C horizon has hue of 7.5YR to 5Y, value of 3 to 7, and chroma of 2 to 6. Some pedons have redoximorphic features below a depth of 4 feet. Texture of individual layers ranges from loamy fine sand to coarse sand in the fine-earth fraction. Included in some pedons are thin loamy and/or extremely gravelly strata. Also, some pedons have a loamy C horizon layer just below the Bw horizon. The C horizon is single grain and loose in the sandy part. The loamy part is typically massive and friable. The thickness and number of subhorizons is variable and corresponds to the thickness and variability of
the alluvial deposits.

COMPETING SERIES: McNulty and Wenonah are other soils currently in the same family. McNulty soils are from outside of LRR R. McNulty soils average more than 60 inches of precipitation per year. Wenonah soils formed in alluvium containing sandstone, siltstone, and shale.

GEOGRAPHIC SETTING: Occum soils are nearly level soils on flood plains, along rivers and streams. Slope ranges from 0 to 3 percent. The soils formed in recent alluvium derived mostly from gneiss, granite, and schist. Mean annual temperature ranges from 45 to 54 degrees F., mean annual precipitation ranges from 35 to 50 inches but the range includes as low as 26 inches in some places east of Adirondack Mountains in the Champlain Valley of New York. The growing season ranges from 115 to 190 days.

GEOGRAPHICALLY ASSOCIATED SOILS: The Agawam, Enfield, Hadley, Haven, Hinckley, Lim, Limerick, Merrimac, Pootatuck, Rippowam, Saco, Suncook, Windsor, and Winooski series are on nearby landscapes. The moderately well drained Pootatuck and the poorly drained Rippowam soils are associated in a drainage sequence. Agawam, Enfield, Haven, and Merrimac soils have a regular decrease in organic carbon with depth. Hadley and Hamlin soils are coarse-silty. Pootatuck soils have low chroma mottles within a 24 inch depth. Hinckley and Windsor soils are on nearby terraces and outwash plains. Lim, Limerick, Saco, and Winooski soils are wetter silty floodplain associates. Suncook soils are sandy, excessively drained soils on floodplains.

DRAINAGE AND PERMEABILITY: Well drained. Surface runoff is negligible to low. Saturated hydraulic conductivity is moderately high or high in the loamy layers and high or very high in the sandy substratum. Many areas of these soils flood for short periods each year, but typically not during the growing season. The soils on higher positions flood occasionally.

USE AND VEGETATION: Cleared areas are used for cultivated crops, hay, and pasture. Common trees in wooded areas are sycamore, white pine, white, yellow, and gray birch, red maple, sugar maple, hemlock, and red and white oak.

DISTRIBUTION AND EXTENT: Holocene floodplains in Connecticut, Massachusetts, New Hampshire, New York, and Vermont; MLRAs 142, 144A and 145. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts

SERIES ESTABLISHED: Windham County, Connecticut, 1980.

REMARKS: Cation exchange activity class placement determined from a review of limited lab data and similar or associated soils.

Diagnostic horizons and features recognized in this pedon are:

1. Ochric epipedon - the zone from 0 to 10 inches (Ap horizon).
2. Cambic horizon - the zone from 10 to 28 inches (Bw1, Bw2 horizons).
3. Fluventic feature - irregular decrease in organic carbon with depth and organic carbon is greater than 0.2 percent within 1.25 meters.
4. Particle-size class - averages coarse-loamy in the particle size control section from 10 to 40 inches (Bw1, Bw2, C1, C2 horizons).

National Cooperative Soil Survey
U.S.A.

LOCATION PIPESTONE MI+CT IN MA NH NY

Established Series
Rev. JDL-NWS-MLK
09/2012

PIPESTONE SERIES

The Pipestone series consists of very deep, somewhat poorly drained soils formed in sandy outwash on outwash plains, lake plains, beach ridges, and water-worked till plains. Slope ranges from 0 to 8 percent. Mean annual precipitation is about 889 mm (35 inches), and mean annual temperature is about 10.0 degrees C (50 degrees F).

TAXONOMIC CLASS: Sandy, mixed, mesic Typic Endoaquods

TYPICAL PEDON: Pipestone sand, on an east-facing, convex, 1 percent slope in an idle field. (Colors are for moist soil unless otherwise stated.)

Ap--0 to 20 cm (8 inches); very dark brown (10YR 2/2) sand, dark grayish brown (10YR 4/2) dry; moderate medium granular structure; very friable; many fine roots; slightly acid; abrupt smooth boundary. [0 to 25 cm (10 inches) thick]

E--20 to 28 cm (8 to 11 inches); grayish brown (10YR 5/2) sand; moderate medium granular structure; very friable; common fine roots; common medium distinct dark yellowish brown (10YR 3/4) masses of oxidized iron in the matrix; moderately acid; abrupt broken boundary. [0 to 25 cm (10 inches) thick]

Bhs--28 to 38 cm (11 to 15 inches); dark reddish brown (5YR 3/3) sand; weak medium subangular blocky structure; very friable; few fine roots; common fine distinct brown (7.5YR 4/4) masses of oxidized iron in the matrix; strongly acid; abrupt wavy boundary. [0 to 25 cm (10 inches) thick]

Bs--38 to 79 cm (15 to 31 inches); yellowish brown (10YR 5/6) sand; single grain; loose; moderately acid; abrupt wavy boundary. [10 to 58 cm (4 to 23 inches) thick]

C--79 to 152 cm (31 to 60 inches); light brownish gray (10YR 6/2) sand; single grain; loose; slightly acid.

TYPE LOCATION: Berrien County, Michigan; about 4 miles northeast of Benton Harbor; 1,172 feet south and 99 feet west of the northeast corner of sec. 28, T. 3 S., R. 18 W.; USGS Benton Heights topographic quadrangle; lat. 42 degrees 10 minutes 59.5 seconds N. and long. 86 degrees 23 minutes 54 seconds W., WGS 84.

RANGE IN CHARACTERISTICS:

Thickness of the solum: 51 to 127 cm (20 to 50 inches)
Rock fragment content: 0 to 10 percent gravel throughout

Ap horizon:
Hue: 7.5YR or 10YR
Value: 2 to 4
Chroma: 1 to 3
Texture: sand, fine sand, loamy sand, loamy fine sand, or loamy coarse sand
Reaction: extremely acid to neutral

A horizon, where present:
Hue: 7.5YR or 10YR, or is neutral
Value: 2 to 4
Chroma: 0 to 3
Texture: sand, fine sand, loamy sand, loamy fine sand, or loamy coarse sand
Reaction: extremely acid to neutral

Some forested pedons have partially or well decomposed O horizons of forest litter up to 13 cm (5 inches) thick.

E horizon:
Hue: 7.5YR or 10YR
Value: 5 to 7
Chroma: 1 to 3
Texture: sand, loamy sand, fine sand, loamy fine sand, coarse sand, or loamy coarse sand
Reaction: extremely acid to neutral

Bhs horizon:
Hue: 5YR to 10YR
Value: 2 or 3
Chroma: 2 or 3
Texture: sand, loamy sand, fine sand, coarse sand, or loamy coarse sand
Ortstein content: 0 to 30 percent of the surface area exposed in a vertical cut through the Bhs horizon and is present in less than 50 percent of the pedons
Reaction: extremely acid to moderately acid

Bs horizon in pedons without a Bhs horizon:
Hue: 5YR or 7.5YR
Value: 3 or 4
Chroma: 4
Texture: sand, loamy sand, loamy fine sand, fine sand, coarse sand, or loamy coarse sand
Reaction: extremely acid to moderately acid

Bs horizon in pedons with a Bhs horizon:
Hue: 5YR to 10YR
Value: 3 to 6

Chroma: 4 to 8
Iron and manganese concretions: present in some pedons
Texture: sand, loamy sand, loamy fine sand, fine sand, coarse sand, or loamy coarse sand
Reaction: extremely acid to moderately acid

BC horizon, where present:
Hue: 10YR
Value: 5 to 7
Chroma: 4 to 6
Texture: sand, loamy sand, loamy fine sand, fine sand, coarse sand, or loamy coarse sand
Reaction: very strongly acid to neutral

C horizon:
Hue: 7.5YR or 10YR
Value: 5 to 7
Chroma: 2 to 6
Texture: sand, fine sand, coarse sand, or loamy coarse sand
Reaction: very strongly acid to neutral

COMPETING SERIES: There are no other series in the same family.

GEOGRAPHIC SETTING: Pipestone soils are on outwash plains, lake plains, beach ridges, and till plains of Wisconsinan age. Slope ranges from 0 to 8 percent but are dominantly 0 to 4 percent. Pipestone soils formed in sandy outwash. Mean annual precipitation ranges from 711 to 914 mm (28 to 36 inches). Mean annual temperature ranges from 7.2 to 10.0 degrees C (45 to 50 degrees F).

GEOGRAPHICALLY ASSOCIATED SOILS: The excessively drained Oakville and Grattan soils and the poorly drained or very poorly drained Granby, Kingsville, and Newton soils are in a drainage sequences with Pipestone soils.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Somewhat poorly drained. The water table fluctuates from near the surface during prolonged wet periods to depths greater than 122 cm (4 feet) in dry seasons. Depth to the top of a seasonal high water table ranges from 15 to 46 cm (0.5 to 1.5 feet) between October and June in normal years. Potential for surface runoff is negligible or very low. Saturated hydraulic conductivity is high or very high. Permeability is rapid.

USE AND VEGETATION: A large part is or has been cultivated. Some areas are in permanent pasture. Special crops such as blueberries, cucumbers, and melons are important crops on this soil. Many areas are in various stages of reforestation. Natural forests are American basswood, eastern cottonwood, northern red oak, bitternut hickory, white ash, swamp white oak, and red maple.

DISTRIBUTION AND EXTENT: MLRAs 96, 97, 98, 99, 142, 144A, 149B in southern Michigan, northeastern Indiana, Connecticut, Massachusetts, New Hampshire and New York.

The series is of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: AMHERST, MASSACHUSETTS

SERIES ESTABLISHED: Gratiot County, Michigan, 1975.

REMARKS: Diagnostic horizons and features recognized in this pedon are:
Ochric epipedon: from the surface to a depth of 28 cm (11 inches) (Ap and E horizons).
Albic horizon: from a depth of 20 to 28 cm (8 to 11 inches) (E horizon).
Spodic horizon: from a depth of 28 to 38 cm (11 to 15 inches) (Bhs horizon).

ADDITIONAL DATA: Soil Interpretation Record: MI0257.

National Cooperative Soil Survey
U.S.A.

LOCATION POOTATUCK CT+MA NH NY RI VT

Established Series
Rev. MFF-SMF-GS
01/2013

POOTATUCK SERIES

The Pootatuck series consists of very deep, moderately well drained loamy soils formed in alluvial sediments. They are nearly level soils on floodplains subject to frequent to occasional flooding. Slope ranges from 0 to 3 percent. Saturated hydraulic conductivity is moderately high or high in the loamy upper layers and high or very high in the sandy substratum. Mean annual temperature is about 10 degrees Celsius, and mean annual precipitation is about 1190 millimeters.

TAXONOMIC CLASS: Coarse-loamy, mixed, active, mesic Fluvaquentic Dystrudepts

TYPICAL PEDON: Pootatuck fine sandy loam - cutover woodland. (Colors are for moist soil.)

A-- 0 to 10 centimeters; very dark grayish brown (10YR 3/2) fine sandy loam; weak medium granular structure; friable; common fine and medium roots; strongly acid; clear wavy boundary. (7 to 23 centimeters thick)

Bw1-- 10 to 41 centimeters; dark yellowish brown (10YR 4/4) fine sandy loam; weak medium subangular blocky structure; friable; common fine and medium roots; strongly acid; clear wavy boundary.

Bw2-- 41 to 53 centimeters; brown (10YR 4/3) fine sandy loam; weak medium subangular blocky structure; friable; common fine and medium roots; moderately acid; few medium prominent strong brown (7.5YR 5/6) masses of iron concentration and few medium faint grayish brown (10YR 5/2) iron depletions; gradual wavy boundary.

Bw3-- 53 to 74 centimeters; dark brown (10YR 3/3) sandy loam; weak medium subangular blocky structure; friable; common medium faint grayish brown (10YR 5/2) iron depletions and common medium prominent strong brown (7.5YR 5/6) masses of iron accumulation; common fine roots; moderately acid; clear wavy boundary. (Combined thickness of the Bw horizons is 36 to 94 centimeters.)

C1-- 74 to 89 centimeters; brown (10YR 4/3) sand; single grain; loose; few fine roots; common medium faint grayish brown (10YR 5/2) iron depletions and common medium prominent strong brown (7.5YR 5/6) masses of iron concentration; moderately acid; clear wavy boundary.

C2-- 89 to 100 centimeters; grayish brown (2.5Y 5/2) sand; single grain; loose; 5 percent gravel; few fine faint pale brown (10YR 6/3) masses of iron concentrations; moderately acid; clear wavy

boundary.

C3-- 100 to 165 centimeters; grayish brown (10YR 5/2) gravelly sand; single grain; loose; 25 percent gravel; moderately acid.

TYPE LOCATION: Fairfield County, Connecticut; town of Easton, 800 feet northwest along Connecticut Route 58 from the intersection with Silver Hill Road, 200 feet east Route 58, and 80 feet west of the Aspetuck River; USGS Botsford topographic quadrangle, latitude 41 degrees 16 minutes 40 seconds N., longitude 73 degrees 19 minutes 32 seconds W, NAD 27.

RANGE IN CHARACTERISTICS: Thickness of the solum and depth to the coarse-textured substratum range from 50 to 100 centimeters. Gravel ranges from 0 to 15 percent by volume in the solum and from 0 to 40 percent in the substratum. Some pedons have up to 15 percent cobbles in the substratum. Unless limed, reaction ranges very strongly acid to slightly acid.

The A or Ap horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 1 to 4. Texture is loam, very fine sandy loam, fine sandy loam, or sandy loam. It has weak or moderate granular structure and is friable or very friable.

The Bw horizon has hue of 10YR to 5Y and value and chroma of 3 to 6. Iron depletions occur above a depth of 60 centimeters. The Bw horizon is dominantly fine sandy loam or sandy loam, but includes thin strata of loam, very fine sandy loam, or silt loam. It has granular or subangular blocky structure, or the horizon is massive. Consistence is friable or very friable.

Some pedons have thin Ab horizon strata.

The C horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 to 6. It is typically has redoximorphic features in some subhorizon. Texture of individual layers ranges from loamy fine sand to coarse sand in the fine-earth fraction. Included in some pedons are thin loamy and/or extremely gravelly strata. Also, some pedons have a loamy C horizon layer just below the Bw horizon. The C horizon is single grain and loose in the sandy part. The loamy part is typically massive and friable or very friable. The thickness and number of subhorizons is variable and corresponds to the thickness and variability of the alluvial deposits.

COMPETING SERIES: The Basher, Iotla, Issue, and Philo series are currently in the same family. Iotla and Issue series are from outside LRRs L, R and S. Basher soils have hue of 7.5YR or redder in the B horizon. Philo soils formed in alluvium derived from sandstone and shale. Iotla soils have redoximorphic features in the upper part of the B horizon. Issue soils are somewhat poorly drained. Iotla and Issue soils also have mean summer temperatures more than 3 degrees Celsius warmer than Pootatuck soils.

GEOGRAPHIC SETTING: Pootatuck soils are nearly level soils on floodplains and along rivers and streams. Slope ranges from 0 to 3 percent. The soils formed in recent alluvium derived mostly from granite, gneiss, and schist. Mean annual temperature ranges from 7 to 13 degrees Celsius, mean annual precipitation ranges from 890 to 1270 millimeters, but the range includes as low as 660 millimeters in some places east of Adirondack Mountains in the Champlain Valley

of New York. The growing season ranges from 115 to 190 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Ellington, Ninigret, Occum, Rippowam, Tisbury, and Winooski soils and the Agawam, Enfield, Hadley, Haven, Hinckley, Lim, Limerick, Merrimac, Saco, Suncook, and Windsor soils on nearby landscapes. The well drained Occum and the poorly drained Rippowam soils are associated in a drainage sequence. Agawam, Enfield, Haven, Hinckley, Merrimac, and Windsor soils are better drained and are on nearby outwash terraces. Hadley, Lim, Limerick, and Saco soils are silty floodplain associates. Suncook soils are sandy, excessively drained soils on floodplains.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Moderately well drained. Surface runoff is slow. Saturated hydraulic conductivity moderately is moderately high or high in the loamy upper layers and high or very high in the sandy substratum. Most areas of these soils flood for short periods each year. Soils on higher positions flood occasionally.

USE AND VEGETATION: Cleared areas are used for cultivated crops, hay, or pasture. Common trees in wooded areas are white pine, white, yellow, and gray birch, red maple, elm, alder, and hemlock.

DISTRIBUTION AND EXTENT: Floodplains in Connecticut, Massachusetts, New Hampshire, eastern New York, Rhode Island, and Vermont; MLRAs 142, 144A and 145. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts

SERIES ESTABLISHED: Fairfield County, Connecticut, 1979.

REMARKS: Cation exchange activity class placement determined from a review of limited lab data and similar or associated soils.

Diagnostic horizons and features recognized in this pedon are:
1. Ochric epipedon - the zone from 0 to 10 centimeters (A horizon).
2. Cambic horizon - the zone from 10 to 74 centimeters (Bw horizons).
3. Fluvaquentic subgroup - irregular decrease in organic carbon with depth and organic carbon is greater than 0.2 percent within 1.25 meters; aquic conditions and low chroma redoximorphic depletions with chroma 2 or less are within a depth of 60 centimeters from the surface.
4. Particle-size class - averages coarse-loamy in the control section from 25 to 100 centimeters.

National Cooperative Soil Survey
U.S.A.

LOCATION RIPPOWAM CT +MA NH NY RI VT
Established Series
Rev. MFF-RAS-SMF
05/2005

RIPPOWAM SERIES

The Rippowam series consists of very deep, poorly drained loamy soils formed in alluvial sediments. They are nearly level soils on flood plains subject to frequent flooding. Slope ranges from 0 to 3 percent. Saturated hydraulic conductivity ranges from moderately high or high in the loamy upper part and high or very high in the underlying sandy materials. Mean annual temperature is about 50 degrees F., and mean annual precipitation is about 47 inches.

TAXONOMIC CLASS: Coarse-loamy, mixed, superactive, nonacid, mesic Fluvaquentic Endoaquepts

TYPICAL PEDON: Rippowam fine sandy loam in woodland at an elevation of about 435 feet. (Colors are for moist soil.)

A--0 to 5 inches; very dark grayish brown (10YR 3/2) fine sandy loam; weak medium granular structure; friable; common fine and medium roots; very strongly acid; clear wavy boundary. (3 to 9 inches thick)

Bg1--5 to 12 inches; dark grayish brown (10YR 4/2) fine sandy loam; weak medium subangular blocky structure; friable; common fine and medium roots; common medium prominent strong brown (7.5YR 5/6) masses of iron accumulation; very strongly acid; clear wavy boundary.

Bg2--12 to 19 inches; dark gray (10YR 4/1) fine sandy loam; weak medium subangular blocky structure; friable; few fine and medium roots; many medium prominent yellowish red (5YR 4/6) masses of iron accumulation; strongly acid; clear wavy boundary. (Combined thickness of the Bg horizons is 6 to 27 inches.)

BCg1--19 to 24 inches; grayish brown (10YR 5/2) sandy loam; massive; friable; few fine and medium roots; common medium prominent strong brown (7.5YR 5/6) masses of iron accumulation; strongly acid; clear wavy boundary.

BCg2--24 to 27 inches; very dark gray (10YR 3/1) sandy loam; massive; friable; few fine and medium roots; moderately acid; clear wavy boundary. (Combined thickness of the BCg horizons is 0 to 8 inches.)

Cg1--27 to 31 inches; dark gray (10YR 4/1) loamy sand; single grain; loose; moderately acid; clear wavy boundary.

Cg2--31 to 65 inches; grayish brown (10YR 5/2) very gravelly sand; single grain; loose; 35 percent gravel; moderately acid.

TYPE LOCATION: Fairfield County, Connecticut; town of Redding, 100 feet south of Cross Highway and 100 feet east of Little River. USGS Botsford Quadrangle; latitude 41 degrees 18 minutes 32 seconds N. and longitude 73 degrees 21 minutes 57 seconds W., NAD 27.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 20 to 40 inches. The difference between mean summer soil temperature and mean winter soil temperature is at least 25 degrees F. or more. Depth to the coarse-textured substratum layers commonly is from 20 to 40 inches but can range to a depth of 45 inches. Gravel ranges from 0 to 15 percent by volume in the solum and from 0 to 40 percent in the sandy substratum. Some pedons have up to 10 percent cobbles in the coarse-textured substratum. Reaction ranges from very strongly acid to neutral with some subhorizon being moderately acid, slightly acid, or neutral within a depth of 40 inches.

Some pedons have an O horizon that is highly decomposed, moderately decomposed, or slightly decomposed plant material. It has hue of 5YR to 10YR and value and chroma of 3 or less.

The A or Ap horizon has hue of 10YR or 2.5Y, value of 2 to 4, and chroma of 1 or 2. Texture is very fine sandy loam, fine sandy loam, or sandy loam. It typically has weak or moderate granular structure but some pedons have subangular blocky structure. Consistence is friable or very friable.

The Bg horizon has hue of 10YR to 5Y, value of 4 to 6, and chroma of 1 or 2 and typically has redoximorphic features. Texture of the Bg horizon is dominantly fine sandy loam or sandy loam. The Bg horizon is massive or has weak granular or subangular blocky structure. Consistence is friable or very friable.

The BCg horizon, where present, has hue of 10YR to 5Y, value of 3 to 6, and chroma of 1 or 4 and typically has redoximorphic features. Texture of the BCg horizon is dominantly fine sandy loam or sandy loam. The BCg horizon is massive or has weak granular or subangular blocky structure. Consistence is friable or very friable.

Included in some pedons are thin Ab horizons with characteristics similar to the A horizon.

The C horizon or layer has hue of 10YR to 5Y, value of 3 to 6, and chroma of 1 to 4. Texture ranges from loamy fine sand to coarse sand in the fine-earth fraction. The C horizon is typically single grain and loose. Some pedons have thin loamy strata and/or extremely gravelly strata in the lower part of the C horizon.

COMPETING SERIES: There are no soils currently in the same family. Briscot, Holderton, and Lim soils are in related families. Briscot soils are from outside LRR R.

Briscot soils are dominantly fine sandy loam or finer to a 60-inch depth and the difference between mean summer soil temperature and mean winter soil temperature is less than 25 degrees

F. Holderton soils have an active cation exchange activity class and have textures finer than loamy fine sand in the substratum. Lim soils have a texture to a depth of at least 18 inches that is commonly silt loam or very fine sandy loam but includes loam with more than 65 percent silt plus very fine sand.

GEOGRAPHIC SETTING: Rippowam soils are nearly level soils on flood plains along rivers and streams. They are in low areas. Slope ranges from 0 to 3 percent. The soils formed in recent alluvium derived mostly from granite, gneiss, and schist. Mean annual temperature ranges from 45 to 54 degrees F., mean annual precipitation ranges from 35 to 50 inches, and the growing season ranges from 115 to 190 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Agawam, Enfield, Hadley, Haven, Hinckley, Lim, Limerick, Merrimac, Ninigret, Occum, Pootatuck, Saco, Suncook, Tisbury, Windsor, and Winooski soils on nearby landscapes. The well drained Occum and the moderately well drained Pootatuck soils are associated in a drainage sequence. Agawam, Haven, Enfield, Hinckley, Merrimac, Ninigret, Tisbury, and Windsor soils are better drained soils on outwash terraces. Hadley soils are well drained silty floodplain associates. Suncook soils are excessively drained sandy soils on floodplains.

DRAINAGE AND PERMEABILITY: Poorly drained. Surface runoff is negligible to low. Saturated hydraulic conductivity ranges from moderately high or high in the loamy upper part and high or very high in the underlying sandy materials. These soils typically flood in the spring of each year. Rippowam soils have a water table at or near the surface much of this year.

USE AND VEGETATION: Most areas are in brushy woodland. Common trees are red maple, willow, and alder. A few areas are cleared and used for pasture or hay.

DISTRIBUTION AND EXTENT: Floodplains in Connecticut, Massachusetts, New Hampshire, eastern New York, Rhode Island, and Vermont; MLRAs 142, 144A, 145. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Fairfield County, Connecticut, 1979.

REMARKS: This revision reflects conformance to a change in soil taxonomy based on a revision to the definition of the cambic horizon made in 1999. Cation exchange activity class placement determined from a review of limited lab data and similar or associated soils.

Diagnostic horizons and features recognized in this pedon are:

1. Ochric epipedon - the zone from 0 to 5 inches (A horizon).
2. Cambic horizon - the zone from 5 to 27 inches (Bg1, Bg2, BCg1, and BCg2 horizons). Evidence of alteration is in the form of description of subangular blocky structure and inferred

absence of rock structure to a depth of 27 inches.
3. Particle-size class - averages coarse-loamy in the control section from 10 to 40 inches.

National Cooperative Soil Survey
U.S.A.

LOCATION SACO CT+MA NH NY VT
Established Series
Rev. MFF-SMF
05/1999

SACO SERIES

The Saco series consists of very deep, very poorly drained soils formed in silty alluvial deposits. They are nearly level soils on flood plains, subject to frequent flooding. Slope ranges from 0 to 2 percent. Permeability is moderate in the silty layers and rapid or very rapid in the underlying sandy materials. Mean annual temperature is about 50 degrees F. and mean annual precipitation is about 47 inches.

TAXONOMIC CLASS: Coarse-silty, mixed, active, nonacid, mesic Fluvaquentic Humaquepts

TYPICAL PEDON: Saco silt loam - grass field. (Colors are for moist soil unless otherwise noted.)

A--0 to 12 inches; very dark gray (10YR 3/1) silt loam; gray (10YR 5/1) dry; weak coarse granular structure; very friable; many fine roots; moderately acid; clear wavy boundary. (10 to 15 inches thick)

Cg1--12 to 32 inches; gray (10YR 5/1) silt loam; massive; friable; few fine roots; common medium faint light brownish gray (10YR 6/2) iron depletions and common medium prominent strong brown (7.5YR 5/8) masses of iron accumulation; moderately acid; clear wavy boundary.

Cg2--32 to 48 inches; gray (5Y 5/1) silt loam with thin strata of very dark gray (10YR 3/1) silt loam; massive; friable; moderately acid; clear wavy boundary. (Combined thickness of the silty C horizon layers is 30 to 50 inches)

2Cg3--48 to 60 inches; gray (10YR 6/1 and 5/1) stratified coarse sand and medium sand; single grain; loose; moderately acid.

TYPE LOCATION: Hartford County, Connecticut; town of South Windsor, 1200 feet west along Newbury Road from the intersection with Ter Street and 270 feet south of Newbury Road. USGS Manchester quadrangle; latitude 41 degrees 49 minutes 49 seconds N., Longitude 72 degrees 37 minutes 23 seconds W., NAD 27.

RANGE IN CHARACTERISTICS: Depth to the coarse-textured substratum layers is more than 40 inches. Gravel ranges from 0 to 5 percent to 40 inches and from 0 to 40 percent below. The soil is strongly acid to neutral to a depth of about 30 inches and moderately acid to neutral below.

Some pedons have O horizons up to 5 inches thick.

The A or Ap horizon has hue of 7.5YR through 2.5Y, value of 2 or 3 and chroma of 1 through 3. Texture is silt loam, mucky silt loam, very fine sandy loam or mucky very fine sandy loam. It has weak granular structure or the horizon is massive. Consistence is friable or very friable.

Individual layers of the C horizon are neutral or have hue of 10YR through 5Y, value of 3 through 6 and chroma of 0 through 2. Layers within a 30 inch depth commonly have value of 5 or 6 and chroma of 1 or 2 and have redoximorphic features. Included in some pedons are thin, Ab horizon strata. Texture of the C horizon to a depth of 40 inches or more is silt loam or very fine sandy loam. Below 40 inches texture ranges to include loamy fine sand through very gravelly coarse sand. Some pedons have subhorizons with texture of fine sandy loam. The upper silty layers are massive or have weak structure. Consistence is friable or very friable. The underlying sandy layers are single grain and loose. The thickness and number of horizons below the A horizon is variable and corresponds to the thickness and variability of the alluvial deposits.

COMPETING SERIES: There are no other series currently in the same family.

The Birdsall, Mansfield, Rippowam, Wayland and Whitman soils are similar soils in related families.

Birdsall, Mansfield and Whitman soils have a regular decrease in organic-carbon with depth. In addition, Mansfield and Whitman soils are coarse-loamy. Wayland soils have a dark A horizon less than 10 inches thick and are fine-silty. Rippowam soils are coarse-loamy and poorly drained.

GEOGRAPHIC SETTING: Saco soils are nearly level soils on flood plains, along rivers and streams. They are in depressed areas. Slope ranges from 0 to 2 percent. The soils formed in recent silty alluvium derived mostly from granite, gneiss, schist, shale and sandstone. Mean annual temperature is 45 to 54 degrees F., mean annual precipitation is 32 to 50 inches and the growing season is 120 to 195 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Agawam, Bash, Enfield, Hadley, Haven, Hinckley, Limerick, Merrimac, Ninigret, Occum, Pootatuck, Rippowam, Suncook, Tisbury, Windsor and Winooski soils on nearby landscapes. The well drained Hadley, moderately well drained Winooski and poorly drained Limerick soils are associated in a drainage sequence. Agawam, Enfield, Haven, Hinckley, Merrimac, Ninigret, Tisbury, and Windsor soils are better drained soils on nearby outwash terraces. Bash, Occum, Pootatuck and Suncook soils are coarser textured flood plain associates.

DRAINAGE AND PERMEABILITY: Very poorly drained. Surface runoff is slow or very slow. In places water is ponded on the surface from late fall through early spring. Permeability is moderate in the silty layers and rapid or very rapid in the underlying sandy materials. These soils flood in the spring and after periods of heavy rainfall.

USE AND VEGETATION: Most areas are in brushy woodland. Common trees are red maple, elm, willow, pin oak, and alder. Fir and spruce are common in the northern areas. A few areas are in low quality pasture.

DISTRIBUTION AND EXTENT: Floodplains in Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont and eastern New York; MLRAs 101, 142, 144A, and 145. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts

SERIES ESTABLISHED: Cumberland County, Maine, 1915.

REMARKS: This revision reflects change in soil taxonomy and general updating. Cation exchange activity class placement determined from a review of limited lab data and similar or associated soils. Saco soils were previously used in Maine but soil temperature studies have resulted in the mesic soil temperature regime not being used currently.

Diagnostic horizons and features recognized in this pedon are:

1. Umbric epipedon - the zone from 0 to 12 inches (A);
2. Fluvaquentic subgroup - an irregular decrease in organic-carbon content between a depth of 25 cm. and 125 cm. and slope less than 25 percent;
3. Particle size class - averages coarse-silty in the control section 10 to 40 inches.

National Cooperative Soil Survey
U.S.A.

LOCATION SCARBORO MA CT NH NY RI VT
Established Series
Rev. WHT-SMF-MFF
03/2010

SCARBORO SERIES

The Scarboro series consists of very deep, very poorly drained soils in sandy glaciofluvial deposits on outwash plains, deltas, and terraces. They are nearly level soils in depressions. Slope ranges from 0 through 3 percent. Saturated hydraulic conductivity is high or very high. Mean annual temperature is about 49 degrees F. (9 degrees C.) and the mean annual precipitation is about 44 inches (1118 millimeters).

TAXONOMIC CLASS: Sandy, mixed, mesic Histic Humaquepts

TYPICAL PEDON: Scarboro mucky fine sandy loam woodland; in an area of Scarboro mucky fine sandy loam at an elevation of about 212 meters. (Colors are for moist soil.)

Oi-- 0 to 1 inch (0 to 3 centimeters); slightly decomposed maple leaves and other plant material

Oa-- 1 to 8 inches (3 to 20 centimeters); dark brown (10YR3/3) mucky peat; thin platy structure; friable; common fine roots; very strongly acid; abrupt wavy boundary. (Combined thickness of Oi, Oe, and Oa horizons is 8 to 13 inches (20 to 33 centimeters).)

A-- 8 to 14 inches (20 to 36 centimeters); black (N 2/0) mucky fine sandy loam; weak medium granular structure; friable; common fine roots; very strongly acid; abrupt smooth boundary. (0 to 14 inches (0 to 36 centimeters) thick.)

Cg1-- 14 to 19 inches (36 to 48 centimeters); grayish brown (2.5Y 5/2) loamy sand; massive; friable; many fine roots; very strongly acid; abrupt irregular boundary.

Cg2-- 19 to 22 inches (48 to 56 centimeters); grayish brown (2.5Y 5/2) sand; massive; friable; few fine roots; 10 percent rock fragments; common medium prominent dark brown (7.5YR 3/2) areas of iron depletion and common medium prominent yellowish red (5YR 4/6) masses of iron; very strongly acid; clear wavy boundary.

Cg3-- 22 to 65 inches (56 to 165 centimeters); grayish brown (2.5Y 5/2) gravelly sand; single grain; loose; 15 percent rock fragments; strongly acid.

TYPE LOCATION: 60 feet north of Electric Avenue near the south edge of Forest Hill Cemetery in the City of Fitchburg, Massachusetts. USGS Fitchburg, MA topographic quadrangle, Latitude 42 degrees, 34 minutes, 0.3 seconds N., and Longitude 71 degrees, 48 minutes, 33.3 seconds W., NAD 1983.

RANGE IN CHARACTERISTICS: Stones range from 0 through 5 percent by volume in the A horizon and upper part of the C horizon and are absent in the lower part of the C horizon. Cobbles range from 0 through 10 percent in the A horizon, 0 through 5 percent in the upper part of the C horizon, and are absent in the lower part of the C horizon. Gravel ranges from 0 through 10 percent by volume in the A horizon, 0 through 20 percent in the upper part of the C horizon to a depth of 30 inches (76 centimeters), and 0 through 50 percent in the C horizon below a depth of 30 inches (76 centimeters). Reaction ranges from very strongly acid through moderately acid in the A horizon and upper part of the C horizon, and from very strongly acid through neutral in the lower part of the C horizon.

The O horizon is commonly mucky peat or muck, but the range includes thin layers of peat at the surface. The O horizon is neutral or has hue 5YR through 10YR, value of 2 or 3, and chroma of 0 through 3.

The A horizon where present is neutral or has hue of 5YR through 2.5Y, value of 2 through 3, and chroma of 0 through 2. It is fine sandy loam, sandy loam, loamy fine sand, loamy sand, fine sand, sand or their mucky analogues in the fine-earth fraction. This horizon commonly is 5 through 14 inches (13 through 36 centimeters) thick, but in some places may be less than 5 inches (13 centimeters) thick or absent.

The upper part of the Cg horizon is neutral or has hue of 10YR through 5Y, value of 3 through 7, and chroma of 0 through 3. Some pedons have few or common fine through coarse redoximorphic features. Texture is fine sandy loam, sandy loam, loamy fine sand, loamy coarse sand, loamy sand, fine sand, or sand in the fine-earth fraction.

The lower part of the C horizon is neutral or has hue of 10YR through 5Y or 5GY, value of 3 through 6, and chroma of 0 through 4. Redoximorphic features range from none through many and are fine through coarse. Texture is loamy fine sand, loamy sand, fine sand, sand, loamy coarse sand, or coarse sand in the fine-earth fraction. The C horizon is structureless and loose, very friable, or friable. It is often stratified.

COMPETING SERIES: These are the Ackerman and Antung series. These soils are from outside LRR R and S. Ackerman soils are more alkaline in the organic horizons and the upper part of the C horizon. They also contain coprogenous material. Antung soils are more alkaline and effervesce in the C horizon.

GEOGRAPHIC SETTING: Scarboro soils are in level or nearly level depressions on outwash plains, deltas, and terraces. Slope is less than 3 percent. The soils formed in sandy glaciofluvial deposits. Mean annual temperature ranges from 46 through 57 degrees F. (8 through 14 degrees C.) and mean annual precipitation ranges from 38 through 55 inches (965 through 1397 millimeters).

GEOGRAPHICALLY ASSOCIATED SOILS: The excessively drained Hinckley, Windsor and Penwood soils, somewhat excessively drained Merrimac soils, moderately well drained Sudbury and Deerfield soils, poorly drained Mashpee(T) and Massasoit(T) soils, somewhat poorly and poorly drained Walpole and Wareham soils are on higher positions on associated

glaciofluvial landforms. The poorly drained Rippowam soils and very poorly drained Saco soils are on nearby flood plains. The very poorly drained Rainberry soils lack a Histic epipedon and have Spodic horizons.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Very poorly drained. Saturated hydraulic conductivity is high or very high. Surface runoff is high or very high. The water table is at or near the surface for 6 to 12 months of the year, and many areas are ponded for short periods.

USE AND VEGETATION: Shrub and brush land or woodland. Common shrubs are speckled alder, smooth alder, rhoda azalea, steeplebush spirea, leatherleaf, labrador-tea, winterberry, highbush blueberry, large cranberry, black huckleberry, poison sumac, and sheep laurel. Common trees are red maple, slippery elm, Atlantic white cedar, tamarack, eastern white pine, willow, and gray birch.

DISTRIBUTION AND EXTENT: Glaciofluvial landforms in Connecticut, Massachusetts, New Hampshire, Rhode Island, eastern New York, and Vermont. MLRAs 142, 144A, 145, and 149B. Scarboro soils are extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Cumberland County, Maine; 1915.

REMARKS: 1. Geographical location (latitude and longitude) determined from the published soil survey.

2. The use of the Scarboro series in Maine, and in MLRA 144B, is relict to before temperature classes. These have been removed from the SC file.

Diagnostic horizons and features recognized in this pedon are:
1. Histic epipedon - the zone from the soil surface to a depth of 8 inches (20 centimeters), (Oi and Oa horizons).
2. Thickness of organic soil materials is 8 inches (20 centimeters).
3. Aquic conditions - Histic epipedon or the zone from 19 to 22 inches (48 to 56 centimeters) has 50 percent or more 2 chroma with redox concentrations (Cg2 horizon).

National Cooperative Soil Survey
U.S.A.

LOCATION SCIO NY+MA ME NH PA RI

Established Series
Rev. JDV-WEH-DAS
03/2013

SCIO SERIES

The Scio series consists of very deep, moderately well drained soils formed in eolian, lacustrine, or alluvial sediments dominated by silt and very fine sand. They are on terraces, old alluvial fans, lake plains, outwash plains and lakebeds. Saturated hydraulic conductivity is moderately high or high to a depth of 100 centimeters and ranges from moderately low through very high below 100 centimeters. Slope ranges from 0 through 25 percent. Mean annual temperature is 9 degrees C., and mean annual precipitation is 940 millimeters.

TAXONOMIC CLASS: Coarse-silty, mixed, active, mesic Aquic Dystrudepts

TYPICAL PEDON: Scio silt loam, on a 2 percent slope in a pasture. (Colors are for moist soil.)

Ap -- 0 to 23 centimeters; dark grayish brown (10YR 4/2) silt loam; moderate fine granular structure; friable; many fine roots; moderately acid; limed; abrupt smooth boundary. (10 to 33 centimeters thick.)

Bw1 -- 23 to 48 centimeters; yellowish brown (10YR 5/6) silt loam; weak medium subangular blocky structure; friable; common fine roots; common medium and fine pores; strongly acid; clear wavy boundary.

Bw2 -- 48 to 79 centimeters; yellowish brown (10YR 5/4) silt loam; weak fine subangular blocky structure; friable; few fine roots; common medium and fine pores; common medium distinct strong brown (7.5YR 5/6) masses of iron accumulation and light brownish gray (10YR 6/2) areas of iron depletion in the matrix; strongly acid; clear smooth boundary. (Combined thickness of the Bw horizon is 38 to 135 centimeters.)

C -- 79 to 102 centimeters; brown (10YR 5/3) silt loam; very weak thick plate like divisions; friable; common medium and fine pores; many medium prominent yellowish brown (10YR 5/8) masses of iron accumulation and distinct gray (10YR 6/1) areas of iron depletion in the matrix; 3 percent rock fragments; strongly acid; abrupt smooth boundary. (20 to 102 centimeters thick.)

2Cg -- 102 to 183 centimeters; grayish brown (2.5Y 5/2) very gravelly loamy sand; single grain; loose; common medium prominent yellowish brown (10YR 5/6) masses of iron accumulation in the matrix; 35 percent gravel; moderately acid.

TYPE LOCATION: Wyoming County, New York; town of Pike, 2 miles north of village of Pike on west side of Campbell Road, 0.7 mile north of junction of Campbell Road and Safford

Road. USGS Pike, NY topographic quadrangle; Latitude 42 degrees, 35 minutes, 17 seconds N. and Longitude 78 degrees, 09 minutes, 26 seconds W., NAD 1927.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 50 through 168 centimeters. Depth to material contrasting with solum texture is 100 centimeters or more. Depth to bedrock is greater than 1.5 meters. Depth to free carbonates is greater than 2 meters. Rock fragments, mainly gravel and cobbles, range from 0 through 5 percent above 100 centimeters and from 0 through 60 percent below 100 centimeters. Stones cover 0 through 10 percent of the surface in some areas.

Some pedons have an O horizon.

The Ap horizon has hue of 7.5YR or 10YR, value of 3 through 5, and chroma of 2 or 3. It is silt loam, very fine sandy loam, or fine sandy loam. Undisturbed pedons have an A horizon with colors similar to the Ap, but also include value of 2. They are 2 through 5 inches thick. Reaction ranges from extremely acid through strongly acid, unless limed.

The B horizon has hue of 7.5YR through 5Y, value of 4 through 6, and chroma of 3 through 6. Redox depletions and accumulations are within a depth of 24 inches (61 centimeters). It is silt loam or very fine sandy loam. Reaction ranges from extremely acid through strongly acid to a depth of 76 centimeters and very strongly through moderately acid below 76 centimeters. Some pedons have a BC horizon.

The C horizon has hue of 7.5YR through 5Y, value of 4 through 6, and chroma of 1 through 6. Texture is silt loam to fine sandy loam. It may contain strata of gravel and sand. It is massive or single grain, and may have plate-like divisions. Reaction ranges from very strongly acid through slightly alkaline.

The 2C horizon, if present, has hue of 7.5YR through 5Y, value of 3 through 6, and chroma of 1 through 4. It is silt loam, very fine sandy loam, or loamy very fine sand in the fine earth fraction. In addition, below a depth of 40 inches (100 centimeters) it can range from fine sandy loam through very gravelly sand. Reaction ranges from very strongly acid through slightly alkaline.

COMPETING SERIES: The Dartmouth series is the only other series in the same family. Dartmouth soils have a gravel content of 0 through 5 percent throughout, and have below a depth of 40 inches (100 centimeters) textures limited to silt, silt loam, very fine sandy loam, or loamy very fine sand and saturated hydraulic conductivity ranges from moderately low through moderately high.

GEOGRAPHIC SETTING: Scio soils are most commonly on terraces or old alluvial fans, but are also on lake plains, outwash plains, lakebeds, and lacustrine mantled uplands. The solum is formed entirely in eolian, lacustrine, or alluvial sediments which may extend to a depth of many centimeters or may be underlain by loamy, sandy, or gravelly material at depths greater than 40 inches (100 centimeters). Slope ranges from 0 through 25 percent. Mean annual temperature ranges from 8 through 10 degrees C., mean annual precipitation ranges from 710 through 1270 millimeters, and mean annual frost-free days ranges from 120 through 180 days. Elevation

ranges from 31 through 457 meters above sea level.

GEOGRAPHICALLY ASSOCIATED SOILS: The Scio series is in a drainage sequence with the well drained Unadilla soils, the well drained and moderately well drained Bridgehampton soils, the poorly drained Raynham soils, and the very poorly drained Birdsall soils. Pope, Tioga, and Hadley soils, and their wetter associated soils are on adjacent floodplains. Alton, Chenango, Copake, and Howard soils, and their wetter associated soils are on adjacent gravelly outwash terraces, kames, and outwash plains.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Moderately well drained. The potential for surface runoff is very low to high. Saturated hydraulic conductivity is moderately high or high to a depth of 100 centimeters and ranges from moderately low through very high below 40 inches 100 centimeters.

USE AND VEGETATION: Most of the soil has been cleared and is used for growing hay, corn, vegetables, fruit, and small grain. Native vegetation is northern red oak, white ash, sugar maple, black cherry, eastern hemlock, and eastern white pine.

DISTRIBUTION AND EXTENT: Massachusetts, Maine, New Hampshire, New York, Pennsylvania, and Rhode Island. MLRAs 101, 139, 140, 143, 144A, 144B, 145, and 149B. The series is moderately extensive.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Allegany County, New York, 1946.

REMARKS: This revision reflects changes to the range in characteristics as well as general updating to metric units. Scio soils have been mapped in frigid areas in the past, but have a Mesic temperature regime. The series will not be used in MLRAs 143 and 144B, or the state of Maine, when older soil surveys in these MLRAs are updated.

Diagnostic horizons and features recognized in this pedon are:
1) Ochric epipedon - the zone from 0 to 23 centimeters (Ap horizon).
2) Cambic horizon - the zone from 23 to 79 centimeters (Bw horizons).
3) Aquic subgroup - Redox depletions with chroma of 2 or less are within 60 centimeters of the mineral soil surface (Bw2 horizon).
4) Particle-size control section - the zone from 23 through 100 centimeters (Bw1, Bw2, C horizons).
5) Lithologic discontinuity - at a depth of 102 centimeters.

ADDITIONAL DATA: Full characterization data for sample no.91MA023009. Pedon analyzed by the NSSL, Lincoln, NE.

National Cooperative Soil Survey
U.S.A.

LOCATION SUNCOOK CT+MA NH NY PA

Established Series
Rev. MFF-SMF-DCP
01/2013

SUNCOOK SERIES

The Suncook series consists of very deep, excessively drained sandy soils formed in alluvial sediments. They are nearly level soils on flood plains, subject to frequent or occasional flooding. Slope ranges from 0 to 3 percent. Saturated hydraulic conductivity is high or very high in the surface layer and underlying strata. Mean annual temperature is about 10 degrees Celsius , and mean annual precipitation is about 1090 millimeters.

TAXONOMIC CLASS: Mixed, mesic Typic Udipsamments

TYPICAL PEDON: Suncook loamy fine sand in a woodland at an elevation of about 60 meters. (Colors are for moist soil.)

Ap-- 0 to 18 centimeters; very dark grayish brown (10YR 3/2) loamy fine sand; very weak coarse granular structure; very friable; many fine roots; strongly acid; abrupt smooth boundary. (15 to 25 centimeters thick)

C1-- 18 to 38 centimeters; dark grayish brown (10YR 4/2) and brown (10YR 5/3) coarse sand; single grain; loose; few fine roots; 2 percent fine gravel; strongly acid; abrupt smooth boundary.

C2-- 38 to 56 centimeters; dark brown (10YR 3/3) loamy fine sand with lenses of coarse sand; single grain; loose; few fine roots; strongly acid; abrupt smooth boundary.

C3-- 56 to 81 centimeters; pale brown (10YR 6/3) medium and coarse sand; single grain; loose; strongly acid; abrupt smooth boundary.

C4-- 81 to 107 centimeters; dark grayish brown (10YR 4/2) fine and medium sand; single grain; loose; strongly acid; abrupt smooth boundary.

C5-- 107 to 165 centimeters; dark grayish brown (10YR 4/2) stratified sand; single grain; loose; 10 percent gravel; strongly acid. (Combined thickness of the C horizons is 140 to 150 cm within a depth of 165 cm).

TYPE LOCATION: Hartford County, Connecticut; Town of Granby, 1000 feet east along Mechanicsville Road from the intersection with Connecticut Route 189, 1200 feet north of Mechanicsville Road, and 50 feet east of the East Branch Salmon Brook; USGS Tariffville topographic quadrangle, latitude 41 degrees 58 minutes 26 seconds N., longitude 72 degrees 48 minutes 12 seconds W., NAD 27.

RANGE IN CHARACTERISTICS: Most pedons are essentially gravel free, but the range includes as much as 10 percent gravel by volume to a 50 centimeter-depth, up to 20 percent gravel from 50 to 100 centimeters, and as much as 40 percent below a depth of 100 centimeters. Unless limed, reaction ranges from very strongly acid to slightly acid.

The Ap or A horizon has hue of 10YR or 2.5Y, value of 2 to 4, and chroma of 1 to 3. Texture is loamy sand, loamy fine sand, sandy loam, or fine sandy loam. The horizon commonly has weak or moderate granular structure or it is single grain. Some pedons have subangular blocky structure. Consistence is friable, very friable or loose. A horizons may be less than 15 centimeters thick in some places.

Individual layers of the C horizon have hue of 7.5YR to 5Y, value of 3 to 6, and chroma of 1 to 6. Texture ranges from loamy fine sand to coarse sand in the fine-earth fraction.
Some pedons have thin buried sandy A horizons that are very dark grayish brown to black.

COMPETING SERIES: These are the Acquango, Aldo, Bigapple, Biltmore, Boplain, Breeze, Caesar, Chute, Dabney, Gardiner, Hodge, Oakville, Osolo, Pahuk, Penwood, Perks, Pinegrove, Plainfield, Poquonock, Ronda, Samoa, Sardak, Sarpy, Scotah, Spessard, Tyner, Wapanucket, and Windsor soils.
Acquango, Biltmore, Gardiner, Pahuk, Samoa, Sarduk, and Sarpy soils are from outside LRR R and S. Acquango soils are very slightly to moderately saline. Aldo soils have a water table and saturation within the series control section for as much as 1 month per year in 6 or more out of 10 years. Bigapple and Breeze soils formed in anthrotransported materials. Biltmore and Spessard soils are well drained. Boplain soils have a paralithic contact within the control section. Caesar, Oakville, Penwood, Plainfield, Tyner, and Windsor soils have B horizons. Chute, Hodge, and Sarpy soils are neutral to moderately alkaline throughout. Dabney and Westport soils receive more than 1500 centimeters of precipitation. Osolo soils have sola thicker than 150 centimeters. Pahuk soils formed in old alluvium and outwash and are not subject to flooding. Perks soils have high chroma mottles within a depth of 100 centimeters. Pinegrove soils formed in acid regolith from surface mine operations. Poquonuck soils have densic horizons within 100 centimeters. Samoa soils formed in eolian materials. Sardak soils are calcareous. Scotah soils have redoximorphic features at depths of 100 to 150 centimeters and saturation for 1 month or less per year in 6 out of 10 years. Ronda soils formed on floodplains of the mesic Piedmont region of North Carolina. Wapanucket soils formed in sandy glaciofluvial or eolian deposits underlain by loamy glaciolacustrine deposits.

GEOGRAPHIC SETTING: Suncook soils are nearly level soils on flood plains. Slope ranges from 0 to 3 percent. The soils formed in recent sandy alluvium derived mainly from granite, gneiss, schist, and quartzite. Mean annual temperature ranges from 7 to 12 degrees Celsius., mean annual precipitation ranges from 1000 to 1270 millimeters, and the growing season ranges from 120 to 180 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the the Agawam, Hadley, Haven, Hinckley, Lim, Limerick, Merrimac, Occum, Pootatuck, Rippowam, Saco, Windsor, and Winooski soils on nearby landscapes. The well drained Occum, moderately well drained

Pootatuck, and poorly drained Rippowam soils are associated in a drainage sequence. Other floodplain associates include the Hadley, Winooski, Lim, Limerick, and Saco soils, all of which have higher silt content. Agawam, Haven, Hinckley, and Merrimac soils are on nearby outwash terraces and are underlain by stratified sand and gravel.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Excessively drained. Surface runoff is negligible. Saturated hydraulic conductivity is high or very high throughout. Flooding varies from once a year to once in ten years, but typically does not occur in the growing season.

USE AND VEGETATION: Most areas are wooded or in brushy unimproved pasture. Cleared areas are in hay or pasture, but a few scattered areas are in cultivated crops. Common trees are sycamore, aspen, cotton wood white and black oak, silver maple red maple, white pine, and ironwood. Understory plants include bayberry, ground cedar, lowbush blueberry, pipsissewa, and hairy moss.

DISTRIBUTION AND EXTENT: Flood plains in Connecticut, Massachusetts, New Hampshire, New York, and Rhode Island; MLRAs 140, 144A, 145, 149A, and 149B. The series is of small extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts

SERIES ESTABLISHED: Hartford County, Connecticut, 1959.

REMARKS: This revision reflects general updating.
Diagnostic horizons and features recognized in this pedon include:
1. Ochric epipedon the zone from 0 to 18 centimeters (Ap horizon)
2. Particle-size class - the control section from 25 to 100 centimeters averages sandy (C1, C2, C3, and C4 horizons).
3. Entisols - no diagnostic horizons present.
4. Udic moisture regime and the mean summer and mean winter soil temperatures at a depth of 50 centimeters differ by 5 degrees Celsius or more.

National Cooperative Soil Survey
U.S.A.

LOCATION SWANSEA MA+RI

Established Series
Rev. PCF-DGG-DAS
02/2014

SWANSEA SERIES

The Swansea series consists of very poorly drained organic soils. They formed in 40 to 130 centimeters of highly decomposed organic material over sandy mineral. These soils are in depressions or on flat level areas on uplands and outwash plains. Saturated hydraulic conductivity is moderately high or high in the organic material and very high in the substratum. The mean annual temperature is about 9 degrees Celsius and the mean annual precipitation is about 1143 millimeters.

TAXONOMIC CLASS: Sandy or sandy-skeletal, mixed, dysic, mesic Terric Haplosaprists

TYPICAL PEDON: Swansea muck - on a 0 percent slope in a wooded area. When described the soil was wet and the depth to the water table was 4 inches. (Colors are for moist soils.)

Oa1--0 to 5 cm.; dark reddish brown (5YR 2/2) broken face and rubbed muck (sapric material); 15 percent fiber, 2 percent rubbed; weak medium granular structure; very friable; many medium roots; less than 5 percent mineral; extremely acid; abrupt wavy boundary.

Oa2--5 to 23 cm.; black (5YR 2/1) broken face and rubbed sapric material; 10 percent fiber, 2 percent rubbed; weak medium granular structure; very friable; common medium roots; less than 5 percent mineral; extremely acid; abrupt wavy boundary.

Oa3--23 to 33 cm.; black (N 2/) broken face and rubbed sapric material; 10 percent fiber, 2 percent rubbed; massive; very friable; few fine roots; contains 5 percent brown (7.5YR 4/4) woody fragments 1 to 4 inches in diameter; less than 5 percent mineral; extremely acid; abrupt wavy boundary.

Oa4--33 to 66 cm.; black (N 2/) broken face and rubbed sapric material; 5 percent fiber, 0 percent rubbed; massive; very friable; few fine roots; less than 5 percent mineral; extremely acid; abrupt wavy boundary.

Cg1--66 to 81 cm.; light olive gray (5Y 6/2) loamy coarse sand; single grain; loose; very strongly acid; abrupt wavy boundary.

Cg2--81 to 165 cm.; light olive gray (5Y 6/2) gravelly loamy coarse sand; single grain; loose; 30 percent gravel; very strongly acid.

TYPE LOCATION: Bristol County, Massachusetts, Town of Swansea, 1,000 feet east of Old

Fall River Road, 1,000 feet south of Interstate 295, and 80 feet north of the telephone line. Latitude 41 degrees 45 minutes 57 seconds N. and longitude 71 degrees 14 minutes 49 seconds W., NAD 27.

RANGE IN CHARACTERISTICS: The depth to the Cg horizon is 40 to 130 centimeters. Cumulative layers of hemic materials comprise less than 25 centimeters and fibric materials less than 12 centimeters of the subsurface and bottom tiers. Woody fragments are in some part of the organic material in most pedons and comprise up to 25 percent of some horizons. Fragments consist of twigs, branches, logs, or stumps and are 2 centimeters to more than 30 centimeters in diameter. Woody fragments are firm but break abruptly under pressure. Reaction is less than 4.5 in 0.01 molar calcium chloride throughout the organic material.

The surface tier has hue of 5YR through 10YR, value of 2 or 3, and chroma of 0 to 2. In some pedons the chroma ranges to 4. It is dominantly sapric material; however, in some pedons it has various proportions of both sapric and hemic materials or has fibric materials. It has weak or moderate, fine or medium, granular or subangular blocky structure or it is massive. Some pedons have a mineral surface layer of sand or coarse sand that is 10 to 25 centimeters thick.

The subsurface and bottom tiers, above the C horizon, have hue of 5YR through 10YR, value of 2 to 3, and chroma of 0 to 3. Chroma or value or both may change from 0.5 to 2 units upon rubbing. Broken faces become darker upon brief exposure to air. The subsurface tier is dominated by sapric material with a rubbed fiber content of less than 16 percent of the organic volume. The subsurface and bottom tiers have platy structure or are massive. They are very friable or friable. Unrubbed organic material resembles herbaceous and woody plant tissues.

The C or Cg horizon has hue of 10YR to 5Y, value of 3 to 6, and chroma of 1 to 4. Redoximorphic features are present in some pedons. It ranges from coarse sand to loamy fine sand and their gravelly analogs but may include some finer-textured lenses or horizons in some pedons. Rock fragment content ranges from 0 to 45 percent and is commonly gravel but includes cobbles in some pedons. Reaction ranges from extremely acid to strongly acid.

COMPETING SERIES: This is the Makinen series which are from outside LRR R and S. The Makinen soils receive less than 813 millimeters of mean annual precipitation and have less gravel in the substratum.

Freetown and Paupack are similar soils in related families. Freetown soils have organic layers greater than 130 centimeters. Paupack soils are underlain by loamy skeletal or clayey skeletal mineral material.

GEOGRAPHIC SETTING: Swansea soils are in swamps and bogs that range from small enclosed depressions to areas of several hundred acres in size. They are on outwash plains, till plains and moraines. Slope ranges from 0 to 1 percent. Mean annual temperature is 7 to 10 degrees Celsius and mean annual precipitation is 1016 to 1270 millimeters. The frost-free period is 120 to 180 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Freetown, Hinckley, Windsor,

Ridgebury, Whitman, and Scarboro soils on nearby landscapes. Freetown soils are on similar landscapes and have more than 130 centimeters of organic material. The excessively drained Hinckley and Windsor soils are on nearby outwash landforms. The somewhat poorly and poorly drained Ridgebury soils and the very poorly drained Whitman and Scarboro soils formed in glacial till are adjacent to areas of Swansea soils.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Very poorly drained. Saturated Hydraulic Conductivity is moderately high or high in the organic material and very high in the substratum.

USE AND VEGETATION: Mostly forested. Native vegetation includes red maple, American elm, green ash, eastern hemlock, Atlantic white cedar, buttonbush, winterberry, swamp azalea, and leatherleaf. Some acreage has been cleared and is used for truck crops. The main crop is cranberries.

DISTRIBUTION AND EXTENT: Swamps and bogs in Massachusetts and Rhode Island; MLRAs 144A, 145, 149B. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Bristol County, Massachusetts, 1979

REMARKS: These soils were previously mapped in Massachusetts as Cranberry bog, Medisaprists, and Muck and in some areas as Adrian soils. The Type Location is pedon T1MA603018, also the typical pedon for the soil survey of Bristol County, MA, Southern Part.

Diagnostic horizons and features in this pedon include:

1. Terric feature - mineral soil from a depth of 66 to 165 centimeters (2Cg horizons).
2. Lithic discontinuity - there is a significant change in particle size at a depth of 66 centimeters (Cg1 horizon).
3. Sapric material from 0 to 66 centimeters (Oa horizons)
4. Histic epipedon from 0 to 33 centimeters
5. Aquic conditions 0 to 165 centimeters
6. Endosaturation 0 to 165 centimeters

National Cooperative Soil Survey
U.S.A.

LOCATION WINDSOR CT+MA NH NY RI VT

Established Series
Rev. MFF-SMF-DCP
03/2014

WINDSOR SERIES

The Windsor series consists of very deep, excessively drained soils formed in sandy outwash or eolian deposits. They are nearly level through very steep soils on glaciofluvial landforms. Slope ranges from 0 through 60 percent. Saturated hydraulic conductivity is high or very high. Mean annual temperature is about 10 degrees C and mean annual precipitation is about 1092 mm.

TAXONOMIC CLASS: Mixed, mesic Typic Udipsamments

TYPICAL PEDON: Windsor loamy sand - forested, 3 percent slope, at an elevation of about 24 meters. (Colors are for moist soil.)

Oe--0 to 3 cm; black (10YR 2/1) moderately decomposed forest plant material; many very fine and fine roots; very strongly acid; abrupt smooth boundary. (0 to 8 cm thick.)

A--3 to 8 cm; very dark grayish brown (10YR 3/2) loamy sand; weak medium granular structure; very friable; many very fine and fine roots; strongly acid; abrupt wavy boundary. (3 to 25 cm thick.)

Bw1--8 to 23 cm; strong brown (7.5YR 5/6) loamy sand; very weak fine granular structure; very friable; many fine and medium roots; strongly acid; gradual wavy boundary.

Bw2--23 to 53 cm; yellowish brown (10YR 5/6) loamy sand; very weak fine granular structure; very friable; common fine and medium roots; strongly acid; gradual wavy boundary.

Bw3--53 to 64 cm; light yellowish brown (10YR 6/4) sand; single grain; loose; few coarse roots; strongly acid; clear wavy boundary. (Combined thickness of the Bw horizons is 23 to 86 cm.)

C--64 to 165 cm; pale brown (10YR 6/3) and light brownish gray (10YR 6/2) sand; single grain; loose; few coarse roots; strongly acid.

TYPE LOCATION: Hartford County, Connecticut; town of South Windsor, 1100 feet northwest along Chapel Road from the intersection of Chapel Road and Ellington Road and 100 feet due south of Chapel Road. USGS Manchester, CT topographic quadrangle, Latitude 41 degrees, 48 minutes, 35 seconds N., Longitude 72 degrees, 36 minutes, 22 seconds W., NAD 1983

RANGE IN CHARACTERISTICS: Thickness of the solum ranges from 25 to 92 cm. Rock

fragments, dominantly fine gravel, range from 0 through 10 percent by volume in the solum and from 0 to 15 percent in the substratum. Thin strata of gravel or thin subhorizons of coarse sand or loamy coarse sand are present in some pedons. Unless limed, reaction in the solum commonly is extremely acid to moderately acid, but the range includes slightly acid. Unless limed, reaction in the substratum commonly is very strongly acid to slightly acid, but the range includes neutral.

O horizons are present in some pedons.

The A horizon has hue of 7.5YR or 10YR, value of 2 or 3, and chroma of 1 to 3. Many pedons have an Ap horizon up to 12 inches thick with value of 3 or 4 and chroma of 2 to 4. The A or Ap horizon is loamy fine sand, loamy sand, fine sand, or sand. It has weak or moderate granular structure and is very friable, friable, or loose.

Some pedons have a thin E horizon with hue 7.5YR or 10YR, value of 4 to 6, and chroma of 1 or 2.

The upper part of the Bw horizon has hue of 7.5YR to 2.5Y, value of 4 to 6, and chroma of 4 to 8. The lower part of Bw horizon has hue of 7.5YR to 5Y, value of 4 to 7, and chroma of 3 to 6. The Bw horizon is loamy sand or loamy fine sand in the upper part and loamy fine sand, loamy sand, fine sand, or sand in the lower part. The Bw horizon has weak granular or weak subangular blocky structure, or it is massive or single grain. Consistence is very friable or loose.

Some pedons have a BC horizon similar to the lower part of the Bw horizon.

The C horizon has hue of 5YR to 5Y, value of 4 to 7, and chroma of 1 to 6. It is fine sand, sand, coarse sand, loamy fine sand, or loamy sand. The horizon is massive or single grain and consistence is very friable or loose.

COMPETING SERIES: These are the Acquango, Aldo, Bigapple, Biltmore, Boplain, Breeze, Caesar, Chute, Dabney, Hodge, Oakville, Osolo, Pahuk, Penwood, Perks, Pinegrove, Plainfield, Poquonock, Ronda, Samoa, Sardak, Sarpy, Scotah, Spessard, Suncook, Tyner, and Wapanucket series. Aquango, Aldo, Biltmore, Boplain, Chute, Dabney, Hodge, Osolo, Pahuk, Perks, Ronda, Samoa, Sardak, Spessard, and Tyner soils are from outside of LRRs L, R, and S. Acquango soils are very slightly to moderately saline within the soil profile. Aldo soils have a water table and saturation within the series control section for as much as one month per year in 6 out of 10 years. Bigapple soils formed in human transported soil material from dredging activities. Biltmore and Spessard soils are well drained. Breeze soils formed in human transported sandy soil materials intermingled with construction debris. Caesar soils contain more coarse sand. Chute, Hodge, and Sarpy soils contain free carbonates and do not have a B horizon. Dabney soils do not have a B horizon and receive more than 152 cm of precipitation annually. Oakville soils typically average 50 percent or more fine sand in the subsoil. Osolo soils have a solum thicker than 1.5 m. Penwood soils have hue of 5YR or redder in the B horizon. Pahuk, Perks, Samoa, and Suncook soils do not have a B horizon. Plainfield soils are less moist in all parts of the control section for the 120 days following the summer solstice. Poquonock soils have a densic contact with in 1 m. Ronda soils formed in alluvium from residuum sources. Sardak soils formed in alluvium and are calcareous. Tyner soils have a thicker solum. Wapanucket soils are underlain

by glaciolacustrine deposits with in the series control section.

GEOGRAPHIC SETTING: Windsor soils are nearly level through very steep soils typically on glaciofluvial landforms but include late-Wisconsin-aged dunes. The steeper slopes are typically on terrace escarpments. Slope ranges from 0 to 60 percent. The soils formed in outwash or eolian deposits of poorly graded sands and loamy sands derived mainly from crystalline rocks. Mean annual temperature ranges from 7 to 12 degrees C, and the mean annual precipitation typically ranges from 965 to 1270 mm, but the range includes as low as 660 mm in some places east of Adirondack Mountains in the Champlain Valley of New York. The growing season ranges from 120 to 190 days.

GEOGRAPHICALLY ASSOCIATED SOILS: These are the Deerfield, Hinckley, Merrimac, Quonset, Suncook, Agawam, Hadley, Haven, Occum, Pootatuck, Scarboro, Sudbury, Walpole, Wareham, and Winooski soils on nearby landscapes. The moderately well drained Deerfield and Sudbury, the somewhat poorly drained and poorly drained Walpole and Wareham, and the very poorly drained Scarboro soils are common drainage associates. Agawam and Haven soils are coarse-loamy over sandy or sandy-skeletal or coarse-loamy terrace associates, respectively. Hadley, Occum, Pootatuck, and Winooski soils are on nearby flood plains.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Excessively drained. Surface runoff is negligible to medium. Saturated hydraulic conductivity is high or very high.

USE AND VEGETATION: Most areas are forested or in low growing brushy vegetation. Some areas are used for silage corn, hay, and pasture. Small areas, mostly irrigated, are used for shade tobacco, vegetables and nursery stock. Some areas are in community development. Common trees are white, black, and northern red oak, eastern white pine, pitch pine, gray birch, poplar, red maple, and sugar maple.

DISTRIBUTION AND EXTENT: Late Wisconsin glaciofluvial or eolian landforms in Connecticut, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont; MLRAs 101, 142, 144A, and 145. The series is of large extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Connecticut Valley Area, 1899.

REMARKS: The use of the Windsor series in Maine, and in MLRAs 141, 144B, and 143 is relict to before temperature classes in soil taxoonomy. These have been removed from the SC file.

Diagnostic horizons and features recognized in this pedon include:
1. Ochric epipedon - the zone from 0 to 8 cm (Oe and A horizons).
2. Particle-size class - averages sandy in the control section from 25 to 100 cm.
3. No cambic horizon and development of color - the zone from 8 to 64 cm demonstrates development of color with no illuvial accumulation of material (Bw horizons).

ADDITIONAL DATA: Reference samples from pedons 54MA023005, 63VT011001, 63VT011002, 64NH017003, 64NH017004, 70CT003003, 70MA011003, 70VT017002, 73MA005003, 73MA005004, 91MA023006, 95NH013001, 96NH013004, 98NY045002, 98NY085002, S07VT011004.

National Cooperative Soil Survey
U.S.A.

LOCATION WINOOSKI MA+CT NH VT

Established Series
Rev. DGG-SMF-DCP
01/2013

WINOOSKI SERIES

The Winooski series consists of very deep, moderately well drained soils formed in alluvial material. These soils are on nearly level flood plains. Slope ranges from 0 through 3 percent. Saturated hydraulic conductivity is moderately low through high. Mean annual precipitation is about 45 inches (1143 millimeters) and the mean annual temperature is about 49 degrees F (7 degrees C).

TAXONOMIC CLASS: Coarse-silty, mixed, superactive, mesic Fluvaquentic Dystrudepts

TYPICAL PEDON: Winooski very fine sandy loam on a 1 percent slope in a cultivated field at an elevation of about 69 meters. (Colors are for moist soil unless otherwise stated.)

Ap -- 0 to 8 inches (0 to 20 centimeters); very dark grayish brown (10YR 3/2) very fine sandy loam; weak fine granular structure; very friable; many fine roots; moderately acid; abrupt smooth boundary. (4 to 18 inches (10 to 46 centimeters thick).

Bw1 -- 8 to 18 inches (20 to 46 centimeters); brown (10YR 4/3) very fine sandy loam; massive; friable; many fine roots; strongly acid; abrupt smooth boundary.

Bw2 -- 18 to 26 inches (46 to 66 centimeters); olive brown (2.5Y 4/4) very fine sandy loam, common medium prominent pinkish gray (5YR 7/2) and faint brown (10YR 5/3) areas of iron depletion; massive; friable; few fine roots; strongly acid; abrupt smooth boundary. (Combined thickness of the Bw horizons is 6 to 30 inches (15 to 76 centimeters).

BC -- 26 to 43 inches (66 to 109 centimeters); olive gray (5Y 5/2) very fine sandy loam; massive; friable; common medium faint light gray (5Y 7/2) areas of iron depletion and faint brown (10YR 5/3) masses of iron accumulation; moderately acid; clear smooth boundary. (0 to 20 inches (0 to 51 centimeters thick).

C -- 43 to 65 inches (109 to 165 centimeters); olive (5Y 5/3) loamy very fine sand; massive; friable; common medium distinct light brownish gray (10YR 6/2) iron depletions and prominent strong brown (7.5YR 5/8) masses of iron accumulation; moderately acid.

TYPE LOCATION: Worcester County, Massachusetts, Town of Lancaster, 100 feet north of Massachusetts Route 117, 900 feet west of the Bolton town line. USGS Hudson, MA topographic quadrangle, Latitude 42 degrees, 27 minutes, 35 seconds N., Longitude 71 degrees, 39 minutes, 7 seconds W., NAD 1983.

RANGE IN CHARACTERISTICS: Solum thickness ranges from 18 through 43 inches (46 through 110 centimeters). Gravel ranges from 0 through 5 percent by volume throughout the soil. Reaction ranges from extremely acid through neutral. Depth to iron depletions with chroma of 2 or less ranges from 14 through 20 inches (35 through 50 centimeters).

The O horizon where present ranges in thickness from 1 or 2 inches (3 through 6 centimeters). The O has hue 7.5YR, value 2.5 or 3, and chroma of 2 or 3. Decompositon of the plant material ranges from fibric through sapric.

The A or Ap horizon has hue of 7.5YR through 5Y, value of 2 through 4, and chroma of 1 through 3. Texture is silt loam, silt, very fine sandy loam, or loamy very fine sand. Structure is subangular blocky, platy, or granular. Consistence is very friable or friable.

Some pedons have Ab and/or AB horizons similar in characteristic to the A or Ap horizon.

The Bw horizon has hue of 7.5 YR through 5Y, value of 2 through 5, and chroma of 2 through 6. Matrix chroma of 2 is below a depth of 20 inches (50 centimeters). Texture is silt loam, silt or very fine sandy loam. Structure is granular or subangular blocky, or it is massive. Consistence is very friable or friable.

The BC horizon, where present, has hue of 10YR through 5Y, value of 2 through 5, and chroma of 2 through 4. Matrix chroma of 2 is below a depth of 20 inches (50 centimeters). Texture is silt loam, silt, very fine sandy loam, or loamy very fine sand. Structure is granular or subangular blocky, or it is massive. Consistence is very friable or friable.

The C horizon has hue of 10YR through 5Y, value of 3 through 6, and chroma of 2 through 4. Matrix chroma of 2 is below a depth of 20 inches (50 centimeters). Texture is silt loam, silt, very fine sandy loam, or loamy very fine sand. Some pedons have thin strata of very fine sand, fine sand, sand, or coarse sand below a depth of 40 inches (100 centimeters). The C horizon is massive or has fine stratification. Consistence is firm through very friable.

The thickness and number of horizons below the A horizon is variable and corresponds to the thickness and variability of the alluvial deposits.

COMPETING SERIES: The Otego soil is the only other soil currently in the same family. Otego soils are formed in alluvium from sandstone, siltstone, and shale. Otego soils do not allow for loamy very fine sand textures in their A, BC, or C horizons.

GEOGRAPHIC SETTING: Winooski soils are nearly level soils on flood plains. They are typically in broad depressions. Slope ranges from 0 through 3 percent. The soils formed in recent alluvial deposits of very fine sand and silt. The source of the alluvium is from igneous and meta-igneous geology, with additions of limestone and dolomite for areas in the Lake Champlain valley, and their resultant glacial materials. Mean annual precipitation ranges from 40 through 50 inches (1016 through 1270 millimeters) and mean annual air temperature from 45 degrees through 52 degrees F. (7 through 11 degrees C.). Mean annual growing season ranges from 120

through 200 days.

GEOGRAPHICALLY ASSOCIATED SOILS: Winooski soils are the moderately well drained member of a drainage sequence which includes the well drained Hadley soils, the poorly drained Limerick soils and the very poorly drained Saco soils on nearby landscapes.

DRAINAGE AND SATURATED HYDRAULIC CONDUCTIVITY: Moderately well drained. Saturated hydraulic conductivity is moderately low through high. Flooding frequency varies from twice a year to once in 10 years. Stream overflow generally occurs during late winter or spring and during periods of high rainfall.

USE AND VEGETATION: Used mainly for growing hay, silage corn and pasture in support of dairying and to some extent for truck crops, potatoes, and tobacco. Native vegetation is forest composed mainly of red maple, silver maple, elm, willow, northern hardwoods, and eastern white pine. Balsam fir and spruce are in the northerly range of the series.

DISTRIBUTION AND EXTENT: New Hampshire, Massachusetts, Connecticut, and Vermont. MLRA's 142, 144A, and 145. The series is of moderate extent.

MLRA SOIL SURVEY REGIONAL OFFICE (MO) RESPONSIBLE: Amherst, Massachusetts.

SERIES ESTABLISHED: Chittenden County, Vermont, 1938.

REMARKS: The Winooski soils mapped in Maine, and in MLRA 144B and 143, are now considered to be in the frigid temperature regime and are relict.

Diagnostic horizons and features recognized in this pedon include:

1. Ochric epipedon - the zone from the surface to a depth of about 8 inches (20 centimeters) (Ap horizon).
2. Coarse-silty particle size - less than 10 percent of the material in the 10 through 40 inch (25 through 100 centimeter) zone is fine sand or coarser, including gravel, and clay averages about 7 percent.
3. Cambic horizon the zone from 8 to 43 inches (20 to 109 centimeters) (Bw1, Bw2, and BC horizons) has evidence of alteration in the form of absence of rock structure or some degree of soil structure.
4. Aquic feature - the zone from 18 to 26 inches has redox depletions and aquic conditions at some time during the year. (Bw2 horizon)

Additional NSSL data: numerous full characterization pedons sampled in CT, MA, NH and VT

National Cooperative Soil Survey
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Appendix G - Topographic Map of Project

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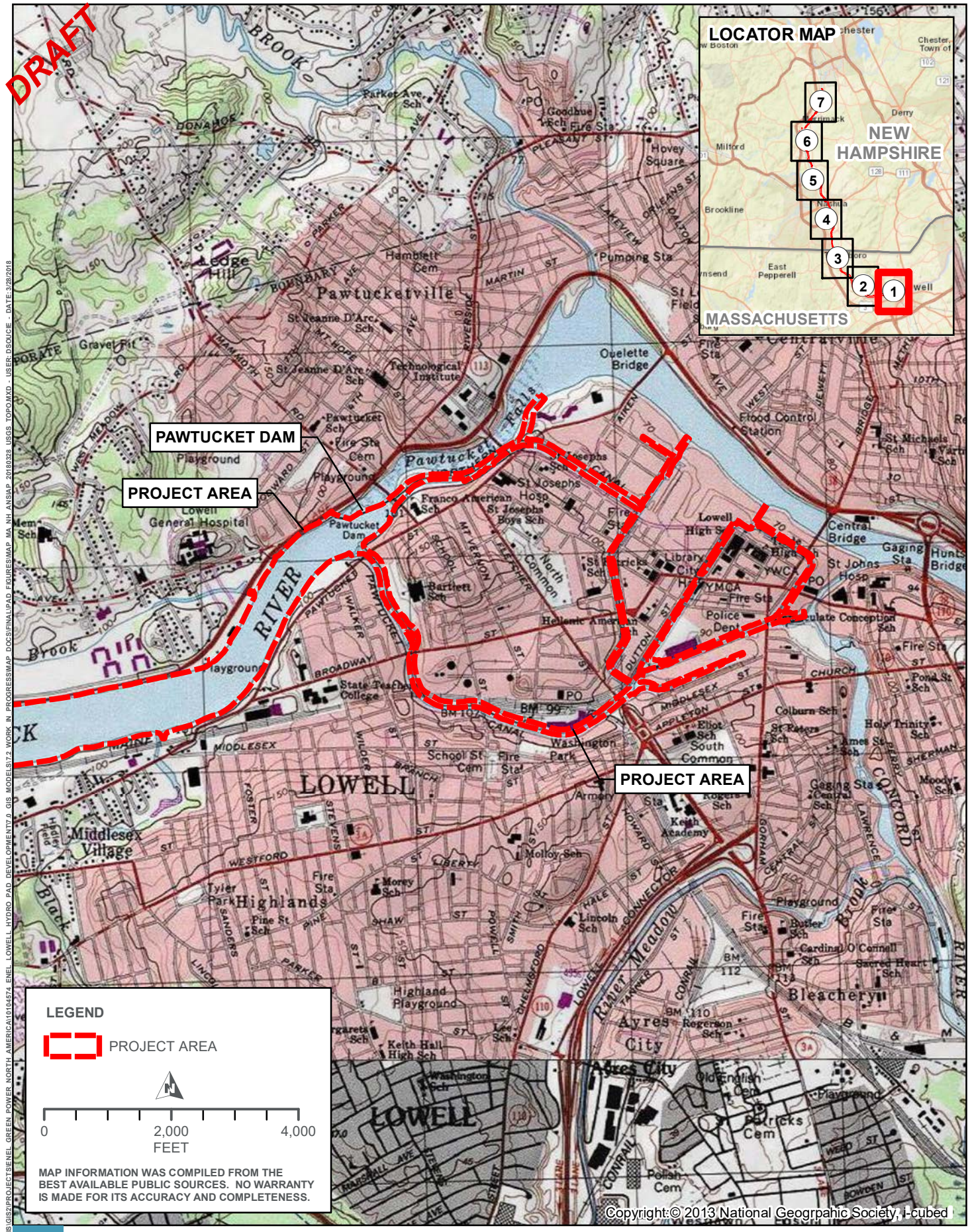

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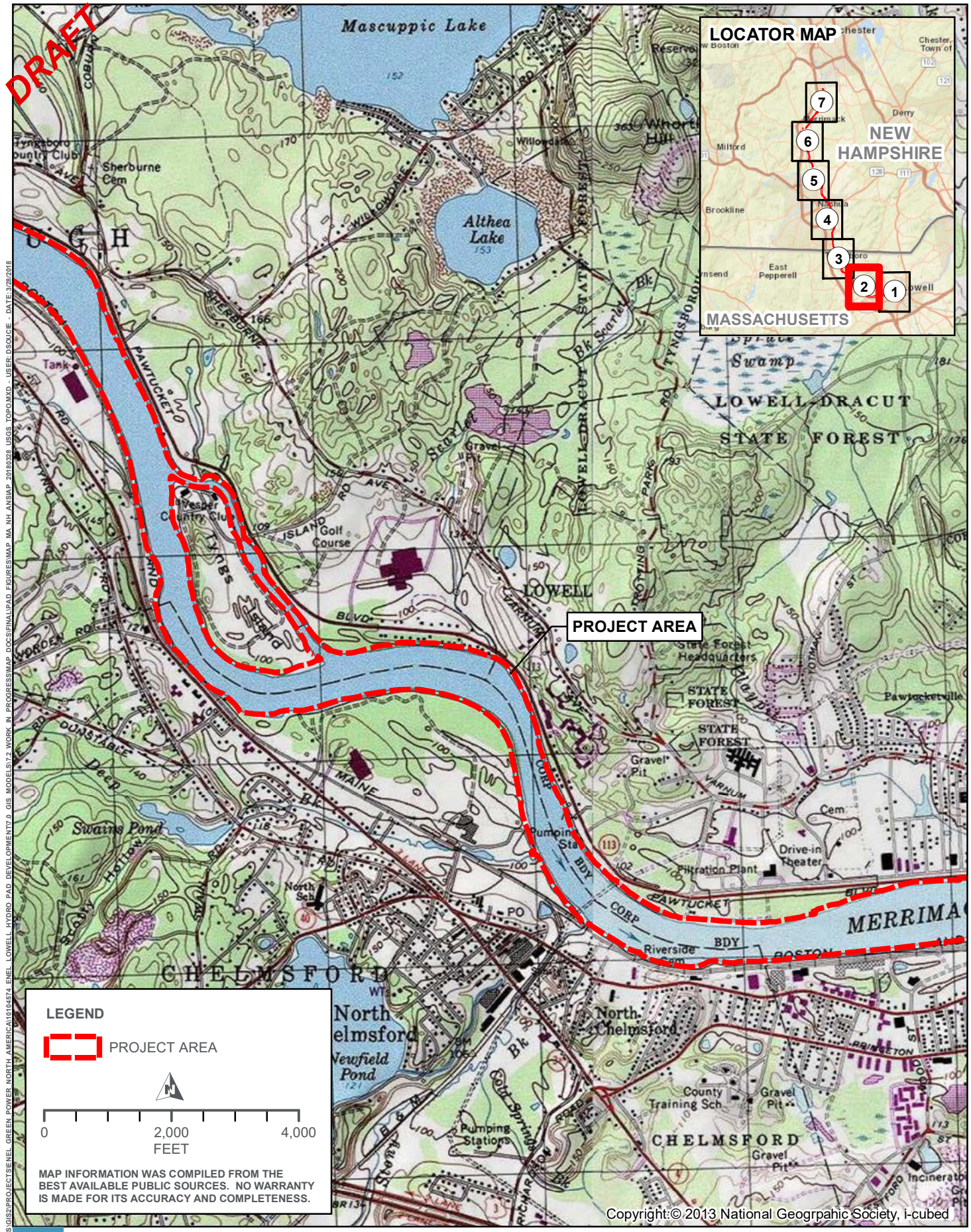
BOOTT HYDRO, LLC.

SHEET 1 OF 7

USGS TOPO
LOWELL HYDROELECTRIC PROJECT
FERC NO. 2790

MARCH 2018



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BOOTT HYDRO, LLC.

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FERC NO. 2790

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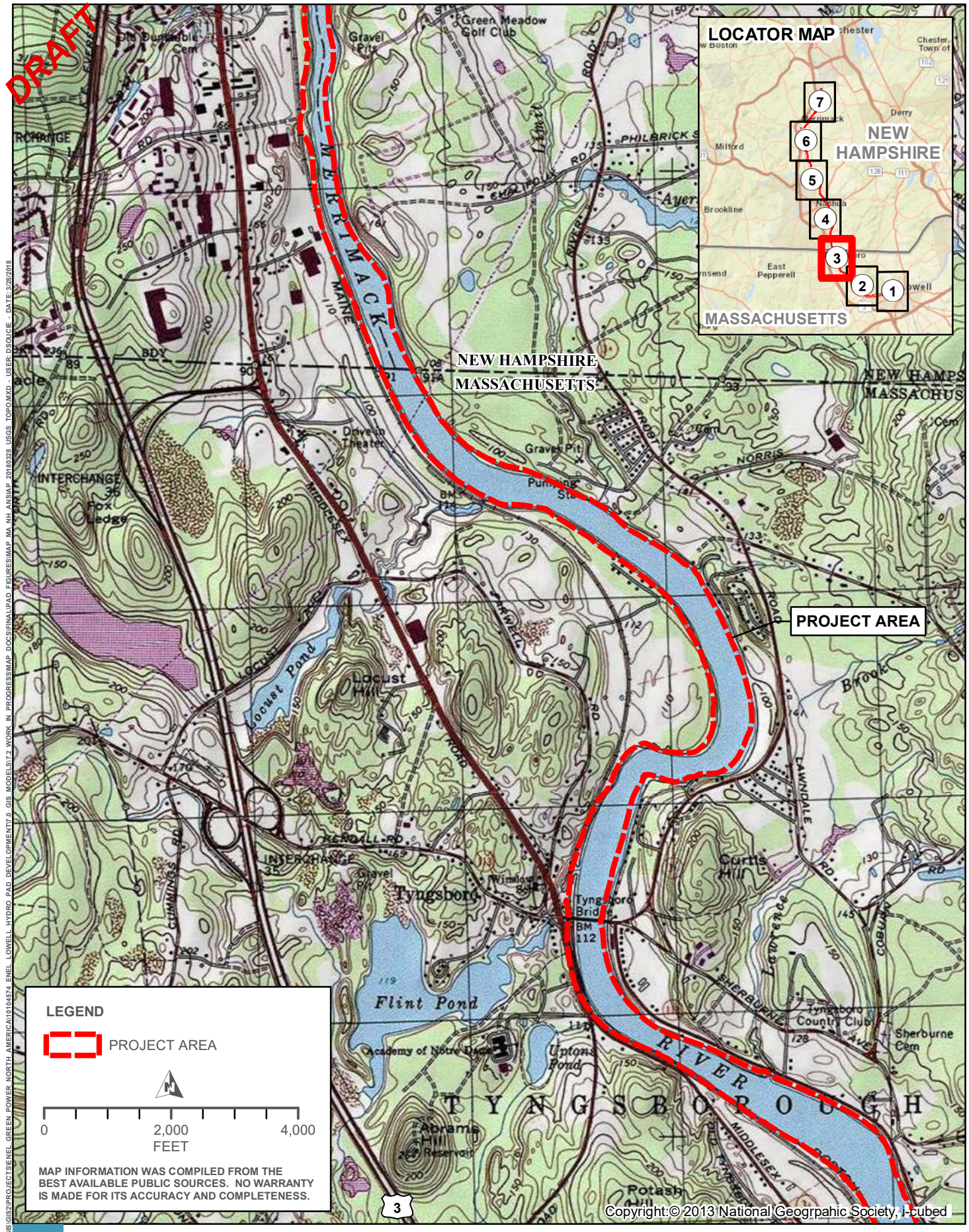

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BOOTT HYDRO, LLC.

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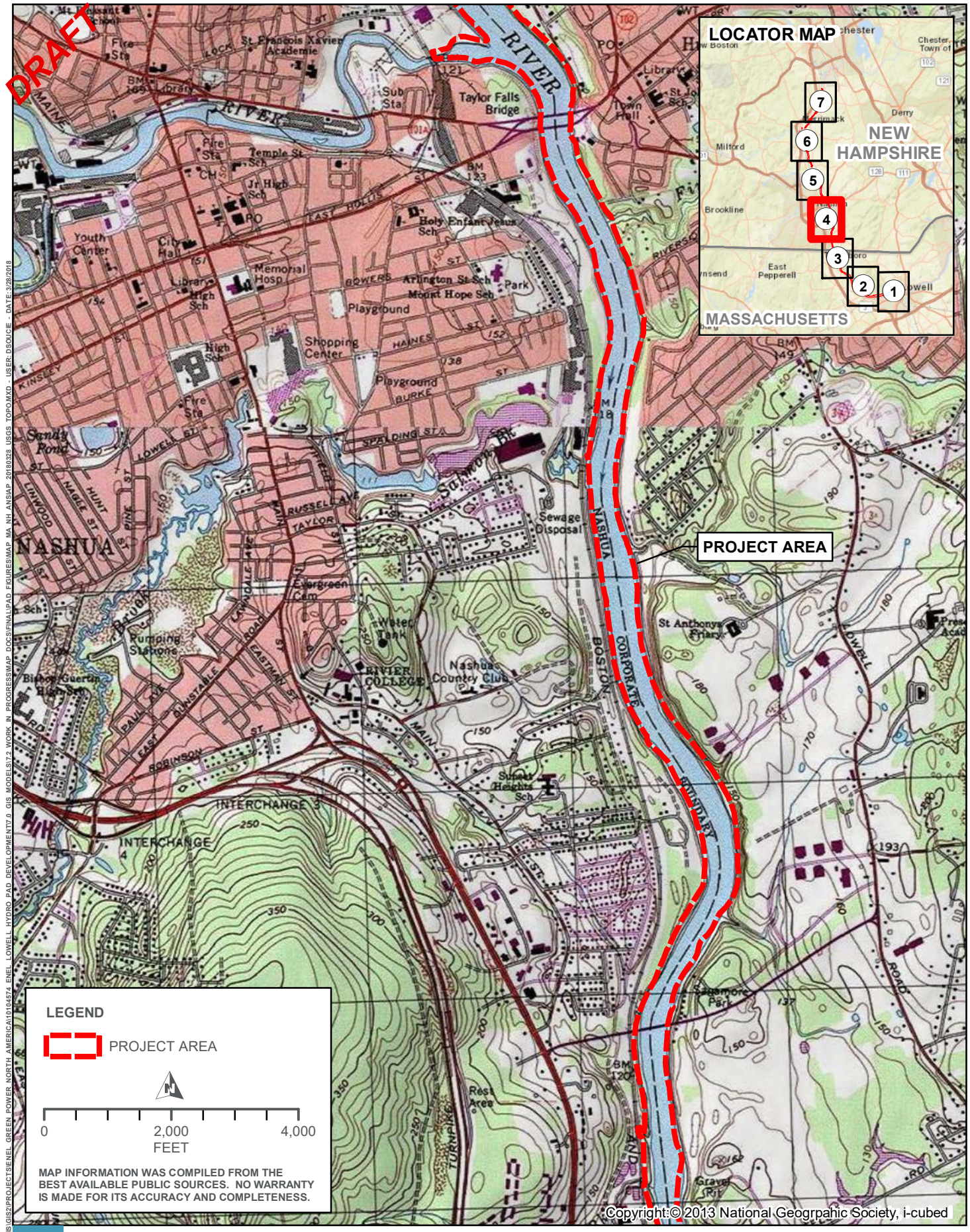

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BOOTT HYDRO, LLC.

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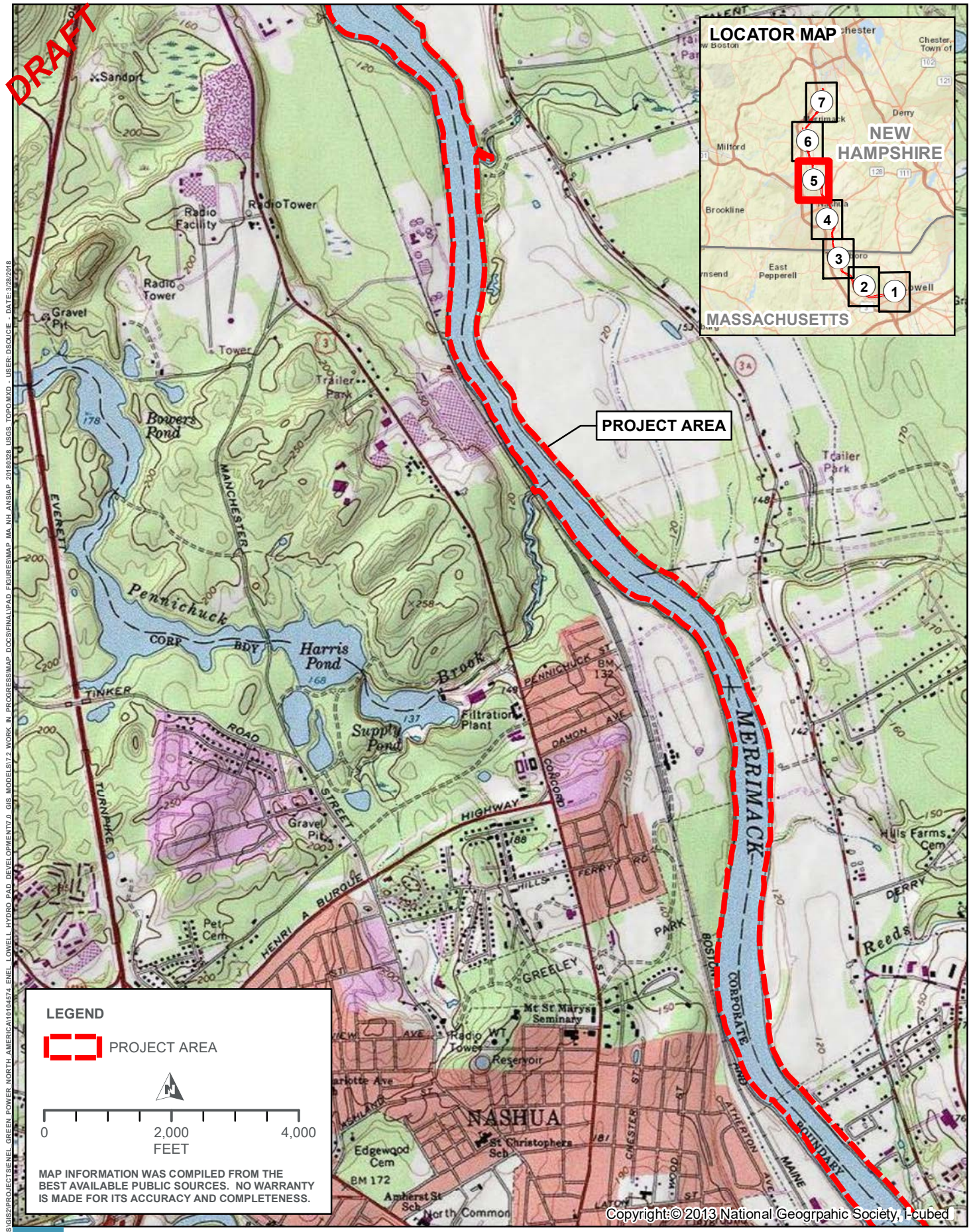

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BOOTT HYDRO, LLC.

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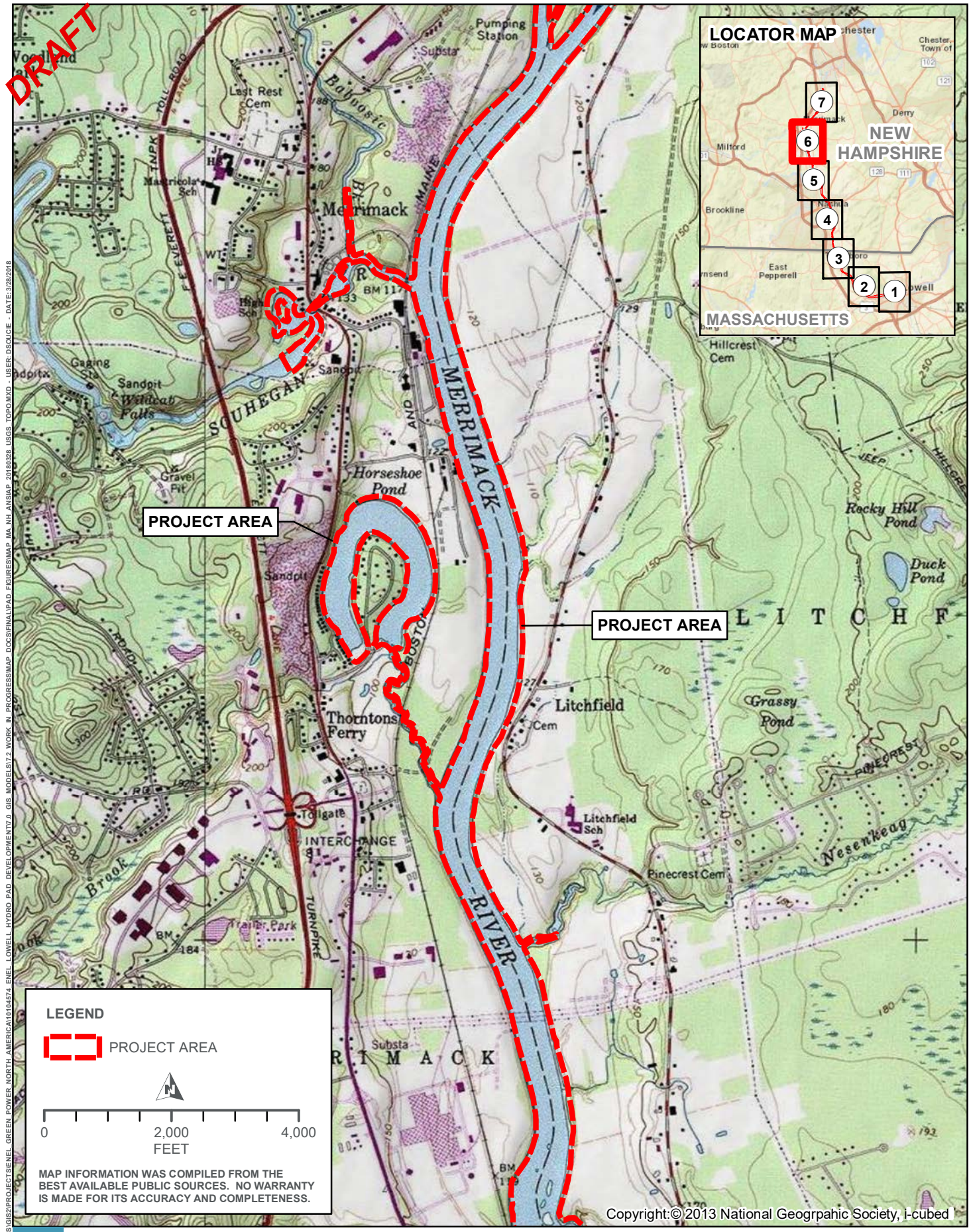

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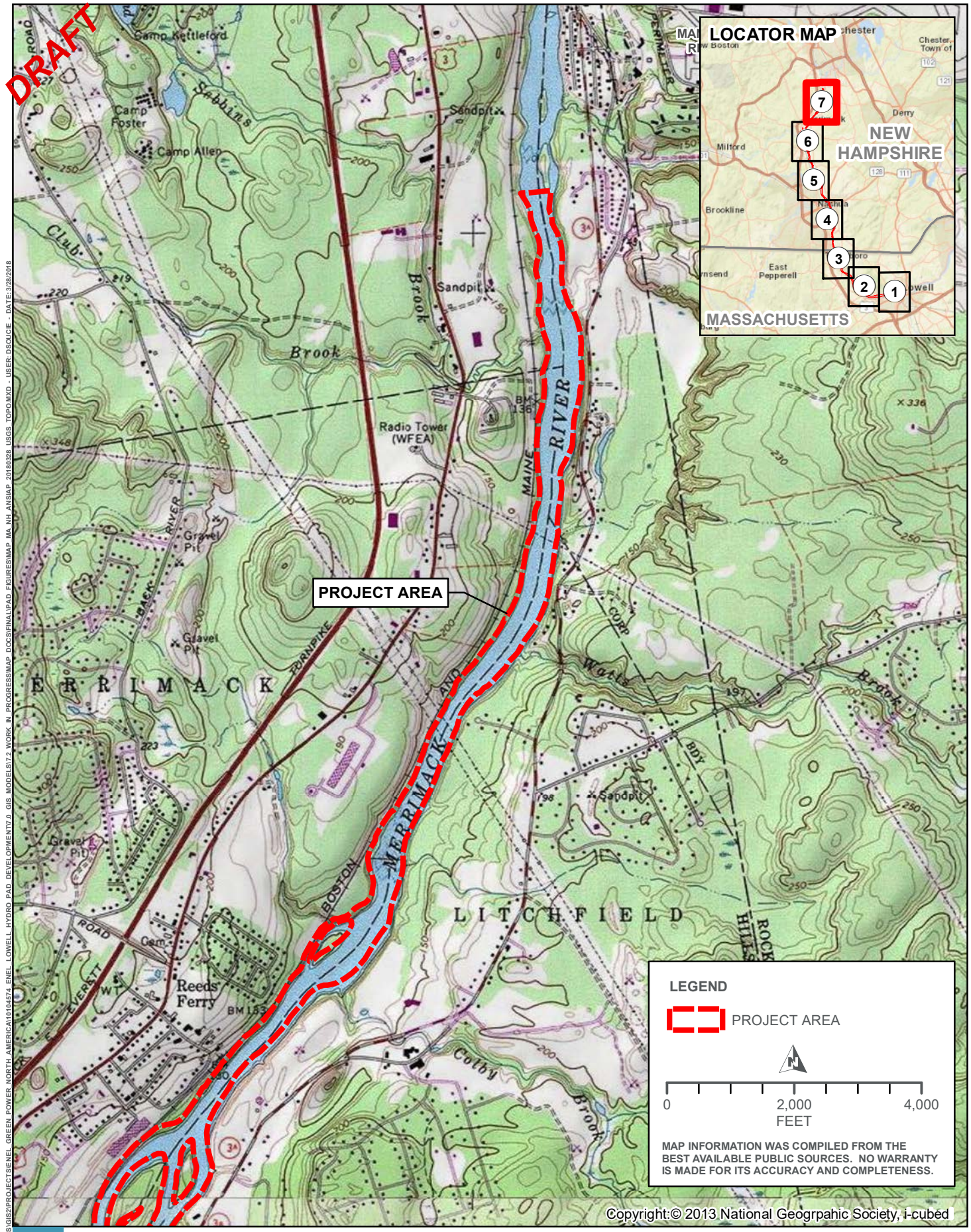

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SHEET 7 OF 7

USGS TOPO
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Appendix H - Flow Duration Curves

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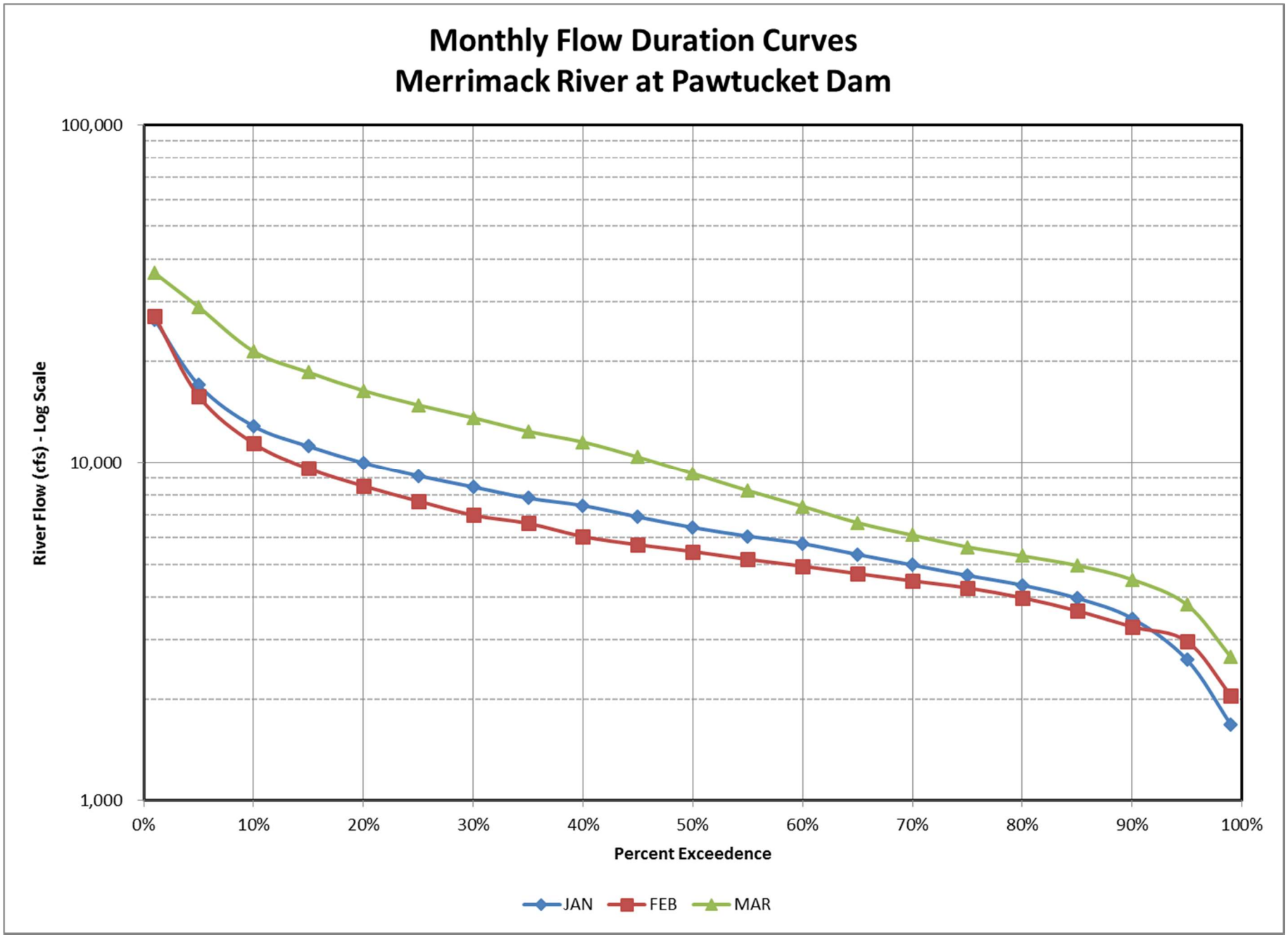
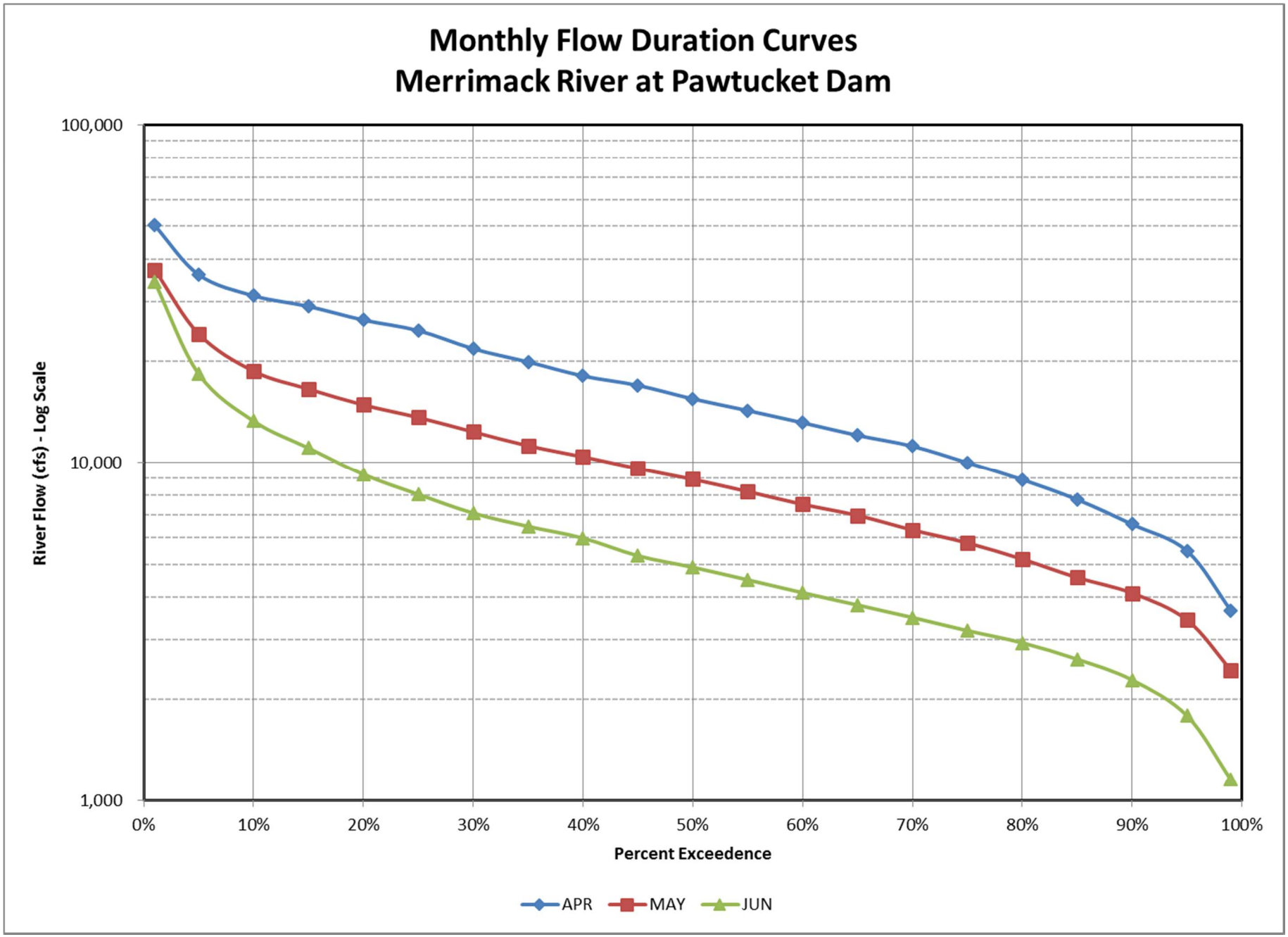
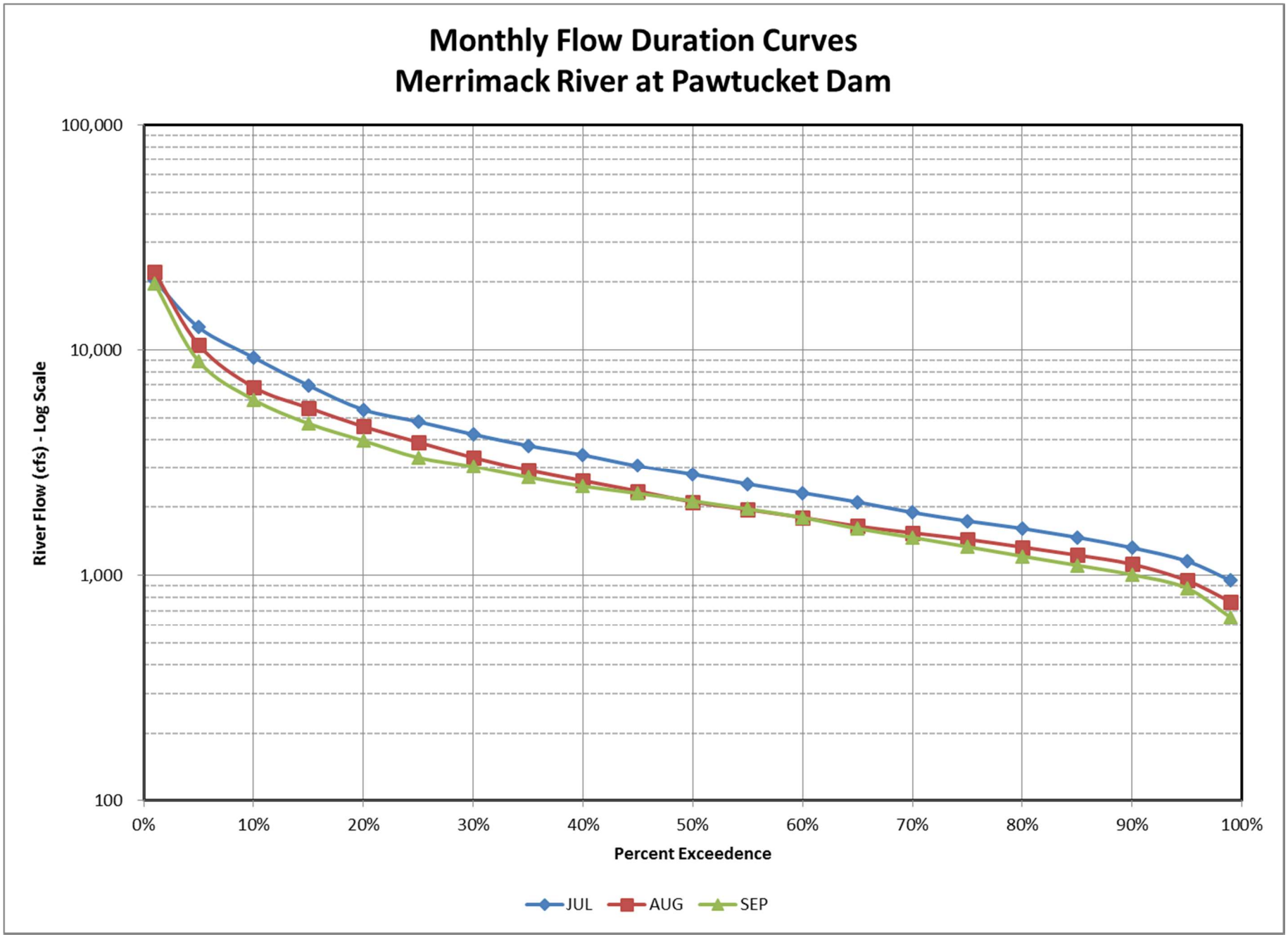
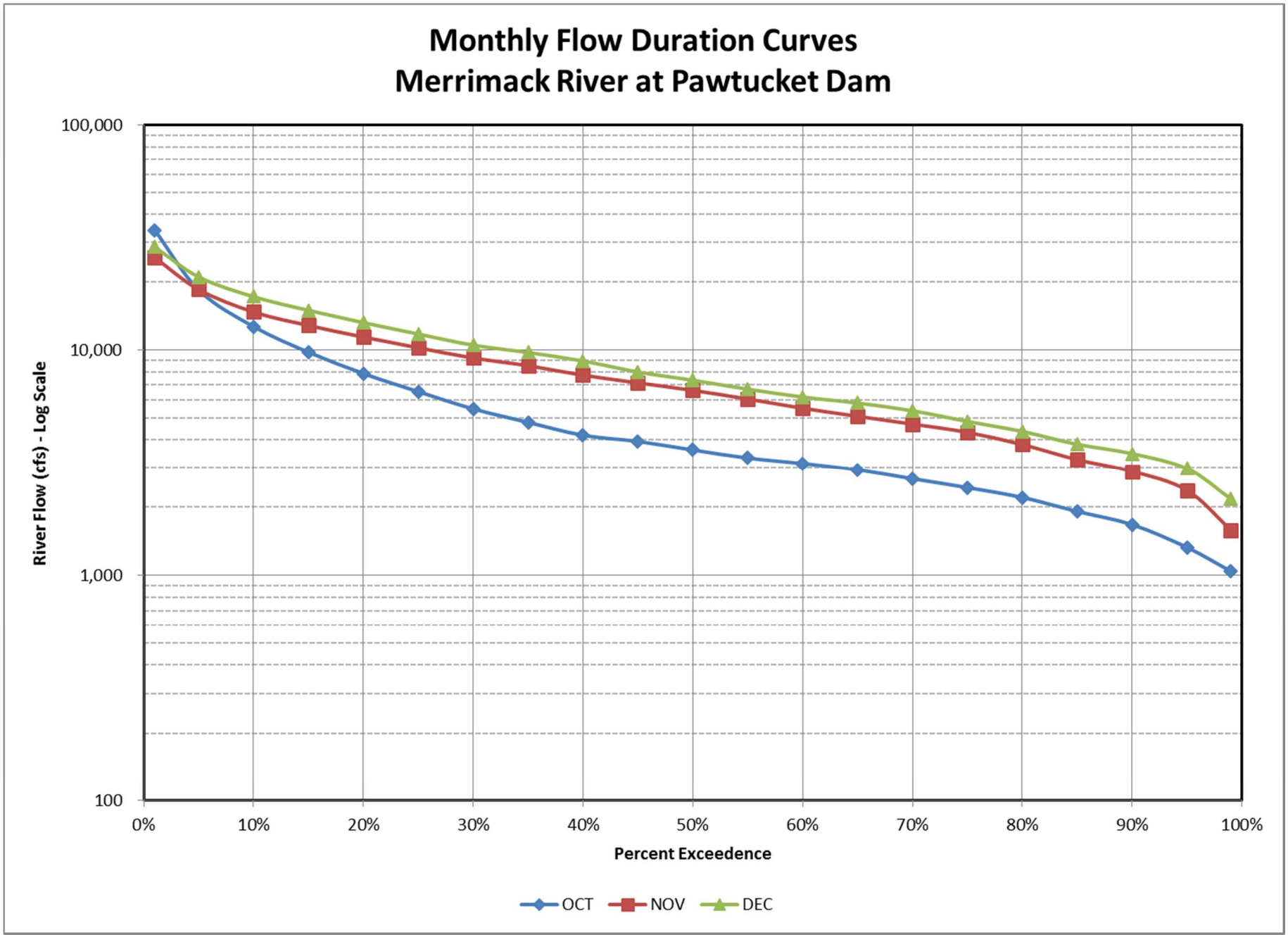

Monthly Flow Duration Curves
Merrimack River at Pawtucket Dam
River Flow (cfs) - Log Scale
100,000
10,000
1,000
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Exceedence
JAN
FEB
MAR


Monthly Flow Duration Curves
Merrimack River at Pawtucket Dam
River Flow (cfs) - Log Scale
100,000
10,000
1,000
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Exceedence
APR
MAY
JUN


Monthly Flow Duration Curves
Merrimack River at Pawtucket Dam
River Flow (cfs) - Log Scale
100,000
10,000
1,000
100
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Exceedence
JUL
AUG
SEP


Monthly Flow Duration Curves
Merrimack River at Pawtucket Dam
River Flow (cfs) - Log Scale
100,000
10,000
1,000
100
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent Exceedence
OCT
NOV
DEC

Appendix I – Historical Information

REPORT

LOWELL NATIONAL HISTORICAL PARK
AND
PRESERVATION DISTRICT

CULTURAL RESOURCES INVENTORY

prepared for

DIVISION OF CULTURAL RESOURCES

NORTH ATLANTIC REGIONAL OFFICE

NATIONAL PARK SERVICE

by

SHEPLEY BULFINCH RICHARDSON AND ABBOTT
ARCHITECTS BOSTON MASSACHUSETTS

REPORT

LOWELL NATIONAL HISTORICAL PARK
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NATIONAL PARK SERVICE

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SHEPLEY BULFINCH RICHARDSON AND ABBOTT
Architects Boston, Massachusetts

1980

TABLE OF CONTENTS

PREFACE

This Report and its accompanying fourteen inventory volumes and seventeen base maps together form the end product of a $99,980 contract (CX1600-9-0005) between the National Park Service and Shepley Bulfinch Richardson and Abbott. The purpose of this contract was to inventory and begin an architectural and socio-economic interpretation of the cultural resources of the Lowell Historic Preservation District and the Lowell National Historical Park as represented by the 895 individual properties which exist in the District and Park.

The project commenced in March, 1979, and was completed in January, 1980. To SBRA's knowledge, no other cultural resources inventory of similar depth and magnitude has ever been undertaken particularly in such a brief time span. Such pioneering work as that of the Cambridge (Massachusetts) Historical Commission and of the Vieux Carré project in New Orleans, Louisiana extended over a number of years.

That this project was successfully completed is entirely due to many dedicated people in Lowell, on the SBRA staff and at the National Park Service.

Among the latter, special thanks are due to Francis P. McManamon and to Bronwyn Krog, who acted almost like a member of the SBRA team and without whom the project could not have succeeded, as well as to Ramon A. Cintron, Contracting Officer, whose understanding of the problems involved in the project went beyond normal expectation.

In Lowell, the people who deserve special mention are the hundreds of owners of the properties being surveyed who were understanding and went out of their way to be helpful; there are so many of these that to mention one would be a disservice to others. At Boott Mills, Melvin Lezberg generously made the Locks and Canals archive and much of his time available, and Roland LaRochelle was constantly helpful. At the University of Lowell's Alumni-Lydon Library, Martha Mayo, Librarian of Special Collections, was especially helpful as well as tolerant of researchers turning the place upside down. And Edward Harley and Robert

MacLeod were equally gracious and full of information at the City of Lowell Memorial Library. We are also thankful to Helena Wright at the Merrimack Valley Textile Museum in North Andover.

Edward S. Rutsch and Michael N. Gimigliano of Historic Conservation and Interpretation, Inc. were indispensable in the research for and writing about the archeological aspects of the project. Pauline Carroll prepared the report on the Lowell canal system.

However, there would have been no project had it not been for the SBRA staff and particularly Edward F. Zimmer, Principal Investigator. His dedication, understanding, long hours spent on the project and scholarship literally held the team together. Anne Booth, Chief Researcher was second only to Ed Zimmer in her contributions to a successful conclusion.

It is hard to single out these two when one considers the hard work put in by other members of the survey/research team: Anne Grady, Edward Gordon, Mickail Koch, Ellen Lipsey, and Brian Pfeiffer.

Last only because she never was officially a member of the team, but certainly not least, to be thanked is Constance Zimmer who proofread all of the material, collated it, prepared it for reproduction, then reviewed the final product; it is probably fair to say that she is and may remain the only person to read all of the material produced.

And, of course, there never would have been a legible final product had it not been for our three Lowell typists, Mary Christmas, Peggy Lightner and Alice Santos.

To all of these people, the Lowell Cultural Resources Inventory project owes a great debt of gratitude and thanks.

LIST OF ILLUSTRATIONS

Chapter One

Chapter Two

Chapter Three

CHAPTER ONE

LOWELL CULTURAL RESOURCES INVENTORY: INTRODUCTION, METHODOLOGY, PERSPECTIVES, AND SUMMARY

INTRODUCTION

Lowell is a city of 95,000 in northeastern Massachusetts, thirty miles north of Boston and three miles from the New Hampshire border. The city is built around the confluence of the Merrimack and Concord Rivers. At the northern side of the city, the Merrimack traverses a long rapids called Pawtucket Falls, before sweeping around a broad bend and receiving the waters of the Concord. Between the head of these rapids and the mouth of the Concord, the waters of the Merrimack drop thirty-two feet. It was this fall of water that drew to Lowell the men, the women, the money, and the technology of this country's first industrial city. Here for the first time agrarian America saw an entire town, and soon a major city spring up that drew its livelihood not from fishing or farming, lumbering or mining, nor from the shipping or buying and selling goods, but from large-scale, mechanized, highly organized manufacturing.

Within a century after its bold beginnings in the 1820s, Lowell's industrial foundation was crumbling. The major corporations that had founded the city began to relocate or to fail, closing their giant textile mills. Lowell entered the Great Depression several years before the country as a whole, and the city is still striving to regain full economic health. Within the last decade, however, there has been a renewed awareness of Lowell's significant role in American history, combined with a realization that the city's historical resources might become economic resources as well.

Awareness led to action. The first step in the early 1970s was the development and broad acceptance of the concept that Lowell should establish an urban cultural park. This park would preserve Lowell's unique historic resources, and interpret the city's history to the nation. The city government made a firm

commitment to the historic park concept, and since 1975 has spent more than twelve million dollars on activities supportive of park-oriented revitalization. The Commonwealth of Massachusetts authorized the Lowell Heritage State Park in 1974 to help preserve Lowell's historic resources and develop public appreciation and enjoyment of those resources. Several private, public, and joint projects to rehabilitate and reuse historic buildings have been completed or are underway.

In 1972 and 1973 federal legislation was introduced to create an Urban National Cultural Park in Lowell. Those bills did not pass, but in 1975 the Lowell Historic Canal District Commission was established by Congress to prepare a plan for the preservation and interpretation of Lowell's historic resources. The report of that commission, together with the cooperative efforts of the National Park Service (NPS), Paul Tsongas (first as a Congressman, then as a Senator), and the Department of the Interior, produced the legislation that was passed by Congress in 1978 and signed into law by President Carter. This law established a two-tiered federal involvement: the Lowell National Historical Park (LNHP or the Park) a unit of the National Park Service, and the Lowell Historic Preservation District (LHPD or the District)--administered by a commission under the Department of the Interior.

The Park consists of the areas planned for intensive visitor use in the interpretation of Lowell and its canal system. The District surrounds the Park as a buffer zone and enables federal assistance in the preservation and revitalization of Lowell. The Park includes within its boundaries the 5.6 mile power canal system, a portion of the central business district, and three major mill complexes. The area within the Park boundaries totals 134 acres, but present plans envision direct National Park Service ownership of only a handful of buildings, with other property remaining in private hands. The District includes the mills or mill sites of most of the rest of the major textile corporations, the remainder of the historic central business district, and areas along the Concord River where smaller factories flourished outside the main waterpower system.

The legislation establishing the Park and the District outlined the broad policies and goals of the federal commitment and drew the geographic boundaries of the two zones. Implementation of the legislative concepts requires a further process of careful planning, based upon a thorough knowledge of the specific historical resources included in the Park and the District. The Lowell Cultural Resources Inventory was therefore commissioned by the National Park Service, North Atlantic Regional Office, Division of Cultural Resources and executed by Shepley Bulfinch Richardson and Abbott, Inc. (SBRA) between March 1979 and January 1980. The information produced by the inventory will be used in Park and Preservation District planning, and is also available through local libraries to Lowell's citizens and visitors. This report is a summary and an initial interpretation of the inventory data. In the remainder of this first chapter, the goals and methods of the inventory are described, the inventory form devised for the project is discussed and illustrated, and the results of the inventory are summarized.

The second chapter describes the prehistoric human use of the area within and around the Park and the District, and assesses the area's current potential for containing archeological remains of those people. The chapter is based on documentary research and surface examination of the District and the Park by professional prehistoric and industrial archeologists.

The third chapter outlines the historical development of Lowell, particularly within the area of the Park and the District, and relates existing buildings, canals, street patterns, and other historic resources such as the foundations and yards of demolished mills and boarding houses, buried canals, trash pits, and other known and potential historic archeological features.

The fourth chapter interprets the inventory data in terms of current patterns of land use and urban activity. This chapter describes twelve distinct areas of the Park and the District, and identifies their historical resources, applying a spatial perspective to the inventory data.

This report is based in its entirety upon the principal product of the Lowell Cultural Resources Inventory--the individual inventory forms and research reports, totaling over 3,700 pages of information on 895 properties. Hopefully this report reflects the richness of the inventory data, and thereby, the bounty of cultural resources in Lowell.

INVENTORY METHODOLOGY

Staff

A team of five surveyor-researchers carried out the inventory tasks of observation, research, recording, assessment, and photography from April through September of 1979. All five have graduate degrees or have done graduate-level study in architectural history, archeology, art history, or preservation studies and were experienced in architectural research and survey procedures. Prehistoric and industrial archeologists assisted in the inventory as consultants, and a technological historian researched and wrote about the canal system. An architectural historian directed the project as Principal Investigator, and a registered architect oversaw the whole effort.

Inventory Form

At the start of the project basic decisions had to be made about the types of information to be sought, and an inventory form to record and present the information had to be designed. The form described below was devised jointly by the NPS and SBRA. The goal was to provide a broad data base for Park and District planners, property owners, developers, and students and scholars of Lowell. A facsimile of the inventory form used in the project follows page 12. Four categories of information were identified and arranged on the form under the headings Identification, Historical Abstract, Descriptive Data, and Visual Assessment. The following discussion of the inventory form focuses on terminology and on the sources and procedures employed. The Historical Abstract category is discussed last, because the research on which each Historical Abstract is based was performed after the field and office work of the other categories.

Identification

The first category, Identification, includes information about the current status of an individual property, and is intended to assist the planners of the Park and the District. Most of this category's information was drawn from city records.

Property owners were identified through the City Engineer's plates. Those maps show the ownership of each parcel in the city, and are updated regularly. The ownership list drawn from these plates was also the basis for defining the individual survey units or properties. Most typically, an individually recorded property consists of a single building on a defined lot, or a vacant lot unrelated to adjacent lots in use or ownership. Secondary buildings and outbuildings are included on the inventory form of their primary building. Adjacent vacant parcels under one ownership are recorded together or with adjacent, improved property of the same owner. Where groups of adjacent buildings are under one ownership, such as in the mill complexes, an inventory form was prepared on each building.

Owner-occupants were identified through the 1977 Lowell City Directory--the most recent issue. Owners residing or operating a business in a premise were regarded as owner-occupants. The question was also answered in the affirmative when the surname of the listed owner matched that of an occupant.

Historic names were found through the research work. Many commercial and industrial buildings are named on historic maps or in directories. For most others, historic names were assigned based upon the earliest or most notable owner or occupant.

Property type relates to the original function of the structure on a property. Distinctions were made between single family dwellings (SFD), two family dwellings or duplexes (2FD), and multiple-unit dwellings (Mult dwl). Industrial structures within mill complexes (mill struc) were differentiated from buildings used for manufacturing purposes that were not part of distinct complexes (other ind). Parcels without buildings, including parking lots, were designated undeveloped (undevel), unless there was strong evidence that they contained significant archeological resources (archeo).

Each property's zoning classification was determined from the city zoning map. Tax information was drawn from the City Assessor's List of Tax Takings dated April 1, 1979, and from consultation with the Assessor's Office. Properties within historic districts were identified through the Boundary Map of the Lowell National Historical Park and through records of the National Register of Historic Places.

Photography

The field work portion of the inventory included the photographing of each property. All photographs were taken with 35mm SLR cameras using black and white film; 50mm and 35mm lenses were most frequently used. The inventory photographs of buildings are intended to record basic architectural information such as massing and roofline, and as much detail as possible. When possible, a view was chosen showing mainly the principal facade, but including an oblique view of one side and the roofline. Photographs of vacant lots record the surface condition, and locate the lot within its setting.

Descriptive Data

This category systematically records basic information about style, structure, use, and materials. Both the Descriptive Data and Visual Assessment categories are based on the surveyor's visual observations of exteriors. (An exception is the information on square footage, which was drawn from the City Engineer's plates.) Narrative descriptions of most buildings were included at the end of the inventory form or within the more extensive research report prepared for the most significant properties.

Many buildings in the Park and the District are difficult to categorize by architectural style. Simple structures that reflect a local, traditional way of building were identified as "vernacular." Many industrial buildings, particularly of the late nineteenth and the twentieth centuries, were designated "utilitarian."

Present use of the ground floor (GF) and upper floors (UF) of inventoried buildings was judged by street-level observation. The terms abbreviated on the field version of the inventory form, such as "off" (office) and "res" (residential), are spelled out on the typed version of the form in the inventory volumes. Commercial (com) use of a building indicates retail, wholesale, or service enterprises such as beauty parlors. Warehouse (warehs) use includes storage on the upper floor of a building by a merchant operating a store on a lower floor.

Stories were counted from ground-level to the cornice or eaves. Lighted attics and the "roof story" of mansard-roofed buildings were designated as half stories.

The square footage recorded refers to the whole property, rather than to the floor space of a building on the property. The major block of a building, exclusive of small additions, forms the basis for both the plan shape and roof type recorded on the inventory form.

Visual Assessment

This category recorded information relative to a property's and an area's potential for rehabilitation and interpretation. The answers required the various surveyors to make consistent judgments throughout the Park and the District. Applying and maintaining consistent standards was a major concern. Each of the choices within each of the questions was defined and discussed by the whole team before field work began, specific cases were discussed by the group as the inventory progressed, and the judgments were reviewed and sometimes modified for the sake of consistency by the project director in the final editing of each form. Each of the major visual assessment questions was regarded as a continuum, and the goal was to position each property accurately, relative to the other properties inventoried.

Building condition, like all the visual assessments, was judged through exterior observation. Buildings in excellent condition included those newly built or rehabilitated, and buildings diligently maintained.

Good condition applied to structures without obvious need of repair, but in less-than-pristine condition. The intention was to reserve the "excellent" category to identify mint-condition buildings and to include a broader group of well-maintained structures within the "good" category. "Needs minor repair" designated buildings with problems such as peeling paint or a few broken windows. "Needs major repair" indicated more extensive or structural problems. The"derelict" designation described buildings that cannot be used without being virtually rebuilt.

The variety of buildings and of their states of repair throughout the District complicated the problem of making consistent judgements of condition, and necessitated some differentiation by types of buildings. A badly burned house in need of a new roof structure and major interior repairs was identified as derelict, while a large industrial building with serious fire damage confined largely to the top floor and roof was judged in need of major repair. The relative scale of the damage in relation to the size of the building was the determining factor in these decisions.

The question of "integrity of historic building fabric" addressed the quantity of surviving historic material, not its quality or condition. Sometimes poorly maintained buildings retain more original material than buildings that have been aggressively maintained, especially when the maintenance has involved removal of deteriorated elements. "Intact original fabric" identified buildings virtually unchanged in appearance since construction. "Intact with evolutionary alterations" indicated structures that had undergone various alterations which did not substantially obscure their original form, and which now present coherent designs reflecting more than one period of development. "Intact with minor changes" was the designation applied to buildings that retained most of their original fabric, but had suffered relatively minor changes or losses unsympathetic to the original design.

A building was identified as having undergone major but reversible changes if its historic fabric was largely obscured or disfigured, but enough original material appeared to survive to provide the potential for rehabilitation to a relatively intact historic

appearance. Buildings were classified as having suffered major and irreversible changes when their historic fabric was destroyed or damaged to such a degree that reconstruction, rather than rehabilitation, would be required to approximate an historic appearance.

The last three visual assessment questions involved specific properties and their surroundings. To provide useful distinctions between properties, only a few buildings or lots on each side of a property were considered in these judgments. In addition, the areas flanking a property were weighed more heavily in these judgments than those facing it or behind it.

In identifying surrounding land uses, "xway" was used to designate major, divided roadways. Other abbreviations indicate recreational (rec) and institutional (inst). Canal or river frontage was recorded when there was a clear and near view of the waterway from the property, even if a street or another lot separated the property from immediate, physical frontage on the waterway.

The question of "integrity of property's historic period setting" focused on a property's surroundings, excluding the property itself, and like the assessment of historic fabric, was concerned more with the survival of historic features than with their condition. The five choices were regarded as forming a continuum, and each setting was judged relative to other settings within the Park and the District. 1920 was chosen as a general cutoff date for the "historic period" in terms of this question, because it marks the approximate start of the city's rapid decline as a textile-producing center, and begins an era characterized by demolition rather than construction. This question sought to identify meaningful and mutually reinforcing groups of historic properties, rather than to regard negatively every change that has occurred in the history of an area, recognizing that no setting remains completely unchanged for very long.

The "intact" category of the historic setting continuum is a relative standard, identifying the most visually intact groups of historic properties in the Park and the District. A setting was designated "intact with minor intrusions and/or losses" when

most of the properties surrounding the one in question contain nineteenth or early twentieth century structures, but some notable changes are apparent. As the scope of this question excluded the property being surveyed, some vacant lots or modern, disruptive buildings were identified as having intact settings, while the historic properties around them, because of those neighbors, had settings that are intact with minor intrusions and/or losses. Combined with the response to the next question, which identifies such disruptive lots or buildings as detracting from the historic character of their areas, properties can be identified that need redevelopment compatible with their settings.

A "moderately disrupted setting" was identified when the surrounding mix of properties included as many reflections of recent periods as of pre-1920 development. A "severely disrupted setting" was one consisting primarily of twentieth century construction or demolition.

The final Visual Assessment question judged the contribution of each property to its setting. Few properties were identified as focal points. Focal points were defined as the principal elements in determining the character of their respective areas, and as visual landmarks. City Hall, the Hildreth Building, and the clock tower at Boott Mills are focal points. Integral properties together define the character of their areas, but do not individually have the visual dominance of a focal point. Middle Street consists of a fine group of late nineteenth century buildings, all "integral to character" of the street. Any historic structure retaining most of its historic fabric was identified as integral. Compatible properties were those which were appropriate to the historic character of their areas in scale and materials but, by their period of construction or present condition, did not contribute to their areas. Detracting properties were those judged inconsistent with the historic properties in their areas in terms of scale, period of construction, siting, materials, and/or condition.

Historical Abstract

The documentary research necessary to complete the Historical Abstract on each property commenced soon after the field work of the inventory began. The sources of information most widely used were the published maps and atlases from the nineteenth and early twentieth centuries that provide general outlines of the buildings standing throughout Lowell. The maps of 1821, 1832, 1841, 1850, and 1868 were particularly useful, along with the 1879, 1896, 1906, 1924, and 1936 atlases. These were consulted on each property and the appearance, disappearance, and other changes in the building outlines were duly noted. The maps and atlases often provided other information as well, such as owners' or buildings' names, or heights and materials of structures. Many other primary and secondary sources were consulted, but the maps and atlases provided the foundation for the research on each property and, interpreted along with stylistic evidence, identified the dates of construction and of major alterations to most structures.

Construction dates and information on the lifespan of previous buildings on a property were documented by indicating the sources of the information. The researchers also recorded whether the dates were directly documented (doc) by the sources cited, extrapolated circumstantially (circum), such as from a single map and stylistic evidence, or estimated (est) without documentary support. Many construction dates could be narrowed down to a decade and were so recorded, e.g. ca. 1832-41, indicating that the structure was built within that time span, not that the construction took nine years.

In completing the historical abstract portion of each form, certain of the questions were addressed only to the current structure on a property, and so were not applicable in cases of vacant lots. Construction date, architect, and original use were not entered for previous structures on a property, but rather only for current structures.

Additional Information

Since considerable descriptive and historical information was gathered that did not fit within the standardized inventory form, two distinct means of presenting this information were employed. In the cases of about two-thirds of the properties, three narrative sections were included with each inventory form, entitled and containing: Additional Description, Additional Historical Information and Sources, and Archeological Comment. The first two of these sections clarified and expanded upon information contained in the first four categories of the form. The archeological narrative briefly reviewed the information on past uses of the site and the present condition of the site and assessed the potential for below-ground resources in each property. Properties identified through documentary research or field observation as potentially significant archeological sites were inspected by the inventory team's archeological consultants.

In-Depth Research

Over one-third of the properties received research attention and visual assessment in far greater depth than their neighbors. A "List for In-Depth Research" was assembled jointly by SBRA and NPS following completion of initial field and research work. Properties representing the full range of construction dates, building types and uses, and locations within the Park and the District were selected. Included were all of the major industrial complexes, most of the nineteenth and early twentieth century commercial buildings in the central business district, and many representative residences and institutional buildings. The canal system and several sites formerly occupied by important buildings or complexes were also studied.

The information sought in this in-depth research was an extension of the Historical Abstract of the inventory form, including information on the date of construction and alterations to structures, identification of designers and builders, and information on the owners, the occupants, and the uses of present and previous buildings on the property. In place of the Additional Description and Additional Historical

Facsimile of the field version of the inventory form on 155-159 Middlesex Street, the Marston Building. The presentation version of this form together with its research report is illustrated later in this chapter.

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RESOURCES INVENTORY

survyr	EG. & MK.
start	5 / 1 / 79
A-D cmp	5 / 8 / 79
E-F cmp	5 / 9 / 79
G comp	6 / 5 / 79
phto taken	5 / 1 / 79

#12

SE

A. IDENTIFICATION 1) Address 155, 157, 159 Middlesex Street

2) Current Owner John O'Laughlin owner occ: yes (no)

3) Historic Name Marston Building unk

4) Current Name (same) unk

5) Property type: (circle one)
SFD, 2FD, mult dwl, (com), church, canal, canal struc, mill struc, other ind, undevel, archeo, govt, other bldg, other

6) Zoning Classification I-A

7) Taxes Payments: exempt (current) delinquent since
Status: (clear) tax title land court

8) Within boundaries of: LNHP City Hall HD Locks and Canals HD (LHPD)
(circle all that apply) Merrimack-Middle Sts. HD Indiv NR LHPD partial

B. HISTORICAL ABSTRACT

1) Construction date 1888 (doc) circum est
source on building

2) Architect or Builder/Designer (unk)

3) Historic Owner George H. Marston unk

4) Original use GF: (com) ind off govt res vacant unknown
(circle all that apply) other
UF: (com) ind off govt res vacant unknown n/a
other

5) Moved: yes (no) date doc circum est
source

6) Previous bldgs on prop: (yes) no date ca. 1881- ca. 1888
(doc) circum est source 1882 map & date on building

C. DESCRIPTIVE DATA

1) Architectural style: (circle one)
fed, grk rev, ital, goth rev, 2nd Emp, High Vic Goth, stick, (Qu Anne), shingle, Col Rev, Romanes Rev, other n/s

2) Present use (circle all that apply)
GF: com ind off warehs govt res (vacant) other n/a
UF: com ind off warehs govt res (vacant) other n/a

3) # of stories 4 4) Property sq ft 3,642

5) Plan: sq (rectang) polygonal( ) ___-shaped other

6) Roof: (flat) shed gambrel hip endwall gable facade gable
mansard other

7) Structural system: wood frame load-bearing masonry (metal frame)
reinforced concrete other

8) Materials, facades:
(F=front) wood clapboard F/S brick(color R red) &bond (common flemish)
(S=side) wood shingle stone(type) &coursing
(R=rear) stucco other wood
(A=all) asbestos other metal
aluminum/vinyl other

trim: other metal
(wood) (shingle) brick(color)
(cast iron) (stone(type) granite sills and lintels
(terra cotta) other

foundation:
brick concrete (stone(type) granite
other not visible

9) Outbuildings (specify) (none)

10) Notable surface and landscape elements: foundation retaining wall (none)
steps fence paved areas sidewalk mature trees
other

D. VISUAL ASSESSMENT

1) Condition of building fabric: excel good needs minor repair
(needs major repair) derelict

2) If deteriorated, causes: fire vandalism (lack of maintenance) n/a
(circle if all applicable) other

3) Integrity of historic building fabric

GF: (intact original fabric)	UF: (intact original fabric)
intact w/ evolu alter	intact w/ evolu alter
intact w/ minor changes	intact w/ minor changes
major but revers changes	major but revers changes
major & irrevers changes	major & irrevers changes

4) Surrounding land uses: (com) (ind) res recr (inst) RR Xway
(circle all applicable) canal frontage river frontage
other

5) Integrity of property's historic period setting:
(circle one)
intact historic setting
intact with minor intrusions &/or losses
(moderately disrupted historic setting)
severely disrupted historic setting

6) Importance of property to historic character of area:
focal point in area
(circle one) (integral to character)
compatible with character
detracts from character
character so disrupted, question not applicable

(circle if applicable) See Section E for comment

Information narratives at the end of their inventory forms, the listed properties were each the subject of a research report from two to dozens of pages in length, providing a detailed description of the property and an historical narrative. A sample research report on a single structure accompanies this discussion. Reports on single sites or structures are typically two to ten pages long, while the reports on industrial complexes include twenty to thirty pages of text and up to twice that number of illustrations. The sample report also demonstrates the presentation version of the inventory form, which consolidates the information from the field form.

The various archives used by the researchers are discussed in some detail at the end of this report, and specific sources are cited in the bibliography.

Mapping the Inventory

All of the inventoried properties in the Park and the District were recorded on a series of 1"=100' scale maps based on the boundary Map of the LNHP. Most properties were identified by address; the rest, such as the mill complexes and canal features, were identified by name. Property boundaries were also recorded. A line of dashes was used to signify primary boundaries, such as those enclosing individually inventoried properties or complexes such as millyards. A line of stars was used to designate secondary divisions, such as parcel lines within a consolidated property, or divisions of ownership within millyards. The number of the map sheet on which a property was recorded was noted on each inventory form.

PERSPECTIVES ON THE INVENTORY

The student, planner, or interested citizen making use of the volumes produced by the Lowell Cultural Resources Inventory would do well to be aware of what the inventory is and what it is not. The volumes are, in effect, a vast, annotated street directory of the Park and the District. They do not form a comprehensive history of the city, but rather provide a source of current and historic data on individual parts of Lowell's built environment. Histories of land

ownership and use, dates of construction and alterations, exterior architectural descriptions, assessments of surviving historic building fabric, and copies of new photographs and historic images of the inventory.

The inventory was shaped in certain directions by the terms of the project contract and by the boundaries of the Park and the District. Together, these factors placed the main emphasis of the effort on buildings, particularly industrial and commercial buildings.

The contract required an inventory of physical, historical resources. Lowell's canal system, bridges, and even vacant lots were among the resources inventoried and studied, and the Park and the District's potential prehistoric and historic archeological resources were researched and assessed. However, the bulk of the city's physical, historical resources are buildings, and they received most of the inventory effort. The contract also specified that the inventory record every property in the Park and the District and set the time and funds available for the study. These conditions restricted attention largely to the exterior of structures. Interiors were virtually as off-limits to the surveyors as subsurface exploration was to the archeologists on the team.

The boundaries of the Park and the District include the canal system, most of the central business district, and the major mill complexes or their sites. They do not include most of Lowell's historic residential neighborhoods, except as single streets buffering the canals or the rivers. The single exception is the portion of the Acre neighborhood which is within the District, consisting of six whole blocks, largely of houses. These characteristics of the Park and the District placed the major emphasis of the inventory on commercial and industrial structures. This focus was not, however, synonymous with a bias toward high-style buildings, nor with a concentration on the art of architecture. Buildings of all periods and types and styles were inventoried, and a broad, representative sample of properties was subject to in-depth research.

LOWELL CULTURAL RESOURCES INVENTORY

IDENTIFICATION 155, 157, 159 MIDDLESEX STREET — MAP SHEET # 32

1) CURRENT OWNER Irish O'Llaughlin — OWNER OCCUPIED NO

2) HISTORIC NAME Marston Building

3) CURRENT NAME Marston Building

4) PROPERTY TYPE commercial — 5) ZONING CLASSIFICATION I-a

6) TAXES: PAYMENTS current — STATUS clear

7) WITHIN BOUNDARIES OF LHPD

HISTORICAL ABSTRACT

1) CONSTRUCTION DATE 1889

SOURCE documentary data on building

2) ARCHITECT OR BUILDER unknown

3) HISTORIC OWNER George H. Marston

4) ORIGINAL USE: GF commercial UF commercial

5) PREVIOUS BLDGS ON PROPERTY yes DATE ca. 1831-ca.1888

SOURCE documents: 1832 map and date on building

DESCRIPTIVE DATA

1) ARCHITECTURAL STYLE Queen Anne

2) PRESENT USE:
GF vacant
UF vacant

3) NO OF STORIES 4

4) FROM SQ FT 3,647

5) PLAN rectangular

6) ROOF flat

7) STRUCTURAL SYSTEM metal frame

8) OUTBUILDINGS none

9) MATERIALS:
FOUNDATION granite

VIEW FROM Southeast PHOTO TAKEN October 1979

FACADE front & sides: red pressed brick in stret. bond; rear: red brick in common

TRIM cast iron storefront; granite sills and lintels; wood; terra cotta

10) NOTABLE SURFACE & LANDSCAPE ELEMENTS none

ADDRESS 155, 157, 159 MIDDLESEX STREET

VISUAL ASSESSMENT

1) CONDITION OF BUILDING FABRIC needs major repair

2) IF DETERIORATED, CAUSES lack of maintenance

3) INTEGRITY OF HISTORIC BLDG FABRIC: GF largely original fabric
UF largely original fabric

4) SURROUNDING LAND USES commercial, industrial, institutional

5) INTEGRITY OF PROP'S NEXT SETTING moderately integrated historic setting

6) IMPORTANCE OF PROP TO NEXT SETTING integral to character

ADDITIONAL DESCRIPTION

See Research Report.

ADDITIONAL HISTORICAL INFORMATION

See Research Report.

ARCHEOLOGICAL CONCERN

This brick structure entirely covers its site, therefore, the archeological potential is low.

Research Report
155-9 Middlesex Street
Marston Building
1889

Sitting on the corner of Middlesex and Marston Streets, the Marston Building maintains the most historically intact original fabric of any nineteenth century structure on the street. Built in 1889, it is an eclectic combination of Queen Anne and Neo-Classical Revival elements.

Rectangular in plan, it is three stories high, three bays wide, and seven bays deep. Tall and narrow, it is decidedly vertical in massing and quite rich in decoration. The front and easterly side are of red pressed brick laid in stretcher bond, while the remainder is of common brick laid in common bond (seven to one). At least a portion of the building must be of metal frame construction, judging from the wide window openings of the facade and easterly side.

Although boarded up, the ground story appears to maintain its original cast iron storefront of piers at the corners and columns flanking the central doorway. The second and third story facade fenestration (which continues around to the first two bays of the easterly side) features continuous windows divided by brick piers with decorative brickwork caps. The third-floor level is set off from the second by large paneled wooden spandrels, except on the central bay, which has a granite panel with "Marston Building" on it. Lintels of decorative brickwork cap the windows. A brick course of stretcher-over at an angle divide the third and fourth stories.

The fourth-story fenestration consists of eight narrow windows with a granite sill and lintel course. Over each grouping of windows is a course of terra cotta tiles, and over the two centrally-placed windows is the date 1889. A corbelled cornice completes the building, topped with a series of crenellations once faced with terra cotta tiles on the facade and easterly side. Originally, two of these rose surmounted the central bay, with a triangular pediment between. However, this feature is now missing (Fig. 1).

The remaining five bays of the easterly side are less richly decorated. Terra cotta tiles and round-arched windows are fourth-story features, as well as the corbelled

155-9 Middlesex St. -2-

cornice which continues across the entire side. Needing major repairs, this building now sits vacant.

For about sixty years, this site was occupied by a boarding house of the Appleton Company, as was much of the northerly side of Middlesex Street. In 1889, the Appleton Company sold part of this boarding house property, and this prime site was purchased by George H. Marston (1).

Marston was associated with George C. Prince in the bookselling and stationery trade on Merrimack Street from 1873 to 1889. During this period he acquired considerable real estate in Lowell, and decided to retire from his partnership with Prince and devote himself to the care of his property (2). On his new Middlesex Street site "he has erected a fine-appearing structure known as the Marston Building. Among the notable buildings erected in this city for several years past, none exceeded this in excellence of construction and neatness of appearance" (3). Marston was listed at this building as real estate and stockbroker from 1890-1892. He died in December, 1892. An incorporator of the Lowell Board of Trade, he also served as one of its presidents.

Also listed in the Marston Building in 1890 was A. C. Stevens, apothecary, and Costilla D. Smith, photographer. The Morning Mail Souvenir states that "Miss C. Smith, who has just moved into her new and elegant quarters in the Marston Building on Middlesex Street, is one of the few successful ladies who have made photography a paying investment. Her new parlors are admirably adapted for her peculiar business, being light and in every way suitable" (4).

In 1894, in addition to Miss Smith, the building was tenanted by Albert Cameron, confectioner; E. C. Lyford, Medicines; Adelina Bonin, dressmaker; George E. Metcalf, insurance agent; and John T. P. Proulx, physician. By 1904, the property had passed into the hands of A. G. Wheelock, who owned considerable real estate in Lowell. In 1914, an individual named Tepfer was the owner.

The 1917 directory lists the occupants as Cameron Brothers, confectioners, Spindle City Shoe Repairing, and Josephine Bissonette, dressmaker (who had also been there in 1904). By 1975, Faber Liquors was the only occupant.

Of special significance because of its retention of its essential historic fabric, the Marston Building is another fine example of Lowell's late nineteenth century commercial

Facsimile of presentation version of the inventory form and research report on 155-159 Middlesex Street. Additional pages follow.

155-9 Middlesex St. -3-

architecture. Bridging the gap between Queen Anne and Neo-Classical Revival architecture, it is also an early Lowell example of metal-frame construction.

The Marston Building stands on the first Appleton Company property on the northerly side of Middlesex Street to be developed commercially (5). By 1892 much of Middlesex Street was dominated by similar commercial structures (Fig. 2). Unfortunately, none of the boarding houses remain to indicate the original land use. Sitting across the street, however, are the earlier nineteenth century Elliot Schoolhouse, Hamilton Schoolhouse (with its Queen Anne facade), and Lincoln Building. This block provides a clear contrast to the Marston Building and illustrates the nineteenth century development of Lowell architecture.

Footnotes

1) The Morning Mail Souvenir of the City of Lowell, 1890, p. 52.

2) Ibid.

3) Ibid.

4) Ibid., p. 32.

5) Ibid., p. 82.

Other Sources

Lowell Board of Trade, 1902.

Lowell: Past, Present and Prospective, 1891.

Lowell Board of Trade Manual, 1905.

1857, 1841, 1850 maps.

1879, 1894, 1906, 1924 atlases.

Lowell city directories.

Figure 2
From Lowell Board of Trade, 1902, opposite page 32.

GEO. H. MARSTON,
REAL ESTATE
STOCK BROKER
OFFICE, ROOM 2, MARSTON BUILDING,
73 Middlesex Street.

Figure 3
1890 Lowell City Directory.

THE MORNING MAIL SOUVENIR OF THE CITY OF LOWELL

Figure 1
From The Morning Mail Souvenir of the City of Lowell, 1890, p. 52.

MISS C. SMITH.
Photographer,
Marston's Building, Middlesex Street,
Lowell, Mass.

Figure 4
Morning Mail Souvenir of the City of Lowell, 1890, p. 32.

Facsimile of the research report on 155-159 Middlesex Street. See preceding pages.

SUMMARY OF THE INVENTORY

The Lowell Cultural Resources Inventory recorded 895 individual properties, and produced 131 research reports that encompassed 305 of the individual properties. 308 residential buildings were identified in the Park and the District, of which 147 are single-family dwellings (in design, if not in use), sixty-two are duplexes, and ninety-nine are multiple-family dwellings. There are 210 structures in the Park and the District built for commercial purposes (including offices, retail stores, and service companies such as barber shops and restaurants), 130 buildings within mill complexes, and twenty-seven other industrial structures. The Park and the District include sixteen structures built as schools, nine built as churches, and twenty-four constructed to house various governmental activities. Ninety-two inventory forms record vacant lots. Some of these represent consolidations of adjacent undeveloped properties. Thirty-three separate components of the canal system were surveyed, along with eleven bridges. Theatres, parking garages, and playgrounds were among the other types of structures and sites inventoried.

These categories represent the property types identified in the inventory, which were defined as the principal, original forms and functions of properties or buildings. "Present Use" in the Descriptive Data category of the inventory form records the current use of properties, and by comparing "Present Use" to "Property Type," information can be gathered on topics such as the number of factories now used for housing, or the number of houses containing shops.

Ninety-nine tax-exempt properties were identified, but this number under-represents the tax-exempt component within the Park and the District, for each Lowell Housing Authority complex within the project area was recorded on a single form, even though most of these complexes have several structures. 134 tax-delinquent properties were identified, including forty-four against which land court action has been initiated.

Only three structures within the Park and the District were found that predate 1820, excluding the basic course of the Pawtucket Canal. Twenty structures

date from the 1820s, along with the reworked Pawtucket Canal and the Merrimack and Hamilton Canals. Forty-four buildings of the 1830s still stand within the Park and the District, and the Western and Eastern Canals date from that decade as well. The Northern Canal and seventy-eight structures from the 1840s were inventoried, along with forty-five from the 1850s, and twenty-seven from the 1860s. Ninety-three buildings of the 1870s, seventy-eight of the 1880s, and 122 of the 1890s were identified. The first quarter of this century added 166 structures still standing within the Park and the District, and the second quarter added forty-five. Sixty-seven buildings have been constructed since 1950 that are within the LNHP and LHPD boundaries.

Fifty-six structures within the project area were judged to be in excellent condition, and eight were identified as in derelict condition. Since the field work of the inventory was completed, a continuing rash of fires in the Acre neighborhood has rendered several more houses derelict, and the city's aggressive demolition program has removed most of these. 412 buildings appeared to be in good condition, 244 needed minor repair, and seventy were in visible need of major repair.

The Park and the District's most important historical resources are the canal system, the remaining major mill complexes, and the central business district's nineteenth century commercial buildings. The District also includes elements of other historic industrial enterprises, particularly along the Concord River. Residential properties within the District represent most of the range of styles, forms, and periods of Lowell's architectural history, but these houses generally fall short of Lowell's historic houses outside the District in quantity, quality, and concentration.

The extensiveness of the inventory should disguise neither the significant historical resources that Lowell has lost in recent decades, nor the city's historic assets that are not included within the Park, the District, or the inventory. Four major mill complexes are now gone--Merrimack Manufacturing Company since the early 1960s, Middlesex Manufacturing Company since 1956, and Tremont Mills and the Lowell

Machine Shop, both demolished in the 1930s. Corporation-built housing, a tremendously significant part of the Lowell industrial system, survives only in scattered fragments.

Outside the Park and the District are many more historic houses than are within the boundaries, and these houses often comprise intact historic neighborhoods. Chapel Hill, Centralville, Belvidere, and the whole area presently referred to as the Acre contain significant concentrations of nineteenth century houses, as do other Lowell neighborhoods. The North and South Commons are both historically important open spaces, and are both bordered by residential and institutional structures significant to the history of Lowell. There are also industrial buildings, complexes, and sites outside the District's bounds that merit attention, such as the C. I. Hood patent medicine laboratory, several small factories west of Fletcher Street, a portion of the Wamesit Canal system off the Concord River, the house of gunpowder manufacturer Oliver Whipple and attached workers' housing, and workers' housing associated with the Massic Falls industrial site on the Concord.

Nevertheless, the inventory makes apparent the bounty of historical resources in the Lowell National Historical Park and Preservation District. The canal system that powered America's first industrial city is intact and still operates, most of the major historic mill complexes and many secondary factories still stand, and in the central business district buildings from Lowell's heyday in the nineteenth and early twentieth centuries predominate. Lowell has a future in its past.

CHAPTER TWO

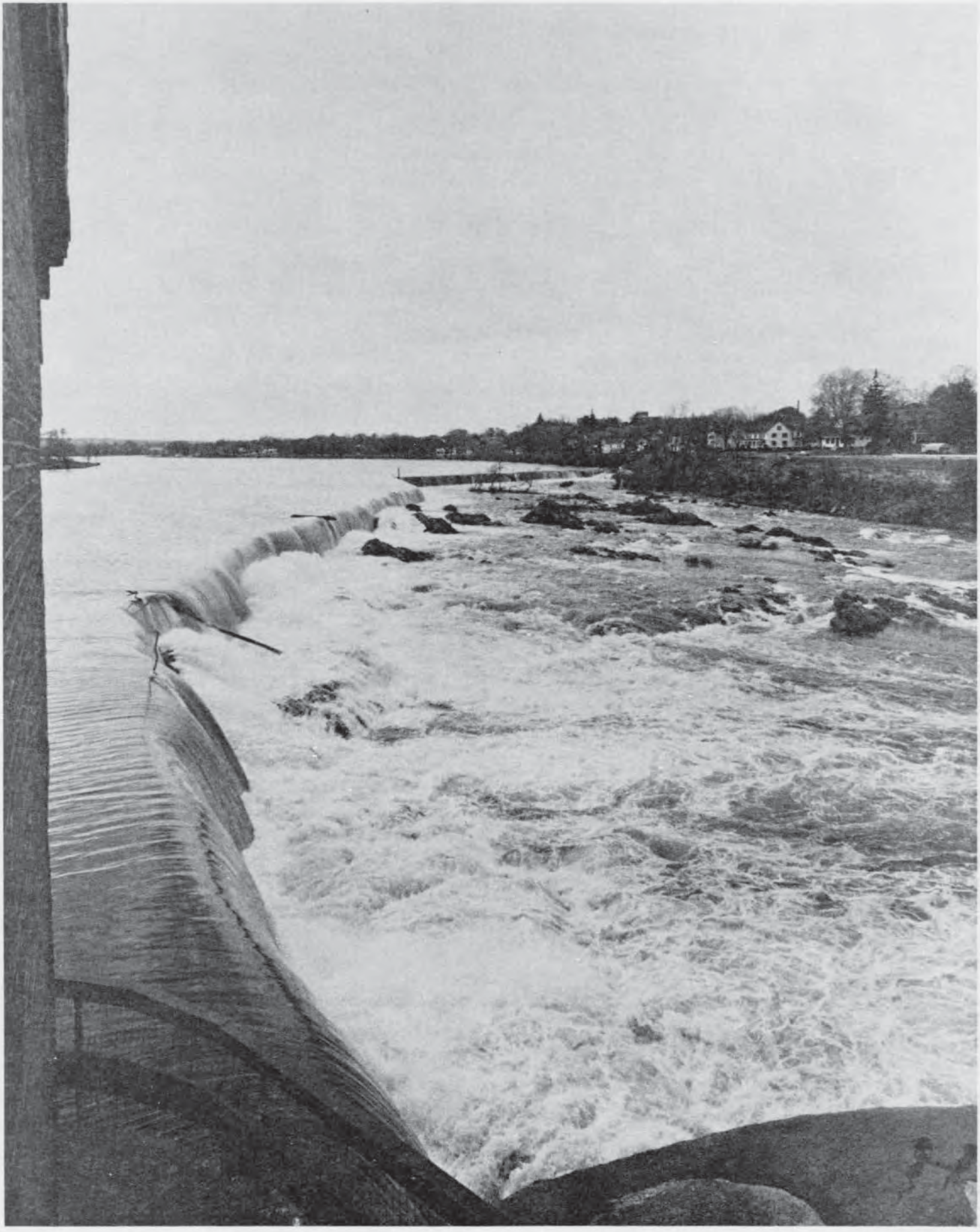
PHYSIOGRAPHY AND PREHISTORIC ARCHEOLOGY OF THE LOWELL NATIONAL HISTORICAL PARK AND PRESERVATION DISTRICT

PHYSIOGRAPHY

The present-day landscape of Lowell is as much a result of the natural environment as it is a product of man's skill and energy. Much of the discussion of Lowell's physical setting centers on the fact that it is a river city. However, to understand the why and how of Lowell's entire physical setting, it is important first to examine the region in which it lies.

The bedrock beneath Lowell averages only twenty feet or so below the ground's surface and, in many places, it is exposed. Recent summaries of the nature of bedrock do not agree concerning its composition and structure, except to call them complicated (U.S. Army 1974: vol. 4, 4-7). Basically, the bedrock is sedimentary rock changed by heat and pressure into several types of metamorphic rock, such as gneisses and schists, and igneous rock formed by the cooling of molten lava, resulting in granite, diorite, and grandiorite (Carroll 1979: 8-10). To complicate this record, the bedrock has been weathered and eroded by continuous water action for millions of years. This erosion process formed the pattern of valleys which carry rivers to the sea (Carroll 1979: 11).

This long-time development of a land surface with eroded valleys has also recently been modified on a large scale by the action of glaciers. The glacial era is thought to have occurred between 100,000 and 25,000 years ago, and to have consisted of four or five cold periods during which ice fields up to one mile thick covered the area (U.S. Army 1974: vol. 1, 23-26). Each event moved all loose material on the earth's surface, as well as scouring, rupturing, and moving much of the harder bedrock beneath.



View of the Pawtucket Dam and Falls from the northeast, 1979.

As the glacier retreated, it left behind deposits of this loose material in two basic forms: glacial till and glacial drift. Glacial till is made up of a mixture of stone, ranging in size from boulders to sand particles which was deposited as the glacier melted. Glacial till is also called hardpan (Flint 1971: 45). Glacial drift consists of similar material washed out of the glacier by streams of water as the ice melted. Glacial streams piled up drift in layers wherever the force of the current slacked sufficiently for particles to settle. Because the stream lost its ability to carry materials of different weights in direct proportion to its current or force, stones or particles of the same size tended to settle in the same place, leaving accumulations of gravel or sand in streamlined piles called kames, drumlins, or eskers.

The Merrimack River originally flowed in a valley that the last glacier left clogged with till and drift. These deposits acted as dams to the river, which found new outlets and ways to the sea. The Merrimack left its old blocked valley just upstream from Lowell, cutting a new channel that washed over the bedrock which was formerly the eastern side of the old river valley (Goldthwait 1925: 42-44). The action of water passing over this sill of bedrock has only begun its erosion work at Lowell, for the jutting bedrock ledge can still be seen at the Pawtucket Falls. Geological deposits within the Lowell area have been historically useful to man; providing sand and gravel for construction; sand for the manufacture of glass; clay for brickmaking; and iron that was smelted from deposits gathered in bogs (Wilson 1917).

The Concord River, which joins the Merrimack at Lowell, is a far smaller river than the latter. Fairly sluggish through most of its course, the Concord falls a total of fifty feet in its last mile before it enters the Merrimack (Carroll 1979: 6).

The ground of the Lowell region is covered with surface layers of soil, primarily fine sandy loams. Thick layers are found along watercourses on the rivers' terraced banks, where they have been deposited by water (Latimer and Lamphear 1924).

PREHISTORIC PEOPLES

Native Americans lived in the Lowell region for thousands of years before Europeans arrived. Archeologists have excavated a wide number of sites in the Northeast and have established that Native American cultures changed through three major temporal periods during their habitation in northeastern North America: the Paleoindian, the Archaic, and the Woodland.

Paleoindian Period

Evidence of early human occupation in the Northeast indicates that by approximately 13,000 before the present (BP), the region was being exploited by human groups. The term "Paleoindian" is used to describe a variety of cultural groups which inhabited North America immediately following the retreat of the Wisconsin ice sheet. These people were once commonly perceived as big-game hunters. In fact, these early inhabitants of the Northeast were probably adapted to a wide range of subsistence resources (Barber 1977; Eisenberg 1979).

The data presently available concerning the Paleoindian period in the Northeast makes it extremely difficult to predict Paleoindian site location with certainty. Recent research conducted in the Connecticut River Valley suggests that river terraces may have been preferred habitation sites during the Paleoindian period (Dincauze and Curran 1977).

Dincauze and Curran's research indicates that by 12,000 BP the environment of southern New England was in a transition period from a spruce-parkland to a spruce-woodland habitat. This evolving forest would have resulted in an environment possessing a high degree of diversity. Under such environmental circumstances, inhabitants would have preferred broad river valleys as habitation sites for several reasons. The development of rich alluvial soils in the floodplains would have supported a variety of wild plant growth for food. Location on a major river would have provided access to the upland areas

via the tributary streams. Perhaps most importantly, river valleys would have generally extended the northern limits of more productive southern habitats (Dincauze and Curran 1977).

Although no Paleoindian sites have been reported in the immediate vicinity of the project area, a single surface find of a reworked fluted point attributed to the Paleoindian period has been reported by an avocational archeologist. He collected it on the second terrace above the Merrimack in Lowell (Winters 1979). Two significant Paleoindian sites have been reported in the region: the Bull Brook site in Ipswich, Massachusetts, and the Swansee site near Keene, New Hampshire (Byers 1959; Curran 1978). Paleoindian points have also been recovered in the Concord River valley and in the Ossippee area of southern New Hampshire (Casjens 1979: Sargent and Ledoux 1973; Winters 1979).

The distrubution of Paleoindian sites and fluted point "find spots" in the region, combined with the Paleo-environmental data as interpreted by Dincauze and Curran, suggest the possibility that the project area was once inhabited or at least used by Paleo-indian groups. The fact that none of these sites has been recorded in the immediate vicinity of the project area may be a function of the inadequacy of archeological site discovery and sampling strategies presently being employed in the Northeast. It is reasonable to assume, as Funk suggests, that many of these early sites may be buried under deep deposits of alluvial or windblown soils (Funk 1972). However, this seems unlikely in the Pawtucket Falls area because the river has not deposited material but rather has been cutting through bedrock. Below the falls, the river's carrying capacity lessens along with its velocity, resulting in considerable silt buildup, especially along the north bank near the outside of the big bend and near the confluence of Beaver Brook.

Although some silt and eroded material was always carried over the falls, it was probably minimal during the prehistoric period compared with the silt carried off during the eighteenth, nineteenth, and twentieth centuries. This is because in the past 300 years, deforestation and cultivation has left the

land far more open and susceptible to erosion than before. Recent rates of silting are estimated at 276,000 tons annually (U.S. Army 1974: vol. 1, 63-64). The silting does not now and did not then affect the land and/or sites on the rock banks of the river in the gorge or falls area, but may well have covered the river's floodplain, which starts downstream from Lowell. In the process, downstream sites may have been covered with silt.

Early Archaic Period

The Early Archaic period (ca. 10,000-8,000 BP) in the Northeast is, like its predecessor, poorly understood because of the paucity of information relating to this period. However, data from the Taunton River drainage in southeastern Massachusetts, combined with the recovery of Early Archaic bifurcated-base projectile points from the Concord and Merrimack River drainages, suggest that early Archaic peoples were exploiting the riverine environments of southern New England (Casjens 1979; Dincauze 1976; Barber 1977).

Data from a series of pollen diagrams suggest that the floral community was enriched gradually as the area was colonized by plant species migrating north and east from regions in which they had taken refuge during the Wisconsin glaciation. By approximately 9,500 BP the southern New England area was covered by a mixed deciduous-coniferous forest roughly analagous to the forest type found in present-day southern Ontario, but much richer in terms of species variety because of the warmer lower latitudes (Dincauze 1973). The southern New England mixed deciduous-coniferous forest included the following species listed in order of their abundance: white pine, poplar, hemlock, maple, and oak (Davis 1969).

The transition from the spruce-woodland forest to a pine-dominated forest coincides with the transition from Paleoindian to the Early Archaic period. This transition was not heralded by any dramatic alterations in cultural pattern; rather there was a continued adaptation of existing exploitative strategies to changing environmental conditions. The environment became increasingly diversified in

terms of the number of exploitable plant and animal species. The gregarious species of large animals, such as the caribou, were replaced by an essentially modern assemblage dominated by a variety of smaller solitary game animals.

The presence of Early Archaic sites within the project area is suggested by the discovery of several bifurcated-base projectile points along the Merrimack and Concord Rivers (Dincauze 1976; Barber 1977; Casjens 1979). Although Dincauze does not believe that the bifurcated base point which was recovered from stratum 5 of the Neville site on the Amoskeag Falls in Manchester, New Hampshire was deposited there by its original makers, its presence does imply that early Archaic peoples were living in the general area. More convincing evidence of the presence of Early Archaic people within the project area is a diagnostic Early Archaic projectile point that was found on an eroded surface of the Poznick site (Thorstensen 1977), which is located in Lowell on the southern bank of the Merrimack River east of the confluence of the Merrimack and Concord Rivers. This site appears to be one locus in a large multicomponent site, MHC 19-MD-47, part of which is located within the project area.

The problems inherent in locating Paleoindian sites under deep alluvial deposits along river terraces also pertain to locating Early Archaic period sites. This is graphically illustrated by the fact that the cultural deposits on the Poznick site reach a depth of five feet and are often separated by sterile flood deposits.

Middle Archaic Period

During the Middle Archaic period (8,000-6,000 BP), the climatic conditions in southern New England continued to change, although much less dramatically than in the preceding periods. The pine-dominated forest slowly evolved into a deciduous forest type dominated by oak and hemlock. The major rivers in southern New England, including the relevant portion of the Merrimack, appear to have reached modern levels during this period. The riverine environment was similar to present conditions, but probably

slightly richer in natural food resources (Dincauze and Mulholland 1977). In general, the environment became more stable, predictable and reliable during the Middle Archaic period.

In most ways, the climate and environment in the Lowell area did not change very much. The old river cut a new course, wearing away the bedrock in its path. The Merrimack River's course at the falls and throughout Lowell is not an old formation with a well-established floodplain and terraces but a relatively new one. This made the Lowell area with its falls a fairly uncommon type of setting even to the early inhabitants of the region. Many of their archeological sites have been found at such places where waterways are constricted, which occurred in the Lowell area at the falls of both the Merrimack and the Concord Rivers.

The recent recorded seasonal variations of the Merrimack's flow are interesting in that they give clues regarding how the Indians may have used the falls as a major food source. Since records have been kept, New England has been receiving forty to forty-two inches of rain annually (Carroll 1979: 36-37), evenly distributed throughout the year. There is great seasonal variation in the river's flow, however, caused by the amount of moisture that the ground can absorb and by the melting of snow and ice, which releases the greater part of the precipitation from the colder months at the spring thaw. The river flow is greatly reduced during the late summer months because the watershed can absorb most of the rainfall and because evaporation is at its greatest during the hot weather.

Several species of fish use these spring floods to make spawning runs into the watershed, and it is at the falls, where fish collect in numbers, that they are easiest to catch. Archeological evidence from this period suggests that the Native Americans collected large amounts of food resources in various places according to season. The significance of this practice is that it allowed people a chance to gather in larger groups. With more sophisticated food preparation and storage techniques, the spring bounty could be stretched out, allowing people to stay in one place for longer periods of time.

During the Middle Archaic period, the number and diversity of sites increase dramatically relative to the preceding periods. This increase in sites may be related to the establishment of a forest environment which contained at least 20% oak (Dincauze and Mulholland 1977). The importance of a forest type that includes at least 20% oak is that oak is a mast-producing tree. Mast (i.e., acorns in the case of oak trees) is a major food source for the white-tailed deer, which appears to have been an important component in the diet of the Archaic and later inhabitants of southern New England. Dincauze and Mulholland (1977) estimate that by 8,000 BP this important 20% oak isopall had reached the border of southern New Hampshire.

Within the Merrimack River valley, published archeological data indicate that by the Middle Archaic period there were communities of hunter-gatherers inhabiting much of the region (Thorstensen 1977; Barber 1977). Dincauze (1976) has suggested that the Middle Archaic component found at the Neville site represents a temporary, possibly recurrently occupied site located to exploit the seasonally abundant anadromous fish. Barber (1977) has interpreted the Middle Archaic component of the Buswell site in the lower Merrimack valley as representative of a seasonal fishing station. Middle Archaic components at several sites along the Shawsheen River might represent activities different from those found at the relatively large fishing areas (McManamon 1977).

The record of Middle Archaic period remains found at Lowell contains some tantalizing clues of what may have been a major locus of habitation. Hints of this former habitation can be found in the Massachusetts Historical Commission Inventory, which notes two sites containing Middle Archaic cultural material: 19-MD-46 and 19-MD-48. The former was situated on the north bank of the Merrimack near the entry of Beaver Brook into the river; it is said to have been more than a mile long. The latter (19-MD-48) was located south of the Merrimack, extending along both banks of the Concord from its confluence with the main river. An even larger site (one mile long) on the south bank of the Merrimack between the falls and the Concord was not identified in the Inventory by cultural period. The first two sites will be mentioned again, because they also were identified as later Native American sites.

Late Archaic Period

The climatic warming trend and forest development continued into the Late Archaic period (6,000-2,000 BP), reaching its peak about 5,000 BP. At this time the deciduous forest was dominated by the mast-producing species of oak and hickory. The climate remained essentially warm and humid until 3,000 BP, at which time there began a very slow, steady, cooling trend in climatic conditions, which has continued with minor oscillations until today (Braun 1974; Fairbridge 1977).

The cooling trend resulted in the elimination of some plant species not suitably adapted to the cool, humid environment. This trend culminated in the gradual replacement of the oak-hickory forest by the modern white pine-hemlock-hardwood forest typical of the present New England Seaboard region.

Judging from the number of known sites with Late Archaic components in the southern New England region, it might be that this period witnessed the maximum prehistoric population density (Dincauze 1975). Bullen (1949) identified a number of sites with a Late Archaic component in the valley of the Shawsheen River, a tributary of the Merrimack River. In the town of Concord a survey of the known prehistoric archeological sites produced thirty-nine sites that contained a Late Archaic component (Casjens 1979).

Within the District, at least two known prehistoric sites contained Late Archaic components: MHC 19-MD-46 and 47. Evidence from the Poznick site suggests that the site was visited repeatedly throughout the Late Archaic period, possibly for the purpose of quarrying the quartz veins in nearby rock ledges (Thorstensen 1977).

Woodland Period

The Woodland period is the next major period which is commonly recognized in the Northeast, dating from ca. 2,500 BP to the time of European settlement. It usually is subdivided into three parts: Early, Middle, and Late Woodland.

Early Woodland Period

The transition from the Late Archaic to the Early Woodland (ca. 2,500-2,000 BP) periods did not involve any drastic alterations in the adaptive strategies of the inhabitants of southern New England. The subsistence strategies of the Early Woodland period seem to have been a continuation of the Archaic pattern characterized by seasonal settlement shifts within a bounded territory.

The hallmark of the Early Woodland period in southern New England is the appearance of coarse, grit-tempered ceramics. This innovation was once believed indicative of a sedentary way of life; however, modern research has discredited this interpretation (Barber 1977). The social and political organization, as well as most aspects of the economic activities during the Early Woodland period, are understood poorly. Within the Merrimack River valley, Early Woodland components seem to exist at several multi component sites, including the Neville, Poznick, and Sweet Apple Tree sites (Dincauze 1976; Thorstensen 1977; Barber 1977).

Middle Woodland Period

During the succeeding Middle Woodland stage (ca. 2,000-1,000BP), specialization in subsistence strategies has been hypothesized (Dincauze 1976). One of the arguments supporting this hypothesis is a noticeable seasonal population shift into the estuarine and coastal areas in order to exploit abundant coastal resources, such as the intertidal soft-shell clam. This increasing utilization of the coastal zone was predisposed by the stabilization of the coastal zone following the termination of the sea level rise and crustal rebounding at approximately 3,000 BP (Braun 1974). By the Middle Woodland period, the marine water temperature had cooled considerably with the result that warm-water shellfish species, such as quahogs and oysters, had been replaced by the soft-shell clam, which is adapted to cool water temperatures. Use of food resources from coastal environments also occurred during the Archaic period (Salwen 1965; Brennan 1976). However, the extent of

this Archaic use of coastal resources is difficult to calculate. In many sections of the coast the areas available for occupation during the Archaic period are now under water.

Evidence from the Wheeler site located in the estuary of the Merrimack River indicates that it was an autumn food procurement station utilized by Middle Woodland people. "The Middle Woodland use of the region seems to be marked by specialized food gathering in the estuarine zone in autumn following which the inhabitants broke into small groups and wintered inland" (Barber 1977: 54-66). In the spring, they returned to the waterways to exploit the spawning fish, whereas summer occupation was elsewhere, perhaps the coast (Barber 1977).

It is difficult to distinguish among Early, Middle, and Late Woodland components for Lowell sites recorded in the Massachusetts Historical Commission Inventory. The only site at which components can be definitely identified is the Poznick site, where material has been found that can be attributed to all three Woodland periods (Thorstensen 1977). Other sites in Lowell attributed to the Woodland Period include 19-MD-46, 19-MD-47, and 19-MD-52. Several sites also contain Archaic period components, indicating that the area supported Native American settlement over a long period. It also shows that the river has not substantially changed the configuration of its new valley, except to slowly erode the bedrock over which it flows.

Late Woodland Period

During the Late Woodland period (1,000 BP to Contact), horticulture began in southern New England with crops of corn, squash, and beans. The earliest recorded date for the use of cultigens in southern New England comes from a charred corn cob from a site on Martha's Vineyard radiocarbon dated to 1,160 AD, plus or minus 80 years (Ritchie 1969). Because of the poor preservation qualities of the acidic New England soils, the floral remains deposited on archeological sites do not often survive. Therefore, this single date should not be interpreted as the earliest possible date for the introduction of domesticated plants.

Agriculture probably increased sedentarism, judging from the appearance of large permanent village sites on elevated river terraces. However, it did not eliminate the necessity for seasonal shifts to exploit certain food sources, such as shellfish and other coastal resources. For example, the Morrill Point site in the Merrimack estuary represents a seasonal Late Woodland site. Barber (1977) speculates that this site may have been a specialized camp used by a small segment of the community.

The Early Historic Period

During the Late Woodland period and continuing into the mid-seventeenth century, the area around Lowell was occupied year-round. The Pawtucket Falls were a valuable resource used in the exploitation of anadromous fish harvested during their spring runs. In 1648 John Eliot traveled to Pawtucket Falls and recorded that"...he found there a great confluence of the Indians, engaged in fishing, and in wild festivities..." (Richardson 1978). This area was utilized also for corn fields by the native inhabitants as evidenced by the large number of hoes recovered at the Poznick site (Thorstensen 1977).

During the early historic period, the area immediately south of and adjacent to the Pawtucket Falls was one of the population centers of the Pennacook Confederacy and the primary residence of the Pennacook Sachem Passaconaway (Richardson 1978). The exact political structure of the Pennacook Confederacy is difficult to reconstruct from the accounts of the English colonists. However, it appears to have been a loose amalgamation of a number of Native American groups who inhabited New Hampshire and northern Massachusetts. This system may not be representative of the political system of the Late Woodland or earlier periods, but rather a makeshift arrangement put together after the devastating plagues of 1616-19, which left much of the area depopulated and the remaining groups weakened politically. When the colonists began to expand into the territories claimed by the Pennacook Confederacy, Passaconaway and several local sachems signed a treaty with the colonial governors placing themselves, their subjects, and their possessions under colonial rule (Richardson 1978). Although

Passaconaway and his people were supposed to retain their tribal lands under this agreement, the inevitable encroachment of the colonial settlements had already begun.

As early as 1629, Passaconaway had deeded all the lands between the Piscataqua and the Merrimack Rivers to John Wheelwright. In 1643, the Massachusetts Bay Colony divided all the lands under its jurisdiction into counties, including much of the land claimed by the tribes of the Pennacook Confederacy. The following year the General Court of Massachusetts Bay Colony instructed the county courts to provide religious education to the natives within their jurisdiction. In the Lowell area this did not come to fruition until 1653, when John Eliot established one of his famous "Praying Indian Villages" at the confluence of the Merrimack and Concord Rivers (Richardson 1978). Although Passaconaway never converted to Christianity, he retained possession of his planting fields in the vicinity of Pawtucket Falls. However, the division of his lands continued with the granting of 1,000 acres on the northern bank of the Merrimack River opposite the Pawtucket Falls to Lt. Peter Oliver, Captain James Oliver, James Johnson, and Ensign John Evered. These men were all members of the Ancient and Honorable Artillery Company, and the grant thus became known as the Military Grant. This large land grant led to a proliferation of smaller grants and purchases, which culminated in the "Wamesit Purchase" of 1686. The Wamesit Purchase deeded all the tribal lands of the Pennacook Confederacy located in the vicinity at Lowell to the colonists, marking the effective end of the Indian occupation in Lowell.

The records of known sites of native American habitations after the European arrival mention the Merrimack's banks below the falls, the banks of the Concord, and the tops of some local hills, where defenses were built to protect the settlements. These are sites 19-MD-46, 19-MD-47, the "Wannalancet site" and the "aboriginal burial ground," all of which are discussed in the Inventory section below.

REVIEW OF PREHISTORIC ARCHEOLOGICAL POTENTIAL

The entire project area possesses a very high potential for containing prehistoric archeological properties. This evaluation is based on the criteria elaborated below.

Criterion A: Contains a known prehistoric site or is located in close proximity to a known prehistoric site.
The site files at the Massachusetts Historical Commission (MHC) list eight known prehistoric sites within or adjacent to the project area. In addition to these sites, John Richardson's research indicates that in 1669 Wannalancet constructed a palisaded fort on what is now Fort Hill in Lowell, for the protection of his people against the raiding Mohawks.
Richardson also locates Native American burial grounds on the east bank of the Concord River between the river and the Lowell Cemetery, probably equated with MHC 19-MD-52.

Criterion B: Contains cultural artifacts or has a history of containing such artifacts.
Although the artifact lists contained on the MHC site file cards are very general in nature, they indicate that a quantity of both Archaic and Woodland period artifacts have been found within the boundaries of the project area.

Criterion C: Located on arable soil, such as exists on the floodplains of major rivers.
The majority of the project area lies within the floodplains of either the Merrimack or the Concord Rivers and possesses arable soil of the Ondawan or Merrimack soil series.

Criterion D: Located on ground that has a slope of less than 20 degrees.
The majority of the project area is located on relatively level river terraces having a slope of less than 10 degrees. In a recent survey of the town of Concord, Massachusetts, Casjens discovered that although all the prehistoric sites that were surveyed were located on ground having a slope of less than or equal to 15 degrees, the majority of sites were located on ground with a slope of less than or

equal to 3 degrees (Casjens 1979). An investigation of known prehistoric sites in Franklin County, Massachusetts, discovered that 81% of all sites were located on ground with a slope of less than 8 degrees (Dincauze et al. 1977).

Criterion E: Located near a permanent water source or wetland and possesses well-drained parts.
Anthony (1978) has demonstrated that 94% of the 115 known prehistoric sites in Worcester County were located within 100 feet of a permanent water source. Similarly, in the town of Concord, all the known prehistoric sites were located within 200 meters of a permanent water source. The major permanent water sources within the project area are the Merrimack and Concord Rivers, Beaver Brook, and Hale's Brook. The vast majority of the project area, including all but one of the known prehistoric sites, is located within 200 meters of a permanent water source.

Criterion F: Located near the site of a specific resource known to have been exploited during the prehistoric period.
The historical record documents the use of the Pawtucket Falls as a major fishing station used by the aboriginal inhabitants until 1686. An analogous situation which documents the utilization of a similar natural resource as early as the Middle Archaic period is the Neville site (Dincauze 1976).

Although the background research indicates that the entire District possesses a high potential for the location of prehistoric archeological properties, the actual probability is greatly reduced by the high degree of land disturbance in the majority of the District. In a recent survey of reported sites in the lower Merrimack River valley, it was determined that of the seven prehistoric sites reportedly located in urban settings, only two could be verified (Barber 1977).

Prehistoric sites contained within an urban setting have a greater probablility of being destroyed than those in rural areas. However, sites from the early periods of aboriginal occupation may be deeply buried under and hence protected by alluvial deposits or

modern fill. If an undisturbed site or part of a site can be found, it would expand the present fragmentary understanding of prehistory in the Lowell area.

A list of reported sites follows. Surface inspection of these sites or their reported locations indicates that the Fort Hill area on the east bank of the Concord River and the north bank of the Merrimack River contain the least amount of industrial-period disturbance among areas with high concentrations of reported sites. In most of the other areas, a very high degree of industrial development has occurred.

Another area of potential interest is the Lowell Manufacturing Company millyard on the north side of the Pawtucket Canal, off Market Street. The 1821 "Plan of Farms...at Patucket" (Figure 3-1) shows a pond or swampy area alongside the canal at that point. Before mills could be built there in the late 1820s, considerable filling was required, reportedly up to a level of twenty feet in some spots. (For more detailed information on the development of this site, see the Lowell Cultural Resources Inventory's research report on the Lowell Manufacturing Company.) While no specific prehistoric activities are known to have occurred in this area, it might have been usable land before the Pawtucket Canal's construction in the 1790s. Any pre-1820 deposits in that area are presumable very deeply buried, and may not have been disturbed by the subsequent development of the site.

SITE INVENTORY
Sites located within (or partially within) the Lowell Historic Preservation District (LHPD) and Lowell National Historical Park (LNHP)

Inventory: Massachusetts Historical Commission Inventory No. 19-MD-46

Location: Northern bank of the Merrimack River between Mammoth Road to Lakeview Avenue. Note: This area includes the area where Beaver Brook flows into the Merrimack. The site width is considered to include the river bank and the first terrace behind it.

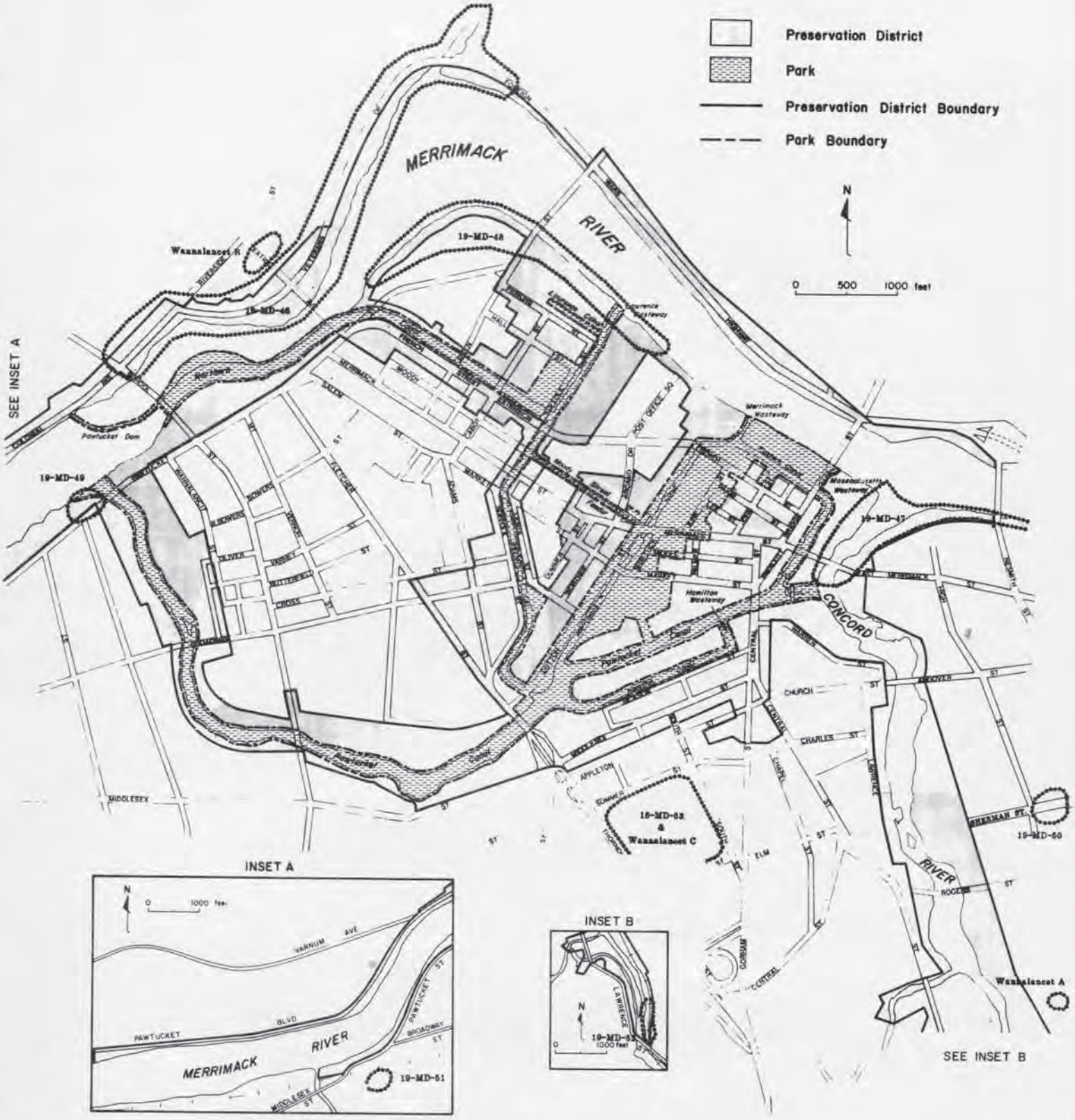
Culture: Massachusetts Archeological Society Site #25 notes that the site contained Archaic and Woodland period material, with the presence of ceramics identifying the later period. The site is described as having been "very large and important, more than a mile in length and to have included the location of fishing grounds used by aborigines in the historic period" (Moorehead 1932).

Pedestrian Survey: The entire area was traversed on foot with a close examination of fortuitous excavations, eroded banks, and cleared areas. Today, the area is traversed by a shore road, the V.F.W. Highway, which is built on a filled embankment. The surface of the area shows it to have been covered by silt-bearing flood waters. The only artifacts observed were large deposits of late nineteenth-century trash, both domestic and industrial, which is part of the road embankment.

Evaluation: Deep testing may reveal silt-covered layers of aboriginal material. A site in this area is also reported on Fishing Island (Winters 1979: personal communication).

Inventory: Massachusetts Historical Commission Inventory No. 19-MD-47

Location: Both sides of the Concord River near its confluence with the Merrimack River.



Map indicating reported prehistoric archeological sites in and around the LNHP and LHPD.

Culture: The Massachusetts Archeological Society Inventory lists the artifacts from this site (#26) with those from site #24. Artifacts recovered here may be in the collections of the Bronson Museum, Attelboro. They are diagnostic of the Archaic, Woodland, and Contact periods. Moorehead (1932) identified this as the site of one of the "Praying Indian Villages."

Pedestrian Survey: The area on the west side of the Concord River is completely developed as an intensively used industrial area. It is in the very heart of the historic industrial district near the mouth of the main canal. Areas of destroyed buildings and collapsed walls gave a fair view of subsurface strata in several locations. These strata were limited to industrial-period debris. On the east bank of the Concord, there is a greater likelihood that a remnant of this site may remain intact. The area has seen continuous use from the nineteenth century onward but development is in the form of terraced gardens, roads, and walks--all part of the landscaping around religious and public buildings. The property of St. John's Hospital is typical of this area (Winters 1979: personal communication).

Evaluation: No area can be tested unless substantial industrial-period material is removed first.

Inventory: Massachusetts Historical Commission
Inventory No. 19-MD-48

Location: South side of the Merrimack River starting at the falls and extending downstream to an area close to the mouth of the Concord River. Site is said to be three-quarters of a mile long.

Culture: Massachusetts Archeological Society Site #25 does not make any cultural identification other than aboriginal. The extent and location of the collection is not noted.

Pedestrian Survey: The area lies in the most

intensively developed portion of the industrial district. The western portion of the site is completely covered by the Northern Canal. A solid row of factory structures lined the river below the bend. Areas cleared of factories today were walked-over, but no traces of aboriginal remains were observed.

Evaluation: The potential for aboriginal cultural resources to have remained undisturbed in this area is low.

Inventory: Massachusetts Historical Commission Inventory No. 19-MD-49

Location: South bank of the Merrimack River above the falls between the Pawtucket Canal intake and Walker Street.

Culture: Massachusetts Archeological Society Site #19 does not make any cultural identification other than aboriginal. A reference, unsupported by comment, is made to its being a "Village site." No collections were found regarding this site.

Pedestrian Survey: This area, which is slightly out of the study area, was found to contain residential, light industrial, and recreational development. The river bank (ponded by the Pawtucket Dam) shows signs of having been repeatedly shored up to prevent erosion. No surface indications of aboriginal culture were observed in the area. Some freshly turned ground and eroded areas revealed no cultural debris.

Evaluation: Test excavations might reveal whether any of the original surface contours and aboriginal cultural-period strata are present.

Inventory: Massachusetts Historical Commission Inventory No. 19-MD-52

Location: On the east bank of the Concord

River between the river and the cemetery, just north of Lawrence Street on the southwest end of Fort Hill.

Culture: The Massachusetts Archeological Society number is 27. It is listed as prehistoric aboriginal in origin, and because ceramics were found it is attributed to the Woodland period. Frederick Burtt, who reported the site, called it a "camp site." B. L. Smith visited the site and recovered lithic debitage but no diagnostic tools.

Pedestrian Survey: This area contains abandoned and marginally operating industry and the Lowell Cemetery. Cemetery workers reported finding no cultural material in their excavations. Surveys of the industrial area show there to be heavy concentrations of industrial material on the surface of the ground.

Evaluation: This site should be investigated in conjunction with other sites reported in the Fort Hill area.

Sites located near the LHPD

Inventory: Massachusetts Historical Commission Inventory No. 19-MD-50

Location: East of the Concord River on Sherman Street between High Street and Fort Hill Avenue.

Culture: The Massachusetts Archeological Society lists this site as #14 and #15. The site was not identified as to culture period. Reference is specifically made to a burial at this site. Recorders include Moorehead (1932) and Bullen (1940).

Pedestrian Survey: This area is covered with urban development, consisting of industrial toward the Concord River, and dense residential away from the river. Empty lots and unused land showed historic cultural

materials only.

Evaluation: This site may have been a single burial, but should be investigated along with the other sites reported in and around Fort Hill.

Inventory: Massachusetts Historical Commission Inventory No. 19-MD-51

Location: Along Middlesex Street between Burnside and Foster Streets, south of Middlesex Street and the railroad underpass.

Culture: Massachusetts Archeological Society Site #20 does not make any cultural indentification other than aboriginal. Reference is made to a "village site" by Moorehead (1931).

Pedestrian Survey: This area is covered with domestic structures and light industry. A survey of several gardens, a fortuitous street excavation, and empty land showed no visible trace of aboriginal cultural material.

Evaluation: If there are any undistrubed portions, testing may reveal aboriginal remains. However, the probability of undisturbed land is small.

Inventory: Massachusetts Historical Commission Inventory No. 18-MD-53

Location: On South Common between Summer and High Streets.

Culture: The Massachusetts Archeological Society assigned #18 to this site. It was attributed to aboriginal culture with no identification of period.

Pedestrian Survey: This site is located in park land. No evidence of aboriginal culture was observed.

Evaluation: Testing may reveal further information.

Inventory: Wannalancet site

This site is attributed to three separate locations by nineteenth-century traditional historians. We have labeled them Wannalancet A, B, C.

Location: Wannalancet A--On Fort Hill in Fort Hill Park. This location is attributed by Cowley (1862: 12).

Wannalancet B--On the north side of the Merrimack on the north campus of the University of Lowell (S. Coburn 1922: 44).

Wannalancet C--On South Common on Roger's Hill (Old Residents' 1891: 388).

Richardson (1978) suggests that all three sites are possibilities but feels that Fort Hill is the most likely prospect. Winters (1979) concludes that Fort Hill and Roger's Hill are the same place and are the location of the village.

Culture: Wannalancet is known to have repaired to the Lowell area and built a palisaded village to protect his people from raids by the Mohawk Indians during the historic period.

Pedestrian Survey: Wannalancet A--Fort Hill is a public park. Eroded areas and cultivated ground revealed no artifacts. Although the hill would be a secure defensive position, the area lacks fresh water. Environmental reconstruction may show that water resources were present.

Wannalancet B--A drive through the campus, along with a pedestrian survey and close visual inspection of several areas of recently disturbed ground, revealed no aboriginal cultural material.

Wannalancet C--No evidence of aboriginal material was found in this area of South Common.

Evaluation: Although all three areas are outside the District boundaries, testing at South Common and Fort Hill may be very productive; testing at the campus would be less so.

Inventory: Aboriginal burial ground

Location: Between the Lowell Cemetery and the Concord River.

Culture: Richardson (1978) mentions that historic indians are reported to have used this area as a burial ground.

Pedestrian Survey: This area was checked for site 19-MD-52 with no success.

Evaluation: Further research should consider the whole Fort Hill Park area.

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CHAPTER THREE

HISTORY OF THE DEVELOPMENT OF LOWELL

In 1820 the area called East Chelmsford was an agrarian district with a population of about 200, living on scattered farms and at the crossings of the few roads. By 1830, the industrial town of Lowell had sprung up in the former farm fields, with nearly 6500 citizens and four large textile manufacturing corporations. Ten years later the population of the city of Lowell was nearly 21,000 and miles of canals powered dozens of textile miles. Throughout the nineteenth century and into the twentieth, Lowell continued to grow. Population peaked at 120,000 by 1920, and in the 1920s and 1930s most of the mills moved out of Lowell or failed. The hard times that hit Lowell are not yet over, but the city's revitalization is clearly underway. This chapter examines the history of Lowell's development, and describes many of the historical resources in the Lowell National Historical Park and Preservation District that reflect the periods and patterns of that development.

Following the initial contact between the native inhabitants and English settlers discussed in the preceding chapter, Lowell's development can be described in seven historical periods:

East Chelmsford Hamlet

From 1686, when Chelmsford farmers purchased much of the present area of Lowell from its native owners, through the first two decades of the nineteenth century, the settlement was predominantly agrarian. Very little that was built in these years still stands in the Park and the District, but the hamlet left an imprint on the area that can still be detected.

The Lowell Experiment

In 1821, the "Boston Associates" selected East Chelmsford as the site for the development of large textile mills. Over the next two decades, Lowell was established. Canals were dug, the streets of the central area were laid out, and a full-fledged city was built. That period gave to modern Lowell its basic plan, and to the Park and the District over five dozen buildings. The initial period of industrial establishment was completed in 1839, when the

tenth and last major textile corporation, the Massachusetts Cotton Mills, was chartered.

The Experiment Expands

From 1840 through 1865, the canal system, the mills, and the city itself all grew, filling in the urban framework established in the preceding decades. Among the extant historical resources from this period are the completed canal system and major buildings in most of the surviving millyards.

The Industrial City Matures

The post-Civil War era brought continued expansion for the textile corporations, increased industrial diversification, and an emergence of the city's commercial and political sectors into a more equal relationship with Lowell's corporate giants. Much of the present fabric of the city dates from this period, which culminated in the dedication of the grand new City Hall in 1893.

Multilingual Lowell

The long-established Irish and the many French Canadians in Lowell were joined in the 1890s and the early decades of the twentieth century by immigrants from a wide spectrum of European countries. Both the population and the industrial output of the city reached their peaks around 1920. The major commercial and industrial buildings surviving from that period have an air of confidence about their designs that the following decades betrayed.

Collapse of Lowell's Textile Industry

The industrial collapse of the 1920s and the 1930s was foreshadowed by the Bigelow Carpet Company's departure from the old Lowell Manufacturing Company millyard in 1914, and the cessation of production by the Middlesex Company in 1918. One after another of the major and minor textile mills and the Machine Shop closed in the following decades, and several were razed. The demolition of the remaining mills and boarding houses of the seminal Merrimack Manufacturing Company in the early 1960s hopefully marked the last time there was more profit in tearing down Lowell's past than in preserving it.

Revitalization of Lowell

The opposite approach to dealing with Lowell's past characterizes the period of the city's development from the mid-1960s to the present. The adoption and implementation of the urban cultural park concept grew out of a determination that Lowell would find its brightest future in the appreciation and preservation of the resources from its past.

EAST CHELMSFORD HAMLET: 1686 to 1820

History

English settlement in the general area of present-day Lowell dates to 1653, when families from Concord and Woburn petitioned the General Court for a grant of land on the Merrimack River near the Indian fishing grounds at Pawtucket Falls. They received the grant and established the town of Chelmsford. At the confluence of the Merrimack and the Concord Rivers, a triangular tract was set off from the larger grant and reserved for the sole use of Indians, who had seasonally gathered fish at those falls for centuries. There John Eliot established one of his "praying villages" for Christian Indians. The grant for that village, called Wamesit, included most of the central area of modern Lowell.

Relations between the Indians at Wamesit and the Englishmen at Chelmsford were peaceable until the mid-1670s, when King Philip's War broke out. Mistrustful of the angry and frightened English settlers and militia, the Pennacooks at Wamesit abandoned their village and fled into the woods in 1675. Throughout 1676 and 1677 they returned periodically, only to flee again. When they left behind their elderly and blind in the winter of 1676, English settlers set a torch to the village, burning the wigwams and their occupants.

Many of the Indians who survived the soldiers' attacks, the torch, and the starvation and sickness that accompanied the exile from Wamesit were captured and sold to slavery. Few of the remainder returned to Wamesit. In 1686, Wannalancit, the last sachem of the Pennacook Indians, sold the Wamesit tract to two English settlers. They transferred ownership of the "Wamesit Purchase" to a group of fifty proprietors,

who divided the land and established farms.

Throughout the next century and more, the area remained agricultural. It was informally regarded as a part of Chelmsford, paying taxes to that town and participating in its affairs until 1725. That year the General Court refused to seat a Wamesit resident who had been elected as a Chelmsford representative. When the Wamesit settlers countered with a refusal to pay taxes to Chelmsford, the area was formally annexed to the town of Chelmsford.

East Chelmsford was bounded on three sides by major rivers, so the early river crossing points did much to determine the locations of major roads (Figure 3-1). By 1774, the Concord River was bridged where East Merrimack Street now spans the river. An early ferry crossed the Merrimack River at the foot of the present Bridge Street. In 1792, the Proprietors of the Middlesex Merrimack River Bridge built the Pawtucket Bridge across the Merrimack River just above Pawtucket Falls.

The roads connecting these crossings were adopted by the nineteenth century town builders as principal streets. The road from Chelmsford ran along the south bank of the Merrimack River and extended all the way to the Town Landing at the crook of the Merrimack below the Pawtucket Falls, the same course followed by present-day Pawtucket Street. About a half mile before its Town Landing terminus, that road crossed the road leading to the Pawtucket Bridge. The bridge road was called Mammoth Road on the north side of the river, and led to New Hampshire. South of the river, the road set the general course now followed by School Street.

Midway between the Pawtucket Bridge and the Town Landing, the road from Chelmsford split and sent one fork eastward across the fields, woodlands, and orchards to the bridge over the Concord River, and from there towards Boston. This road established the course of Merrimack Street, Lowell's main thoroughfare. The way to Billerica branched south from that main road and ran along the west bank of the Concord River. The Billerica road became Central Street.

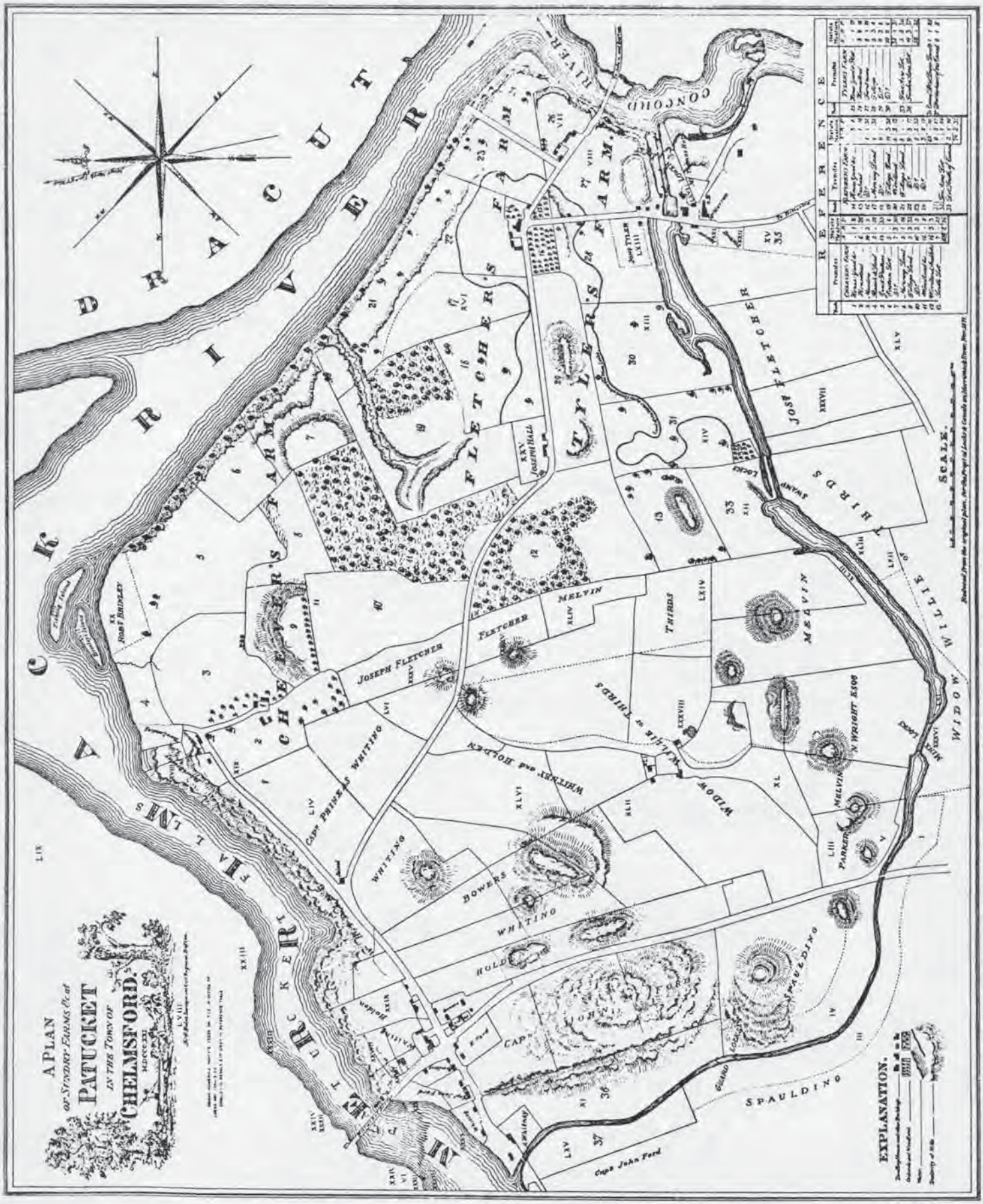

Figure 3-1 Map of East Chelmsford in 1821, by John G. Hales.

In 1792, the same year the Merrimack River was bridged, even more momentous events were afoot in the area. A group of Newburyport merchants obtained a corporate charter as the Proprietors of Locks and Canals on Merrimack River. Their purpose was to build a navigational canal around Pawtucket Falls in order to open the New Hampshire hinterlands for trade with their town at the mouth of the river. The Pawtucket Canal was completed in three years at a cost of about fifty thousand dollars. From its starting point above the falls, the 9,000 foot canal curves south and then east, skirting high ground just south of the falls, and meets the Concord River near its junction with the Merrimack River.

In 1793, a year after the Proprietors of Locks and Canals were incorporated, a competing canal corporation was chartered called the Proprietors of the Middlesex Canal. Boston interests financed this ambitious effort, expending over $600,000 by 1803 to construct a twenty-seven mile canal linking the Merrimack River from a point about a mile above the Pawtucket Falls to the Charles River at Charlestown, and hence to the port of Boston. The longer canal circumvented not only Pawtucket Falls, but also all the lesser rapids downstream on the Merrimack River. In the face of such competition, the tolls collected and the level of the maintenance of Pawtucket Canal gradually declined.

Even before the canals brought new activity to the agrarian hamlet, other non-agricultural concerns had established themselves in East Chelmsford. As early as 1697 the Proprietors of the Wamesit Purchase had offered a plot of land to anyone who would build a mill on River Meadow Brook, a small stream that flowed into the Concord River about a mile south of the confluence with the Merrimack River. That offer was apparently not accepted, although a century later River Meadow Brook was extensively developed by Moses Hale as a waterpower source for mills. The stream is now called Hale's Brook.

In the 1730s Nicholas Sprague, Jr. built a fulling mill on the east side of the Concord River near its mouth. Small sawmills, grist mills and others followed which used the water power resources of the Concord River, River Meadow Brook, and even the

mighty Merrimack. Several of these establishments warrant mention, although none even hinted at the scale of the industrial complexes that were to come in Lowell.

Just outside the District, the Chelmsford Glass Company was established in 1802 at Middlesex Village, where the Middlesex Canal meets the Merrimack River. One of the longer-lived of early American glassworks, the factory operated there until 1839. John Ford ran a sawmill just above the Pawtucket Falls, one of the few mills to exploit the waterpower of the Merrimack River before the 1820s.

Moses Hale's mills on River Meadow Brook were more typical, as they were built on a stream far easier to harness than the Merrimack. In 1790 Hale built a fulling, dyeing and dressing mill there and in subsequent years he expanded, adding grist and sawmills and a wool-carding operation. Hale introduced the manufacture of a new product to the area in 1817 when he began grinding gunpowder on the River Meadow Brook.

Three other early waterpower developments on the Concord River took place on sites that were more fully exploited after Lowell was established. By 1820 Thomas Hurd owned most of the mills near the mouth of the Concord. The most important of these was on the west bank, immediately south (upstream) of the mouth of the Pawtucket Canal. Hurd acquired the cotton spinning mill built there in 1813 by local citizens Phineas Whiting and Josiah Fletcher, and before 1821 Hurd built a small power canal to operate a wool-weaving mill. The Middlesex Company, one of the major Lowell textile establishments, bought the site by 1830.

Upstream from Hurd, Nathan Ames, a blacksmith, established an iron forge at Massic Falls, ca. 1800. John Fisher became a partner in 1812. An island in the narrow river at those falls made the harnessing of waterpower a relatively simple matter. In the early nineteenth century, a dam was constructed from the island to the east bank, and a mill bridged out to the island from the west bank. The channel it straddled was its waterpower source. The forge operated until 1836, when Perez Richmond bought the site and established paper and batting factories.

Figure 3-2 Spalding House, 383 Pawtucket Street, built 1761, photographed ca. 1920.

Figure 3-3 Whipple's Powder Mill, Lawrence Street, built ca. 1821, photographed 1979.

Still further upstream, Oliver Whipple built a power canal along the west bank of the Concord River just above Hale's Brook in the early 1820s. Whipple came to East Chelmsford in 1818 to manage Moses Hale's powder mill. He used the new canal to operate his own, larger powder mill. Whipple later rented out mill space along the canal and sold power to other small manufacturers.

Despite the modestly-scaled industrial activity and the two transportation canals circumventing Pawtucket Falls, the East Chelmsford hamlet was still primarily agricultural in 1820. Approximately two hundred people inhabited the area on scattered farmsteads and in small clusters of houses, taverns, mills, and stores at Middlesex Village (the northern terminus of the Middlesex Canal), Falls Village (where the Pawtucket Bridge crossed the Merrimack), and around the Pawtucket Canal's Lower Locks and nearby Concord River bridge. There were also small settlements in West Dracut across the Pawtucket Bridge from Falls Village, and in Tewksbury across the Concord River bridge on sites now within Lowell and partially within the LHPD.

Historical Resources

Aside from the general routes of Pawtucket, School, Merrimack, Central, and Bridge Streets, and the basic course of the Pawtucket Canal, very little remains in the Park and District from the pre-1820 period. The 1821 map of "Patucket" by John G. Hale indicates approximately sixty "Dwelling Houses and other Buildings" in East Chelmsford (Figure 3-1). Of these, only the Spalding House at 383 Pawtucket Street, built ca. 1761, survives (Figure 3-2). On the north side of the Merrimack River in Pawtucketville (once West Dracut), the Colonel Varnum House at 81-83 Varnum Avenue may date within a decade of the 1792 construction of the Pawtucket Bridge.

The only survivors among the early mills and their canals are the rebuilt Whipple's Canal and a single building of his gunpowder factory on Lawrence Street. That rubblestone mill dates to ca. 1821 (Figure 3-3).

Additional historical resources may survive from the East Chelmsford hamlet as archeological remains.

The iron forge site at Massic Falls on the Concord was redeveloped for paper and batting mills after 1836 and remained active throughout the nineteenth century. Those later mills are now also gone. Below-ground testing would be required to determine if any remains of the early use of the site are still extant. On the Whiting-Fletcher spinning mill site, where Hurd built a small canal and operated a wool weaving mill before 1821, the Middlesex Company later developed a major millyard (demolished in 1956). Middlesex drew water for power from both the Concord River and the Pawtucket Canal. The canal Middlesex used off the Concord River throughout the nineteenth century followed the course of Hurd's early canal. Beneath the parking lot now on that site, evidence of the basic course, if not actual elements of Hurd's canal, may survive.

The East Chelmsford settlers farmed the land, fished in the rivers, and traded at the river crossings. Their utilization of the resources of the area was more like that of their Indian predecessors than like the industrialists that followed. The great fall of water at Pawtucket Falls was to the settlers mainly an obstacle--useful when it blocked fish, a nuisance when it blocked boats--and the Pawtucket Canal was solely a means of circumnavigating the obstacle. In the period that followed 1820, the power of the fall of water became the area's most important natural resource, and the canal became a means of harnessing that power.

THE LOWELL EXPERIMENT: 1821-1839

History

The transformation of the hamlet East Chelmsford into the industrial city of Lowell was astonishingly quick. The 200 farmers and tradesmen of 1820 were already outnumbered by carpenters, masons, laborers, and mill workers in 1824, when the population is estimated to have been 600. Two years later, 2,500 lived in the newly chartered Town of Lowell. The burgeoning industrial development attracted 3,500 residents by 1828, and 6,500 by 1830. Additional corporations were chartered in the early 1830s, and their workers and the accompanying storekeepers, milliners, doctors, clerks, and other townspeople swelled the town's population to 12,000 by 1832.

1834 saw the first of many annexations, when Belvidere, the part of Tewksbury on the east bank of the Concord River, was added to Lowell. The town's amazing growth was acknowledged by the state in 1836, when Lowell was incorporated as the third city in Massachusetts, with a population of 17,500. 21,000 lived in the city by the end of the initial period of development in 1840.

The events that transferred East Chelmsford into the city of Lowell were not foreshadowed by Hurd's mills on the Concord River, or Hale's expanding industrial complex on River Meadow Brook, but rather by a new sort of factory that developed on the Charles River at Waltham near Boston. In 1814 a fully integrated cotton mill was established there that could perform every process necessary to transform raw cotton into finished cloth. Most American cotton mills at that time produced cotton yard, which they sent out to handweavers to make into cloth. Even the English textile industry, far more advanced technically and much larger in scale, divided the many stages of cloth production among separate establishments.

The Boston Manufacturing Company at Waltham had three other characteristics that made it unusual among American textile mills of the time. First, it utilized power looms. This English invention was decades old, but the exportation of power looms or even drawings of them from the British Isles was strictly

prohibited. The initiator of the Waltham factory, Francis Cabot Lowell, had closely observed these mechanized looms on a visit to England and Scotland and in 1814 essentially reinvented the device in Boston, with the aid of an American master mechanic, Paul Moody.

The Waltham enterprise was also atypical among American textile mills of that time in that it was well-capitalized, under the corporation form of organization. Francis C. Lowell recruited the other shareholders from among his Boston mercantile associates. This group that provided the capital for both the Waltham factories and the founding of Lowell is commonly referred to as the "Boston Associates."

Another peculiarity of the Waltham operation was its work force. The company recruited young women from the surrounding area to operate the mills' machinery and lodged them under careful supervision in company-owned boarding houses. Most American textile factories of the early nineteenth century had constant difficulty finding and keeping enough operatives, and they usually hired whole families and staffed their mills with men, women, and even children. Most of the young women of the Waltham factory worked there a few years, then left to marry or to return to their families. The use of the power loom, corporate capitilization, the fully integrated organization of the production process, and the recruitment and housing of a work force of young women were the special characteristics of the Waltham operation that would be adopted in transforming East Chelmsford into Lowell.

The most compelling result of the establishment of the Boston Manufacturing Company in Waltham for the "Boston Associates" was its immense and immediate profitability during a time when other American cotton mills were failing. With the addition of a second mill in 1818 and a third in 1820, Boston Manufacturing quickly reached the limits of the waterpower available from the Charles River at Waltham. By 1820, the "Boston Associates" began seeking a larger site with greater waterpower potential, where they could apply the Waltham formula on a grand scale and even add calico printing to their plain cotton cloth production.

Patrick Tracy Jackson, Kirk Boott, Warren Dutton, Paul Moody (Francis Cabot Lowell having died in 1817) investigated sites as far afield from Boston as Gardiner, Maine. In the autumn of 1821, they selected the area around the Pawtucket Falls on the Merrimack River at East Chelmsford. They purchased four-hundred acres of farmland within the crook of the Merrimack River, west of its confluence with the Concord River. They also bought up the shares of the Proprietors of Locks and Canals on Merrimack River, the corporation that owned the Pawtucket Canal and accompanying Merrimack River water rights. In February, 1822 the Merrimack Manufacturing Company was chartered by shareholders Jackson, Appleton, Kirk Boott and his brother John Wright Boott, and Paul Moody, the master mechanic. Land and canal ownership was transferred to the new corporation, and Kirk Boott was appointed as the first treasurer and agent, with day-to-day executive authority for the venture.

The burst of construction activity that followed must have seemed frenzied to the displaced farmers and other residents of East Chelmsford. The decrepit Pawtucket Canal was broadened and deepened, and its system of locks was redesigned. As a transportation canal it originally had four sets of locks to raise or lower vessels bypassing the Pawtucket Falls. In rebuilding the canal, three sets of locks for navigation were retained, but just two main levels were established, divided by the Swamp Locks at the midpoint. A new canal, the Merrimack, was dug north from the Swamp Locks basin to the banks of the Merrimack River over a thousand yards away. The Merrimack Manufacturing Company, the first great mill complex, was built beside the river. Its waterwheel was in motion by September of 1823, and later that fall cotton cloth was being produced.

In addition to the various mill buildings and a print works for producing calicoes, the corporation built double houses of brick and wood and longer brick rows on the streets parallel to the Merrimack Canal, directly in front of the millyard. The operatives (mostly unmarried females) were lodged in boarding houses, while the more skilled workers (usually men with families) were provided individual apartments referred to as tenements.

In 1824 a second mill was built in the Merrimack yard, and the next year a third. The first two were equipped with Waltham-built machinery. The third mill, however, was outfitted with machines built in the new Machine Shop still under construction at Swamp Locks within the fork of the Pawtucket and the Merrimack Canals.

The initial intention of the "Boston Associates" apparently was to carry out the entire East Chelmsford development under the aegis of the Merrimack Manufacturing Company, and in 1824 new mills were planned for a site southeast of the Swamp Locks. Figure 3-4 shows the plan for that project, with a new canal parallel to the Pawtucket Canal below Swamp Locks, mills along the island between the canals, and row after row of freestanding boarding houses, of the Merrimack Company's double-house type. Before that plan was carried out, however, the directors of the Merrimack Company decided that the possibilities at East Chelmsford were too vast to be developed under a single management, and two crucial changes were agreed to and implemented. First, new companies would be allowed to purchase mill sites and waterpower. In 1825 the Hamilton Manufacturing Company was incorporated and Merrimack Company sold to the new corporation a site for two mills and the accompanying waterpower rights with which to operate them. The waterpower was delivered by a new canal in the location of the one indicated on Figure 3-4.

The second part of the Merrimack Company's reorganization involved divesting itself of all its real estate (except its own millyard and housing sites), of the canal system, and of the Machine Shop. Rather than offering these assets for sale on the open market, or creating a new corporation to administer them, Merrimack Manufacturing revived the Proprietors of Locks and Canals. That corporation, which built the Pawtucket Canal in the 1790s, had been inactive since Merrimack had bought up its shares in 1821-22. Its charter was still in effect, however, so several Merrimack shareholders recapitalized Proprietors of Locks and Canals by purchasing the shares. Then the Merrimack Company sold to that corporation the undeveloped land, the canals, and the Machine Shop. Kirk Boott assumed the posts of Agent and Treasurer of the Proprietors of Locks and Canals, while still retaining the same positions at Merrimack Manufacturing Company.

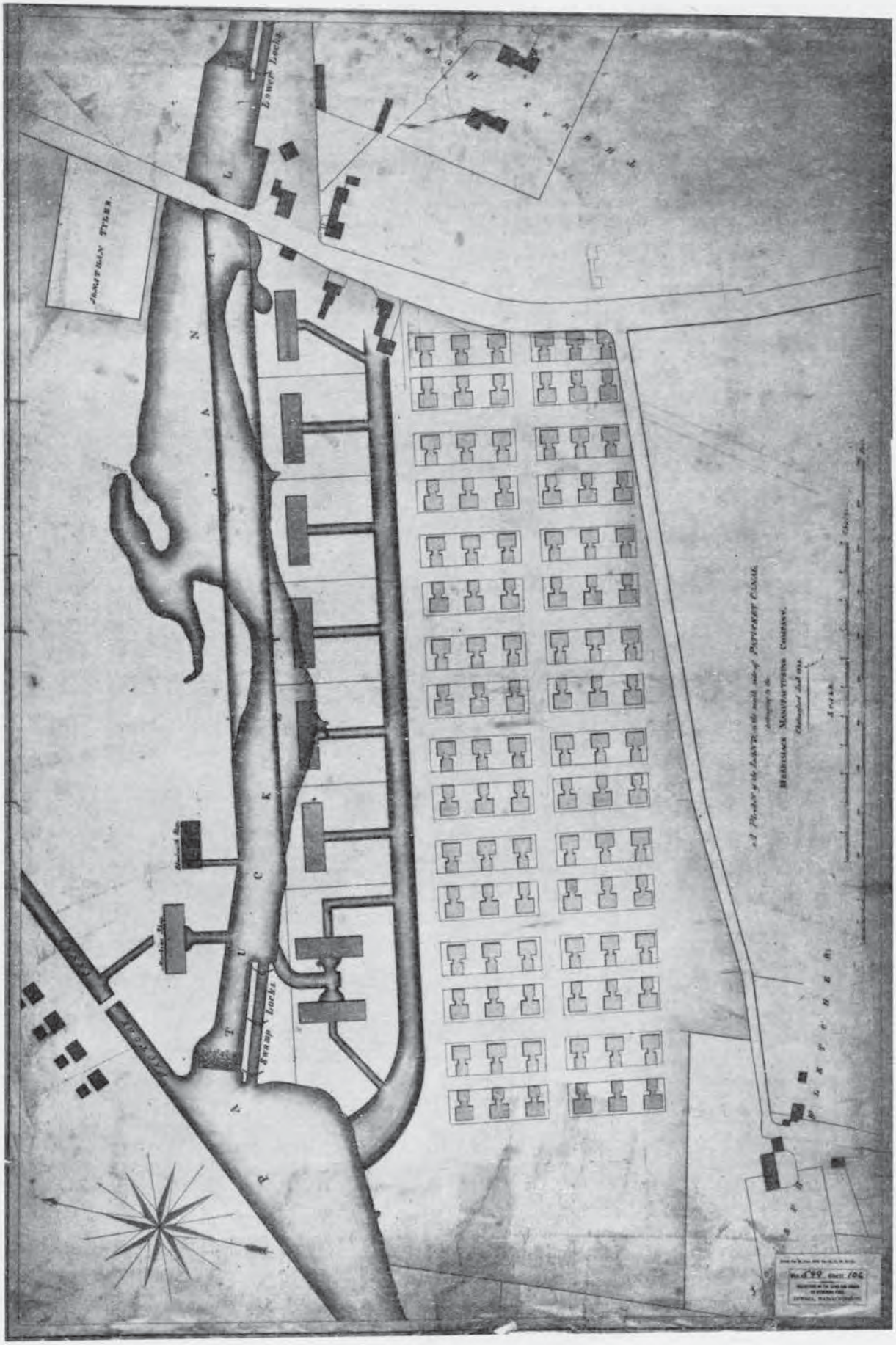

Figure 3-4 "A Plan of the Land, on the south side of the Patucket Canal, belonging to the Merrimack Manufacturing Company. Chelmsford, Jany. 1824."

Once the decisions were made to accept new manufacturing corporations, and to re-establish the Proprietors of Locks and Canals to take charge of real estate development, machine building, and the canal system, the pattern was set for the full industrial development of the area. Around the mills, the other aspects of a complete town were beginning to emerge. In 1824-25, the Merrimack Company built a stone church near its employee housing which was named St. Anne after Kirk Boott's wife. Rev. Theodore Edson, the Episcopal minister hired by Boott, later estimated the settlement consisted of about 600 people in 1824.

Anticipating the need for additional residential space for the rapidly growing population, a corporation was chartered in 1825 to build a bridge across the Merrimack River just above the Concord River confluence, to make East Dracut accessible to the burgeoning industrial community. Shops began to rise along the two main streets of the new Merrimack Street and Central Street, which followed the courses of two old roads. By 1826, the population numbered about 2,500, and the General Court granted a petition establishing the new township of Lowell out of the eastern part of Chelmsford. Nearly 3,000 acres located west of the Concord River and south of the Merrimack River formed the new town.

The same year as the town was established, the Hamilton Canal was completed, extending almost two-thousand feet from the Swamp Locks basin, parallel to the lower Pawtucket, and discharging back into the Pawtucket's lower level. On the "island" between the new and the old canals, two Hamilton mills were operating by 1827.

Two more corporations were chartered the next year, the Appleton Manufacturing Company and the Lowell Manufacturing Company. The Appleton Company aquired the southwest end of the power island already occupied by the Hamilton Company, while Lowell Manufacturing began building its cotton and carpet weaving mills across the Pawtucket Canal from Hamilton, between the Merrimack and Pawtucket Canals. The Lowell Canal was dug from the Merrimack Canal to the Pawtucket Canal, bringing "upper level" Merrimack Canal water through Lowell Manufacturing's breast wheels, then discharging it into the lower Pawtucket Canal, a drop of thirteen feet. Lowell Manufacturing's site was so swampy

that the first stones for the foundations were laid upon the ground, then built upon as fill was dumped around them to create a new surface at a dry and useable level. Mill sites were not chosen for ease of construction, but rather for efficient delivery of waterpower.

In 1828, the town's population topped 3,500. Two years later, the town's population reached 6,500, and a brick Town Hall was erected across Merrimack Street from St. Anne's Church. The digging of the long Western Canal had begun in 1828, but was halted by the depression of that year. In 1830 the work resumed, to bring water from Swamp Locks basin to new mill sites on the Merrimack River, just west of the Merrimack millyard. Helping finance that work were several investors who were new to Lowell, including Amos and Abbott Lawrence, Boston's leading textile merchants. The Lawrences received a charter as the Middlesex Company in 1830 and began woolen textile production on Thomas Hurd's Concord River site. The Lawrences became shareholders and selling agents of many of the Lowell mills, and gave their name to the mill town which sprang up in the 1840s and in the 1840s helped found the mill town that bears their name located eight miles downstream from Lowell on the Merrimack River. The Lawrences invested in all three Lowell textile corporations chartered in 1831--the Proprietors of the Tremont Mills, the Suffolk Manufacturing Company, and the Lawrence Manufacturing Company. By 1832 all three of these new companies could utilize Western Canal waterpower at their sites west of the original Merrimack millyard.

The 1832 "Plan of the Town of Lowell and Belvidere Village" drawn by Benjamin Mather provides an excellent reference for assessing Lowell's first decade of growth and examining the basis for some later patterns (Figure 3-5). Mather records both actual and planned development on such sites as the Suffolk, Tremont, and Lawrence millyards, but generally shows them as they were built. In the northeast corner of Lowell, he even shows a "Contemplated Canal" where the Eastern Canal would be built three years later, and indicates mills along its east and north sides, where the Massachusetts and Boott Mills were established later in the decade. Mather shows a "Rail Road" exiting from Lowell toward the southeast, complete with an

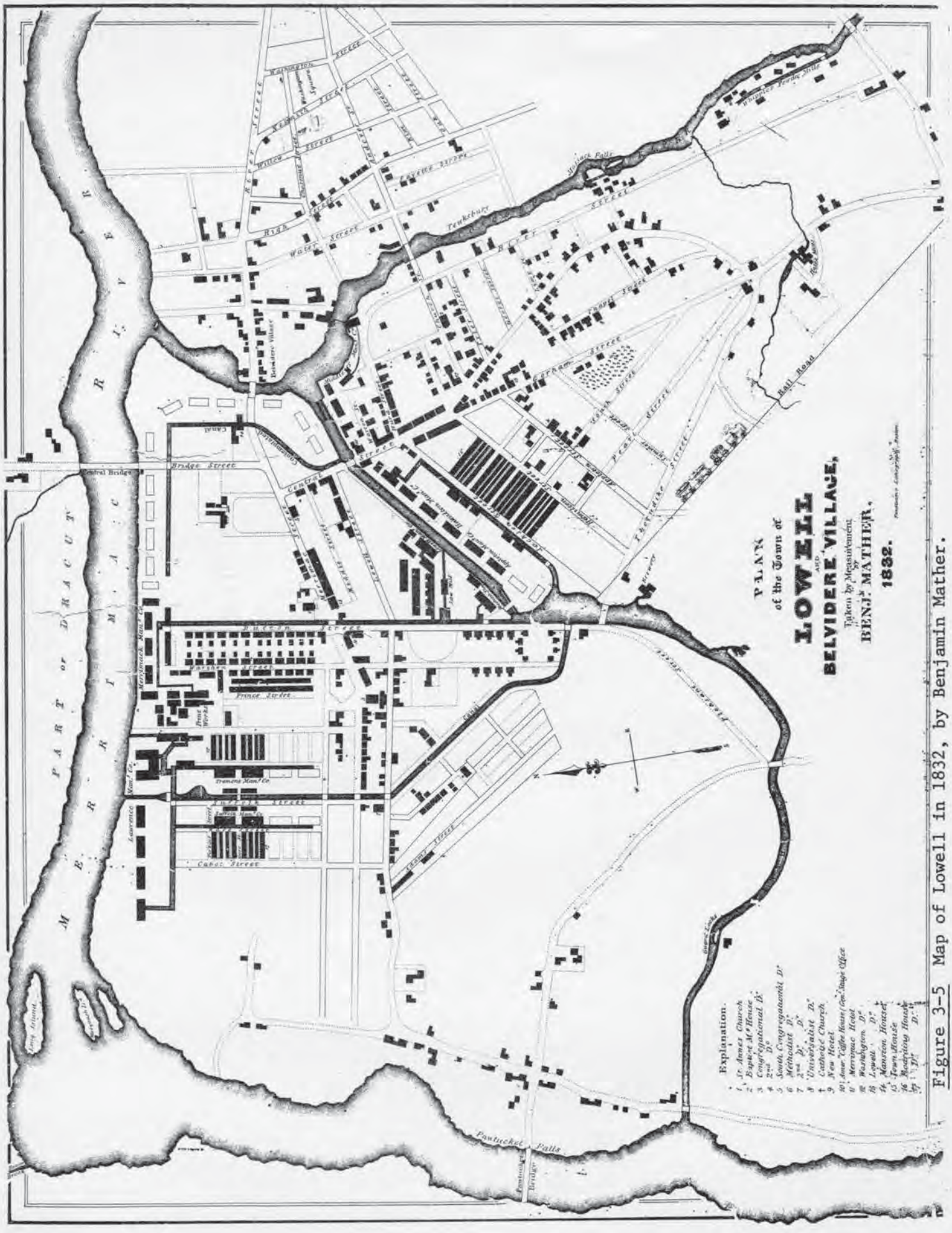

Figure 3-5 Map of Lowell in 1832, by Benjamin Mather.

engine and top-hatted engineer, a passenger car and two baggage cars. The Boston and Lowell Railroad was under construction along that route by 1832, but the first train did not run until three years later.

Lowell's population exceeded 12,000 in 1832, and Mather's map shows the uneven patterns of development resulting from this extremely rapid growth combined with the strategically scattered siting of millyards. The routes of the principal streets were all inherited from the rural hamlet of East Chelmsford, as was the arc of the Pawtucket Canal. The major new elements were the fan of canals from the midpoint at the Swamp Locks basin, and the mills positioned along them according to the dictates of waterpower. Water had to be delivered at a high level to the breast wheels, then flow away unimpeded. These requirements placed the mills around the Swamp Locks, and along the Merrimack River below the bend.

Arrayed in front of each millyard was the company-owned housing built for the workers in the mills. The boarding houses' proximity to the millyards was necessitated by the long, fourteen-hour workdays, and also expressed the paternalistic relationship of the corporations toward the female workers. Unless the corporations could safeguard the young women's reputations, few would be willing to leave home to work for the mills.

The housing built by the seminal Merrimack Manufacturing Company differed architecturally from that of later companies, but set the spatial relationship of housing in relation to the millyard copied by the others. Merrimack's housing consisted mostly of double houses or four-unit buildings, in either brick or wood, set along Dutton and Worthen Streets perpendicular to the millyard. The Dutton Street houses are visible at the center of Figure 3-6. Only Prince Street had Merrimack Company housing in longer rows.

The Hamilton Company's housing adopted the overall siting introduced by the Merrimack Company and set the precedent more widely followed in terms of building type. That company built pairs of block-long brick rows set back-to-back across the Hamilton Canal from the millyard. As Mather's map shows, Appleton, Suffolk, and Tremont Mills generally followed this pattern. Lawrence and Boott Mills would later adopt

the same model, as would the Massachusetts Mills, although the pattern had to be altered somewhat to fit the latter's L-shaped millyard. Lowell Manufacturing had an irregularly-shaped millyard between the Merrimack and the Pawtucket Canals, and built rows on a less rigid configuration. The Machine Shop's work force was predominantly male, so the employee housing the Proprietors of Locks and Canals provided to those employees consisted of double tenement houses more suitable for families. They were placed along Dutton and Worthen Streets and around a court off Dutton, between the Merrimack and Western Canals. Most of the corporations placed the agent's house near the boarding houses symbolically between their operatives and other elements of the town.

The Middlesex Company apparently built no conventional boarding houses. The company did own considerable real estate in the neighborhood of its millyard, and perhaps lodged employees in buildings originally constructed for other purposes.

By 1832 two concentrations of shops, offices, and institutional buildings had formed in Lowell near the the corporation housing of the established mills. Merrimack Street around the Merrimack Canal could rightfully claim to be the town center. On the east side of the canal were St. Anne's Church, the new Town Hall, and several shops. On the west side were the town's leading hotel, the large, brick Merrimack House; the Bank block, said to be the town's first brick commercial building (1826); the Congregational Church; the Merrimack Company's school; and more shops. The Boston and Lowell Rail Road located its depot at the corner of Dutton and Merrimack (Figure 3-7), and after the line opened in 1835 the importance of this area of town was even more firmly established. Philander Anderson, a cartographer and engineer for the railroad, signed the design for the depot. Its three sides of Doric colonnades must have made it one of the most stylish Greek Revival buildings in town, until a train would pull directly through the "temple."

The other concentration of commercial buildings lined Central Street from Merrimack Street on the north to beyond the Gorham Street intersection on the south. Before 1820, there had been a tavern or two located near the Lower Locks of the Pawtucket Canal along the

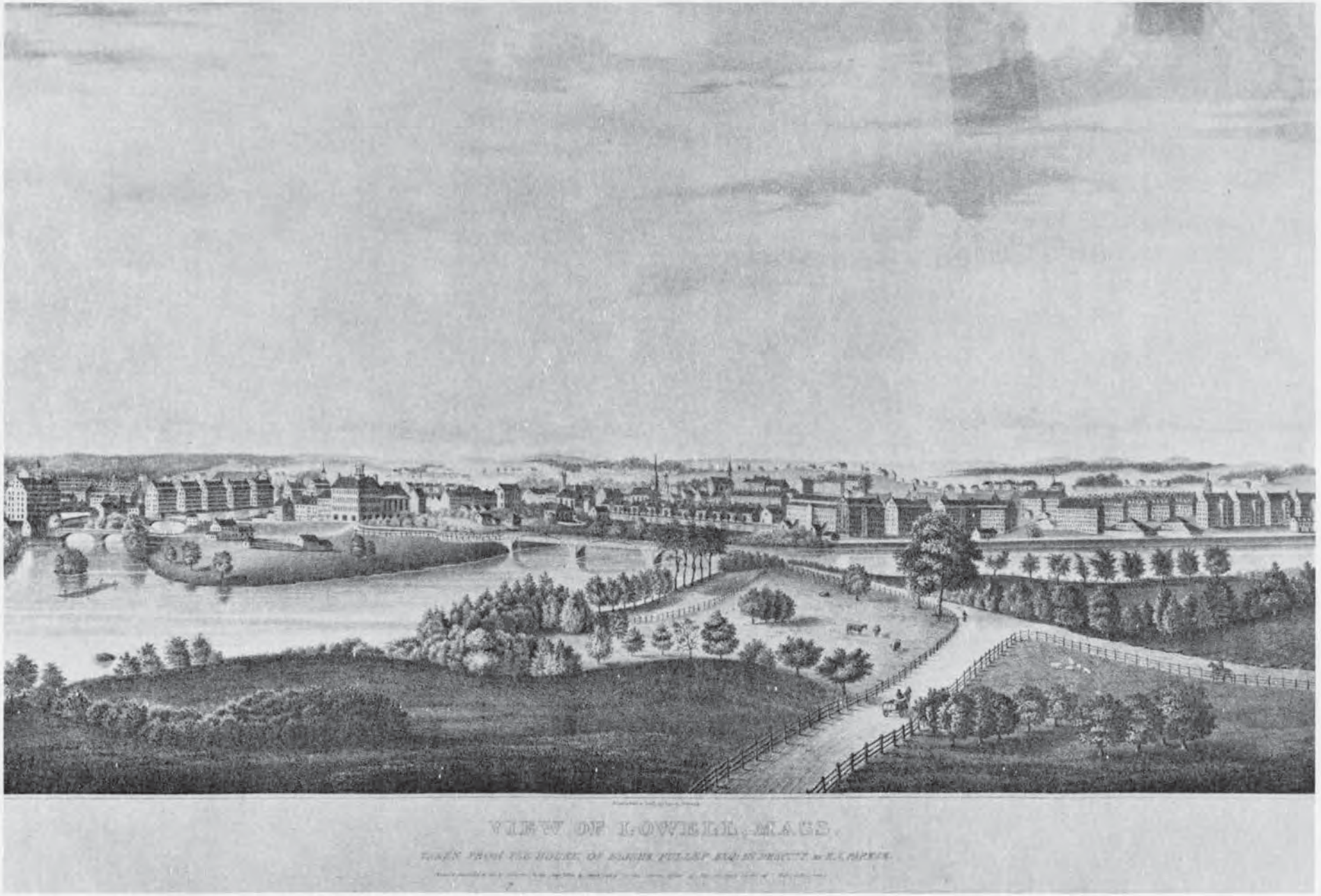

Figure 3-6 "View of Lowell, Mass. Taken from the House of Elisha Fuller, Esq: In Dracutt, by E. A. Farrar." Pendleton's Lithography, Boston, 1834.

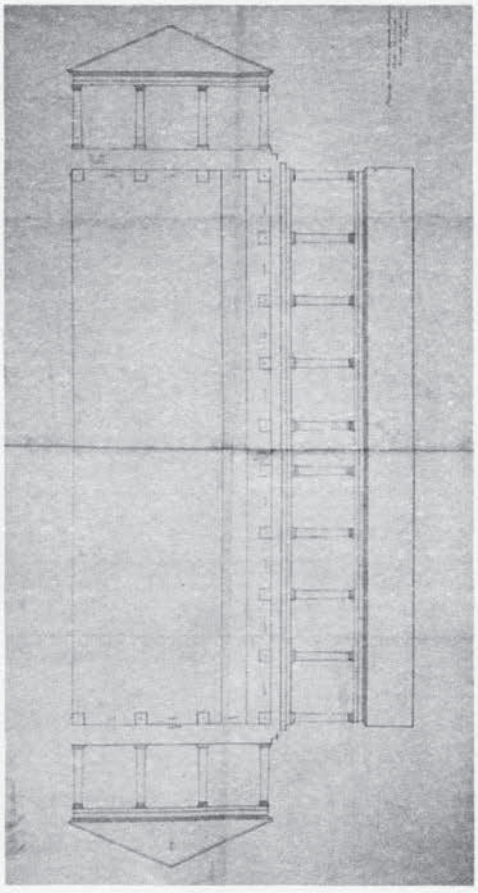

Figure 3-7 Plan and elevations for the Boston and Lowell Rail Road station, Lowell. Drawn by Philander Anderson, 1835.

road that became Central Street. By the early 1830s several hotels and substantial brick blocks graced Central Street, which was advantageously sited between the Middlesex millyard on the east and the Hamilton and Appleton Companies on the west.

Throughout the entire central area of Lowell, including both Merrimack and Central Streets, deeds to parcels bought from the Proprietors of Locks and Canals contained explicit restrictions specifying a set back for sidewalks and requiring that buildings over twelve feet tall be built of brick or stone and roofed with slate or other incombustible material. Two kinds of structures initially resulted from these restrictions--substantial brick blocks, usually three stories tall, which contained shops, offices, and living quarters; or modest, wood-frame shops, called "ten-footers" for their careful avoidance of the height restriction on wooden buildings.

The two types were not necessarily the products of different builders or different types of investors. In 1836 Tappan Wentworth, a prominent Lowell lawyer, hired Horace and Samuel Howard, a housewright and a mason, respectively, to build shops and houses on Merrimack near Kirk Street. The contracts describe a three-story brick building flanked by five or six small shops, to be built ten feet tall of "lath and plaster."

The Proprietors of Locks and Canals' ownership of most of the central area of town not only affected the form of buildings erected on lots the company sold, but also influenced broader patterns of the town's growth. The Proprietors retained large undeveloped parcels through the 1830s that were neither used for mill sites nor available for private residential or commercial construction. By the early 1830s many merchants, storekeepers, tailors, milliners, doctors, lawyers, teachers, and others had come to Lowell to serve the growing population of industrial workers. These townspeople mostly settled primarily outside the central area where most undeveloped land was still owned by the Proprietors of Locks and Canals.

Chapel Hill, the largest early non-corporate residential area, was on the southeast side of town, beyond the Central Street commercial area and the Hamilton

and Appleton millyards. The Universalist Church built in this area by 1832 gave the section its name. It was east of Chapel Hill on the Concord River that independent manufacturers such as Ames and Fisher and Whipple built their establishments, whose workers bolstered the residential growth at Chapel Hill.

Various other residential concentrations existed. Belvidere Village on the east side of the Concord River was part of Tewksbury until 1834, when it was annexed to Lowell. On the opposite side of town, the pre-1820 settlement at Falls Village saw added residential development, and a fine stone hotel was built on Pawtucket Street in 1824, called the Stone House (Figure 4-34).

Another important residential area was not well indicated on Mather's map nor on a more accurate and detailed map drawn in 1835 (Figure 3-8). Only a few houses are shown on the western side of the Western Canal, where it strikes off at a diagonal from the Swamp Locks basin. The Lowell directories of the early 1830s indicate, however, that most of the town's sizable Irish population lived in that area called the Acre. Contemporary accounts describe the housing as huts built on a tract which was kept off the market by a dispute over ownership. Apparently the huts and the social standing of their occupants were too humble to gain Mather's attention and recording. Saint Patrick's, the church of the Irish Catholic community, is indicated by Mather. This wooden church was built on land donated by Kirk Boott for the Proprietors of Locks and Canals and was dedicated in 1831.

Lowell's rapid growth in the 1820s accelerated in the 1830s. The Boott Cotton Mills were chartered in 1835 and like most of its predecessors, entered into a contract with the Proprietors of Locks and Canals to have four mills built and equipped. The Boott Mills were situated on the Merrimack River between the Merrimack Company and Bridge Street. Waterpower was supplied by the new Eastern Canal, which flowed north from the Pawtucket Canal just above the Lower Locks, paralleling the last stretch of the Concord River, then turning ninety degrees to parallel the Merrimack River. In that stretch the canal flows west while the river flows east. The Eastern Canal and the first of the Boott Mills were in operation by mid-1836.

Figure 3-8 "Plan of Lowell Village from a survey by U. A. Boyden in March 1834. Drawn for the Boston and Lowell Rail-Road Co. with additions by Philander Anderson March 1835."

The construction of Boott Mills and its accompanying boarding houses necessitated the removal of Kirk Boott's own house, which had stood alone on the large tract of land between Merrimack Street and the Merrimack River, west of Bridge Street. The house was moved to Falls Village near Pawtucket Street, and John Street was laid out north from Merrimack Street across the former houselot to the millyard. This new street and the new mill spurred the commercial development of the northern side of Merrimack Street, which had lagged behind the southern side, but most of the former grounds of Boott's house were not sold by the Proprietors of Locks and Canals until 1845.

In 1836 the town's population exceeded 17,500. A commission appointed by the town recommended that a city form of government be adopted. The Massachusetts General Court concurred and chartered Lowell as the third city in the state, following Boston and Salem.

The new city, in conjunction with the Middlesex County government, built a combined public market and courthouse on Lowell Street (renamed Market Street) which was opened in 1837. Behind the Market House was the town landing on the Pawtucket Canal where produce, lumber, bricks, and other supplies were unloaded from rafts and small boats that had made their way down the Merrimack River from New Hampshire, or that had travelled up from Boston via the Middlesex Canal.

Kirk Boott died suddenly in 1837 at age 47. As agent of the Merrimack Manufacturing and of the Proprietors of Locks and Canals he had been the most influential individual in the early planning of the town. His death came near the end of the initial period of Lowell's development, for it was in 1839 that Massachusetts Cotton Mills, the last of the large Lowell textile corporations to be initiated, received its charter. Massachusetts bought the mill site between the Boott millyard and the Concord Rivers. The Proprietors of Locks and Canals contracted to build four mills, and by 1840 the first was in production. That year the city's population had reached 21,000, a hundredfold increase in twenty years.

By the early 1840s, the mills were straining the capacity of the canal system, and the city's rapid and

uncontrolled growth was made all the more uneven by the Proprietors of Locks and Canals' retention of sizable undeveloped tracts in the heart of the city. These problems were confronted and to a degree solved in the ensuing decades, in a distinct, second phase of Lowell's development.

Historical Resources

Considering the very substantial development in Lowell since 1840, it would not be surprising if the city retained very few structures dating from the 1820s and 1830s. The twenty buildings within the Park and the District constructed in the 1820s, and forty-four built in the 1830s that still stand constitute an historical resource of the highest importance to Lowell.

Growth of all the elements of Lowell in the 1820s and 1830s is striking, but it was the mill complexes of the major textile corporations that dominated the new city and were its reason for existence. Five major complexes were built in the 1820s--Merrimack, Hamilton, Lowell Manufacturing, Appleton, and the Machine Shop--but none of their structures of that first decade remain. The rebuilt Pawtucket Canal, the Merrimack Canal, and the Hamilton Canal are the most important extant elements of the industrial infrastructure of the 1820s. The Lowell Canal, dug in 1828 to power Lowell Manufacturing's mills, has been covered over since ca. 1910, but remains in operational condition beneath the pavement.

Some of the millyards built in the 1830s--Suffolk, Lawrence, Boott, and Massachusetts Mills--contain major buildings from their original construction campaigns. Two others of that decade have been razed--the Middlesex Company and the Tremont Mills. In the Suffolk millyard only the Counting House (562 Suffolk Street) and a boarding house (199 Cabot Street, Figure 4-10) still stand from the 1830s. Both are built of brick with granite trim, have pitched roofs and very little decorative trim. The oldest mills to survive in one of the major millyards in Lowell are Mills No. 3 and No. 4 of the Lawrence company. They date to the millyard's initial development in 1833-34. They have since been joined by a connector mill, and

Figure 3-9 Mill No. 2, Boott Cotton Mills. Built 1835, top floor added ca. 1880, photographed 1979.

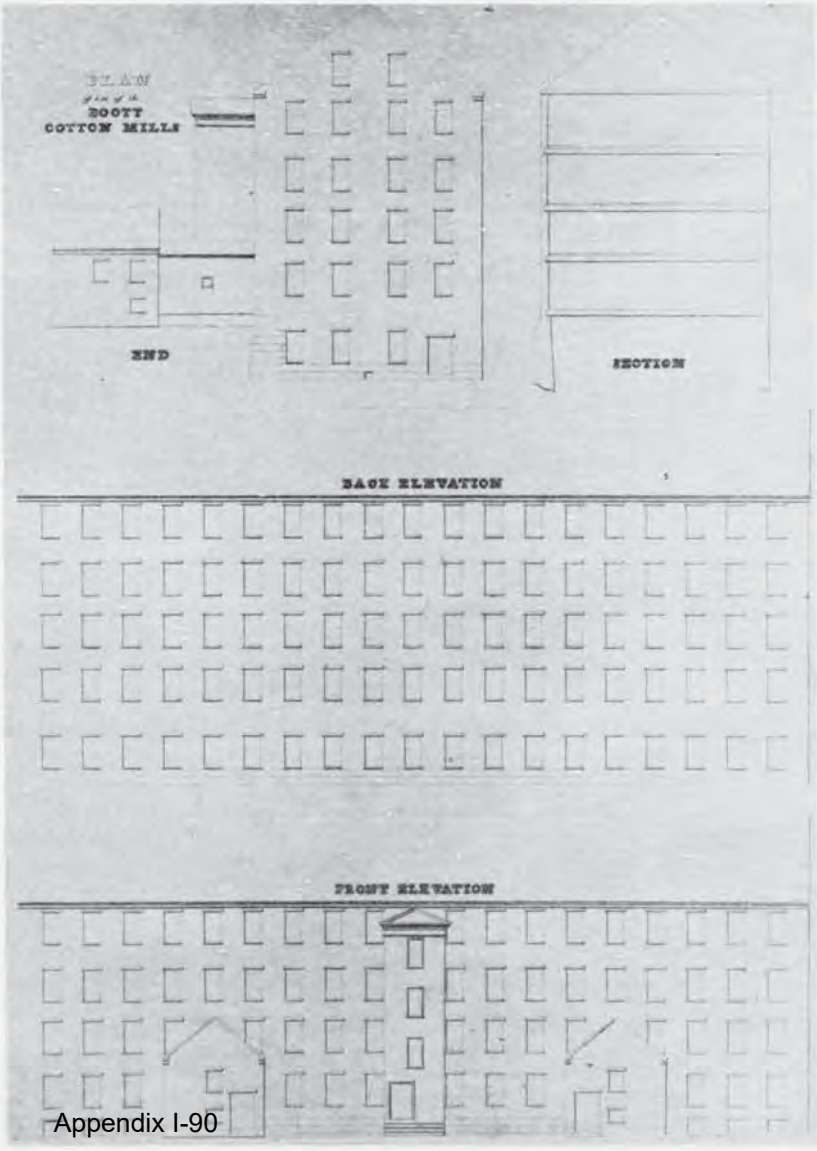

Figure 3-10 "Plan of one of the Boott Cotton Mills," 1835.

have had stories added. A portion of a cotton storehouse built ca. 1833 also survives in that millyard.

The Boott millyard retains the most complete group of initial buildings. All four original mills and the Counting House still survive. They are now joined by connector mills into two long structures, and increased one floor in height (Figure 3-9). These brick mills were originally four stories tall, 150 feet long, and 45 feet wide--typical dimensions for Lowell mills of the 1820s and 1830s (Figure 3-10). Their original end-wall gable roofs were lost when the flat-roofed upper floors were added, and central stair towers were removed after the connector mills with new stair towers were built. The four original mills in the Massachusetts millyard also survive, dating from 1839-41 (Figure 4-8). The Western Canal, its short spur, the Lawrence Canal, and the Eastern Canal all date from the 1830s as well.

The major component missing from all of the mill complexes is the corporation boarding houses and tenement rows. The pairs of boarding houses, set perpendicular to the millyards, were a crucial part of the architectural framework of Lowell's early industrial plan. Only fragments of these housing schemes survive.

The Suffolk Company retains the greatest number of relatively intact examples of corporation housing--namely two. The boarding house at 199 Cabot Street previously mentioned was fortuitously saved through conversion to industrial use when the neighboring rows were torn down. A Suffolk rowhouse at 113-131 Cabot Street was built ca. 1845-50, and is described later in this chapter. A former Massachusetts Mills boarding house is the most prominently sited of the surviving boarding houses. Built ca. 1839-40, the long brick row at 28-56 Bridge Street is commonly called the Bridge Street Boarding House. It has been converted to storefronts on the ground floor, but retains most of its paired, parapet-linked chimneys, and even some of its dormers. Adjacent on Bridge Street (#70-96) is the Surf Building, an apartment block with a commercial ground floor. At its core are two Boott boarding houses built ca. 1835, linked together and thoroughly remodeled ca. 1900. Traces of the two former boarding houses can only be seen on the back walls, but they do preserve, albeit somewhat faintly, the historic relationship of residential buildings to

the millyard. Another Boott boarding house used by H.& H. Paper Company stands west of the Surf Building, separated by a long parking lot that was the site of four more boarding houses. It too has been drastically altered, but like the Surf Building, demonstrates the original relationship of boarding house and millyard.

Four agent's or superintendent's houses of the 1821-1839 period are extant. The earliest is the wooden house at 243 Worthen Street, built about 1825 for Paul Moody, superintendent of the Machine Shop. At that time Worthen Street had not yet been laid out, and Moody's house faced Dutton Street across a large decorative, semi-circular pool. The Lawrence Company agent's house at 119-121 Hall Street is an imposing rubblestone mansion occupied by the Lowell Day Nursery. It was occupied by Lawrence or Tremont agents for nearly a century, from 1833 to 1926. The rectory of St. Jean the Baptist Church at the corner of Merrimack and Austin Streets (outside the LHPD) was built ca. 1835-40 by the Suffolk Company as its agent's house. More modest is the brick house behind St. Anne's Church, built ca. 1835 for the first agent of Boott Mills, Benjamin French. French may have had the house built with his own funds, for he continued to live there through the 1840s, after Linus Child had become Boott Mills' agent and Boott and Massachusetts Mills had built a double house for their agents on Kirk Street.

Important examples of alternative forms of company-owned housing have been found at two locations just outside the District. On either side of Wamesit Court off Dutton Street near Fletcher are three small, wood-frame cottages, one-and-a-half stories tall, linked into trios by lateral wings. Circumstantial evidence suggests that five of these cottages were built by the Lowell Manufacturing Company alongside the Lowell Canal in 1828-32 and were removed to their present site after 1850. If these cottages are former corporate housing, their idiosyncratic form in Lowell may relate to Lowell Manufacturing's recruitment of carpet workers from Medway in southern Massachusetts, where similar wooden cottages were built in the early nineteenth century as workers' housing.

Oliver Whipple's house stands at the corner of Moore and Whipple Streets near his powder works and canal (but beyond the District). It is a two-story, wood-frame Greek Revival house with a long ell at the rear, built in the 1820s. The rear ell is outlined on maps as early as 1832. There are entrances to several dwelling units along its length. It is probable that Whipple housed some of his workers there behind his own residence, in sharp contrast to the major Lowell corporations separation of different classes of workers into different types of housing.

While most of the buildings now standing along the main business streets of Merrimack and Central were constructed much later in the nineteenth century, Lowell retains excellent examples of commercial and institutional architecture from the 1821-1839 period. St. Anne's Church and rectory and the Old Town Hall are most prominent. The First Unitarian Church at 72 Merrimack Street built in 1832 as a freestanding structure, but now part of the continuous block of buildings, has bold Greek Revival cornice and pilasters.

The Bank Block of 1826 (350-376 Merrimack Street) exemplifies the basic form employed for commercial construction throughout Lowell's early years. The trabeated granite ground floor accommodating store-fronts, the two brick upper floors, the end-wall gable roof, and the long rectangular plan were typical of many early structures long since replaced. The brick building at 509 Market Street, built in 1833-34 by bricklayer Joel Davis, is a similar structure, although it has been more altered on the ground floor and is more symmetrically composed on the upper floors. Its location and date of construction link it to the establishment of the Suffolk, Tremont, and Lawrence Mills nearby.

A highly idiosyncratic building in the same general area (582 Merrimack Street) was erected in 1832 for one Doctor John B. Barnes. It stands just west of the Western Canal. It was refaced with buff-colored brick in the 1920s, but its side and rear walls show the original load-bearing, rubblestone construction and four-story height that earned the building the nickname "Barnes' Folly." One of the contracts for its construction is recorded in the Registry of Deeds.

It states that the structure was built to accommodate shops below and residences above.

The Union Block at the Corner of Central and Middlesex Streets and the Nesmith Block at the corner of John and Merrimack Streets employ the same basic elements as the Bank Block, but add a curved-corner motif favored by Lowell builders for decades thereafter (Figure 4-17). Its use may have been inspired at least in part by the city's irregular street plan, which results in numerous acute and obtuse-angled corners. The Union Block was built before 1832. Originally about twice the length that survives today, it shows a rather tentative use of the motif, responding to an oblique-angled intersection with a simple, rounded, right-angled plan. The Nesmith Block, built soon after 1835, adopts its acute-angled intersection precisely, and displays equivalent facades to both of the streets it faces (Figure 4-14).

The Central Street area retains more buildings of the 1821-39 period than Merrimack Street due to more intensive redevelopment of the latter. At least a dozen buildings of that period stand on or near Central Street within the District. The Old Market House (40 Market Street) is the most prominent among the dozen. It is similar in its simple Greek Revival styling to the original form of the Old Town Hall, and has received considerably less alteration. The Mansur Block at 101 Central Street bears the name of an early Lowell grocer and real estate developer (Figure 3-12). When built in ca. 1836, the building was twice its present length, extending to the corner of Market Street.

136 Central Street is a fragment of the American Hotel building, which was built and has been demolished in several stages. The portion now standing on Central Street owes its appearance to remodelings of ca. 1860-70, but an inn and tavern occupied the site much earlier, and may survive in fragmentary form in a small brick building dating from the 1830s which is attached to the rear of the main block.

Two other early hotels which retain more of their original appearances are located in the Tower's Corner area where Central and Gorham Streets meet. J. J. Turner's Hotel at 278 Central Street is a brick

Figure 3-11 The Coburn Row, 100-126 Appleton Street, built ca. 1832-34, photographed 1979.

Figure 3-12 The Mansur Block, 101 Central Street, built ca. 1836, photographed 1979.

structure, built ca. 1825. Mrs. Betsey Hildreth operated a private boarding house in the building in the 1820s. Later it was a hotel called the Union House, and still later, the Farragut Hotel. The porch and mansard roof are additions, but the outline of the double, parapet-linked end-wall chimneys are visible beneath modern aluminum siding.

The Lowell Hotel stands nearby on Gorham Street (#80) in part of a trio of early Lowell buildings that is unmatched anywhere in the Park and the District (Figure 4-19). The three-story hotel was constructed of brick ca. 1831, with trabeated granite storefronts. One of its early owners was Horace Howard, the housewright who helped build the store and "ten-footers" for Tappan Wentworth on Merrimack Street. Howard was occasionally listed in the city directories as a designer or architect, and he is known to have drawn the plans for the city-county Market House. He was also an early owner-occupant of the middle house in the Gorham Street trio (#72-76), which was built ca. 1832. This two-story double house is highly unusual for its early construction of ashlar granite. 62 Gorham Street is a two-story brick structure, built ca. 1830. Originally a house for a tailor (who had a shop elsewhere), it had storefronts by 1850, and perhaps earlier. All three buildings in this group have incurred some alterations, particularly to the ground floors, but they retain their original forms, and even more significantly, their original relationship to one another.

The Gorham Street trio originally marked the approximate boundary between the predominantly commercial district of upper Central Street, and the residential area south of it. Numerous Greek Revival houses from Lowell's early decades still stand south of the LHPD in the neighborhood historically called Chapel Hill and now known as Back Central Street.

There is an important early residence near this area and within the LHPD. The rowhouse at 100-126 Appleton Street was built ca. 1832-34 by Cyril Coburn (Figure 3-11). The facade is of brick with granite trim, while the sides and rear are of local rubblestone, a combination occasionally seen elsewhere in Lowell. The original eight dwelling units of the row were owned by individuals until the mid-1840s, when

the Hamilton Company bought up the row to house skilled workers and their families, demonstrating the compatibility of Lowell's private and corporation-built housing.

The narrow southward extension of the District along the Concord River includes some historical resources dating from the 1821-1839 period. Luther Lawrence built a brick-ended house in the early 1830s on Lawrence Street (#48). He was a brother of Amos and Abbott Lawrence, the textile merchants and financiers. Luther served as the second mayor of the new city of Lowell, before dying from a fall into a Middlesex Company wheelpit in 1839. Tappan Wentworth, a prominent lawyer and developer, later bought and remodeled the house, and his heirs occupied it into the twentieth century.

There are a few other houses of the 1821-1839 period further south on Lawrence Street related to the industrial development along the Concord River. The house at 202 Lawrence Street was built ca. 1840 near Richmond's paper and batting mills. It is a one-and-one-half story cottage with then stylish Greek Revival features such as a front-facing gable roof and a recessed entryway flanked by engaged Doric columns. The house at 8 Clarks Court, between Lawrence Street and the Concord River, is more old-fashiond with its end-wall gable roof and centered entry. It was built ca. 1834-37 by William Stickney, a carpenter who worked nearby at Whipple's Powder Mills. The other far-flung reach of the district that contains resources from the 1821-39 period is the northwest portion, on both banks of the Merrimack River along the Pawtucket Falls. The Old Stone House (267 Pawtucket Street) is the most imposing (Figure 4-34). The large rubblestone structure was built in 1824 as a hotel. Much more modest is the Federal-style house at 279 Pawtucket Street, a wood-frame structure built in 1827 for Jones Dow, a tailor. Across the river on Riverside Street, three brick houses of the 1820s or 1830s mark the small settlement that continued to develop on the Dracut side of the Pawtucket Bridge.

Among certain types of structures important in the initial development of Lowell, such as boarding houses, archeological resources may be of more

consequence than the few buildings that still stand. The Merrimack, Middlesex, and Tremont millyards and the Machine Shop yard, all major components of the Lowell Experiment, have been demolished. The potential these sites have for containing important below-ground archeological remains of the 1821-1839 period varies considerably. The Merrimack Company's mills were the first to be built, and were the most recently demolished. Only a portion of the millyard is within the District, however, and most of the included area has recently been redeveloped. The new Lowell High School Annex, under construction in 1979, occupies most of the Merrimack Company housing sites contained in the District. An office of the Union National Bank and three tall apartment towers have been built in recent years on the former millyard. Their parking lots may cover subsurface millyard remains, but this possibility cannot be confirmed without below-ground testing.

The Middlesex millyard, between Warren Street and the Concord River, actually predates Merrimack as an industrial site. A cotton-spinning mill was established there in 1813 and a wool-weaving mill before 1821. Several structures from the Middlesex Company's development of the millyard in the early 1830s survived until the millyard was razed in 1956. The parking lot pavement now covering the site is ridged and pitted, indicating uneven settling of fill over subsurface features of the old yard. Above-ground the retaining walls on the Warren Street side of the yard include parts of building foundations. On the other side of the millyard a heavy stone arch projects out of the ground near the Lower Locks of the Pawtucket Canal. The arch is related to Middlesex's raceway off the Pawtucket Canal. These features are indications of the survival of considerable below-ground remains on the Middlesex site. These remains probably relate not only to the 1821-1839 period, but to the whole history of development on that site, since the millyard underwent gradual, evolutionary change from the 1810s until demolition in 1956.

The Tremont millyard is even more promising than the Middlesex. The millyard has not been redeveloped since the demolition of most of its structures in the 1930s. Many foundations and cropped walls are visible throughout the yard. A one-story ruin of mill

and wheel house stands at the southern end of the millyard, containing four 1919-24 electric generating turbines in place. Like Middlesex, the Tremont millyard has remains from several periods of mill construction.

The Machine shop site appears to offer little in the way of accessible, below-ground remains of its early structures. The yard underwent intensive redevelopment throughout its productive years, sacrificing the majority of its earliest fabric to expansion until the yard was razed in the early 1930s. Much of the yard has been redeveloped, and the parking lots on the remainder do not reveal uneven settling suggestive of below-ground foundations.

Other millyards have undergone more selective demolition. Among them, the Hamilton millyard may contain below-ground remains of some interest. A print works was constructed on the eastern end of the millyard in 1830, and its structures were demolished in 1935 and 1936. Photographs taken during demolition show substantial footings and foundations still in place when the filling of the site began, which must still exist today.

The importance of company-owned boarding houses to the comprehensive planning of Lowell and the paucity of surviving examples enhances the significance of any archeological remains of these structures. There are numerous boarding house sites that have not been redeveloped. Robert Schuyler's excavation in 1977 of Merrimack Company boarding houses, now the site of the new High School annex, adds to knowledge of the daily lives of Lowell mill operatives. Four Boott Mills boarding houses were demolished in the 1930s and their sites are used as paved parking lots. The site of the parking lot east of Elliot Street and south of Jackson contained Hamilton Company boarding houses until ca. 1930, and has not been redeveloped. Lawrence Company boarding houses stood on the block bounded by Hall, Perkins, Suffolk, and Cabot Streets, and most of that area is now paved and used for parking.

Elsewhere in the District, some secondary industrial sites potentially contain significant 1821-39 remains, though redevelopment affected many of these sites. The Belvidere Woolen Company millyard opposite the

Middlesex Company site across the Concord River was largely razed in the 1930s, except for one last Company storehouse at the foot of Chestnut Street, which was recently removed. Many of Belvidere's buildings still standing in the early twentieth century dated from the 1850s, but the industrial use of the site and some of its structures dated to development in the 1820s and 1830s. A parking lot now covers the site, and it is uncertain how extensive below-ground features might be.

The site of Richmond's paper and batting mill, established in 1836, has been cleared of buildings except for a ca. 1850 storehouse and a ca. 1870 mill. On the rest of the site, the grade has been changed through the addition of fill, beneath which there could be remains of the earlier millyard.

Whipple's Powder Mills were active throughout the 1821-1839 period. The area was extensively redeveloped in the later nineteenth century, leaving a single rubblestone building of the old powder works, and probably little potential for the survival of other 1821-39 material, even below the ground.

The unfolding of the "Lowell Experiment" from 1821 to 1839 was and is still viewed as a period of astonishingly rapid growth and achievement. The streets and canals built in that period determined the urban form framework of central Lowell. While most of the early buildings are gone, several mills, a few agent's and boarding houses, and many commercial and institutional buildings are still in use within the Park and District. Over the next twenty-five years, the city grew substantially within the industrial city plan already established.

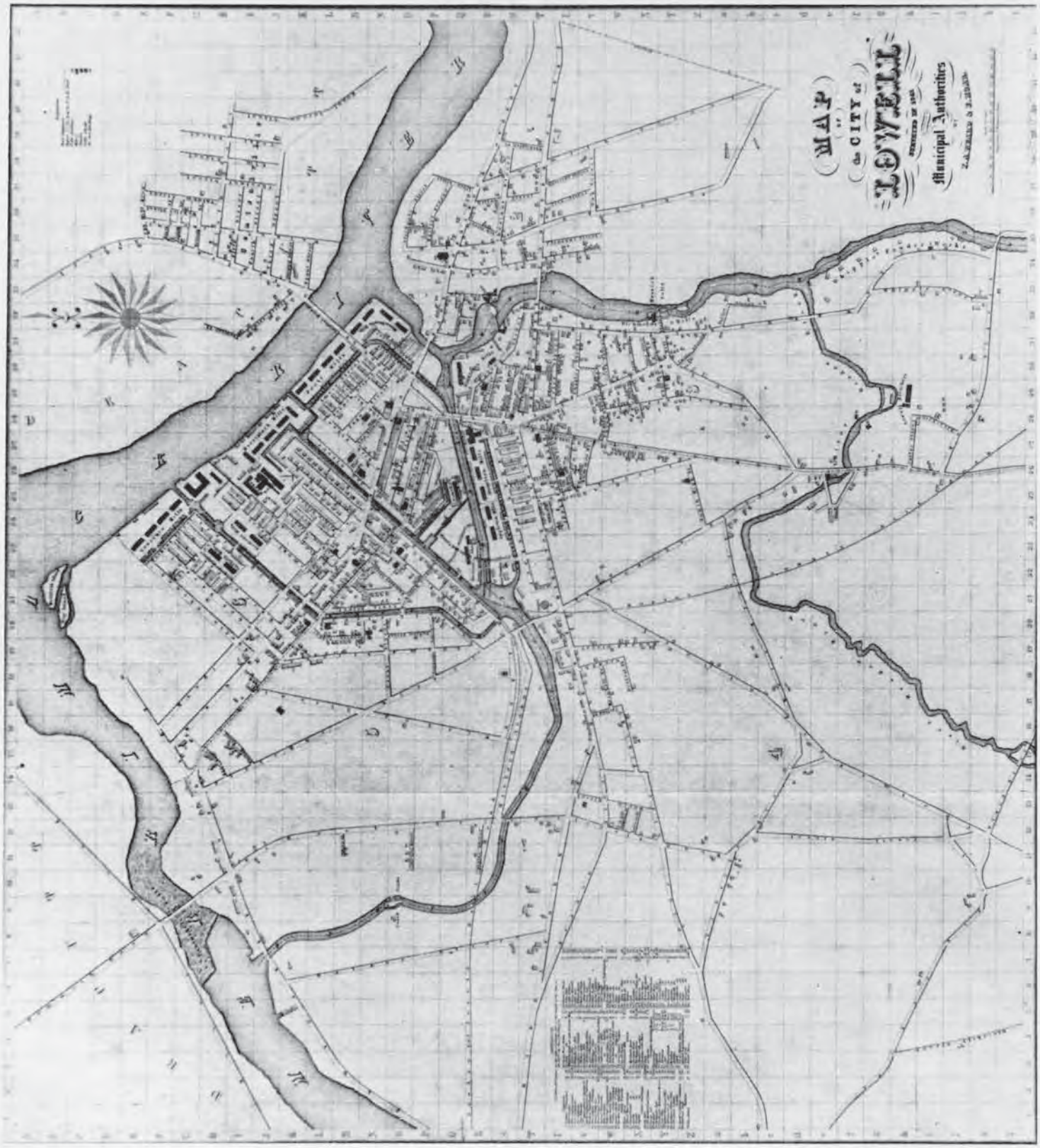

Figure 3-13 "Map of the City of Lowell" in 1841, by Beard and Hoar.

THE EXPERIMENT EXPANDS: 1840-1865

History

The severe economic depression that struck the United States in 1839 checked but did not halt the rapid growth of Lowell and the Lowell textile corporations. The population of nearly 21,000 in 1840 exceeded 33,000 in 1850 and neared 37,000 in 1860. The slowed growth in the 1850s reflected the national economic troubles of the mid-'50s. The spindles turning in the city more than doubled between 1843 and 1868, from about 200,000 to over 450,000.

Massachusetts Cotton Mills, chartered in 1839, proceeded with the construction of its mills despite the 1839 depression, pressing the first one into production by 1840. The depression years were even profitable at Lowell Manufacturing Company, where an ingenious employee named Erastus Bigelow succeeded in developing the first power loom for carpets between 1839 and 1842. Of broader importance to the future development of the city were the studies of the power canal system commissioned by the directors of the Proprietors of Locks and Canals. In 1839 James F. Baldwin carried out an assessment of the system, and in 1840 James B. Francis, the British-born chief engineer of the Proprietors of Locks and Canals, repeated the study and concurred with Baldwin's conclusions. As Locks and Canals had hoped, Baldwin and Francis proved that the various corporations were drawing considerably more water than allocated under the terms of their mill power contracts. On the basis of this evidence, the Proprietors of Locks and Canals renegotiated the agreements with the corporations, increasing the number of mill powers for which rents were paid from about sixty-five to nearly ninety.

Both Baldwin and Francis reported that the system was operating at its maximum capacity. They found that the canals were carrying so much water that it created turbulence which depleted available power. In the dry months, several of the companies, especially Lawrence, Suffolk and Tremont Mills on the Western Canal, were not receiving the water they needed. The engineers' major recommendation was that another canal be built to supplement the Pawtucket Canal and that water rights upriver be bought. The new canal's course would run parallel to the Pawtucket Falls before turning inland. It would be a costly project,

and it was not until the mid-1840s that the decision was made to dig the canal.

The final sale of a mill site on the Lowell canal system was made before the Northern Canal was begun. In 1844, the Prescott Manufacturing Company was chartered and it purchased a lot between the Eastern Canal and the Concord River south of the Massachusetts millyard (Figure 3-13). From the start, the investors in the Prescott Company overlapped with shareholders of the Massachusetts Mills, and in 1847 Massachusetts bought out Prescott.

In 1844 Uriah Boyden, James Francis' assistant at Locks and Canals, installed and tested an experimental turbine in an Appleton Company mill. Francis witnessed the tests, and was convinced of the superiority of the turbine over the breast wheels used by all of the Lowell mills. Turbines produce more useable power with a given amount of water than breast wheels, and occupy far less space. Turbines are also less subject to variable water conditions than wheels. Francis' endorsement caused most, if not all, new mills built in Lowell after that time to be powered with turbines and the gradual conversion of existing mills. Boott Mills, for example, installed turbines in the massive mill it built in 1847-49, and by 1859 had replaced all the breast wheels in its earlier mills (Figure 3-14).

It was the corporations' eagerness to expand that spurred both the plans for the new canal and the concern with making the most efficient use of the available water power. In 1845 the Lawrence Company began construction on a new mill over 250 feet long, the Merrimack Company was building a mammoth new mill, and the Hamilton Company started work on a mill over 300 feet long. The standard length of the Lowell mills of the 1820s and 1830s was 150 feet. In the Suffolk, Tremont, Hamilton, and Appleton millyards, mills were constructed which linked pairs of existing structures, an action made feasible in part by advances in fireproofing technology. The connector mills were generally more richly detailed than the mills they linked, and were designed to appear as central pavilions of long, freestanding mills.

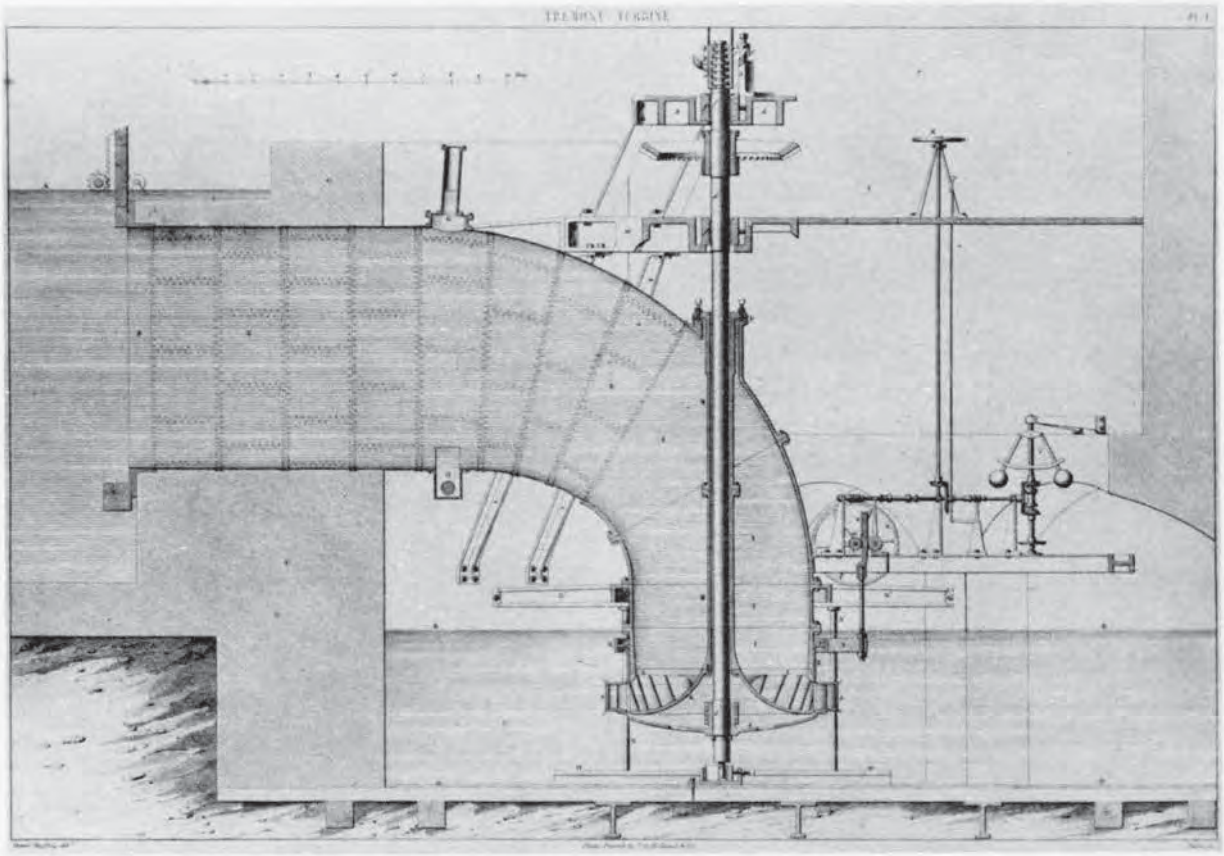

Figure 3-14 "Tremont Turbine." Plate I in James B. Francis' Lowell Hydraulic Experiments, 1855.

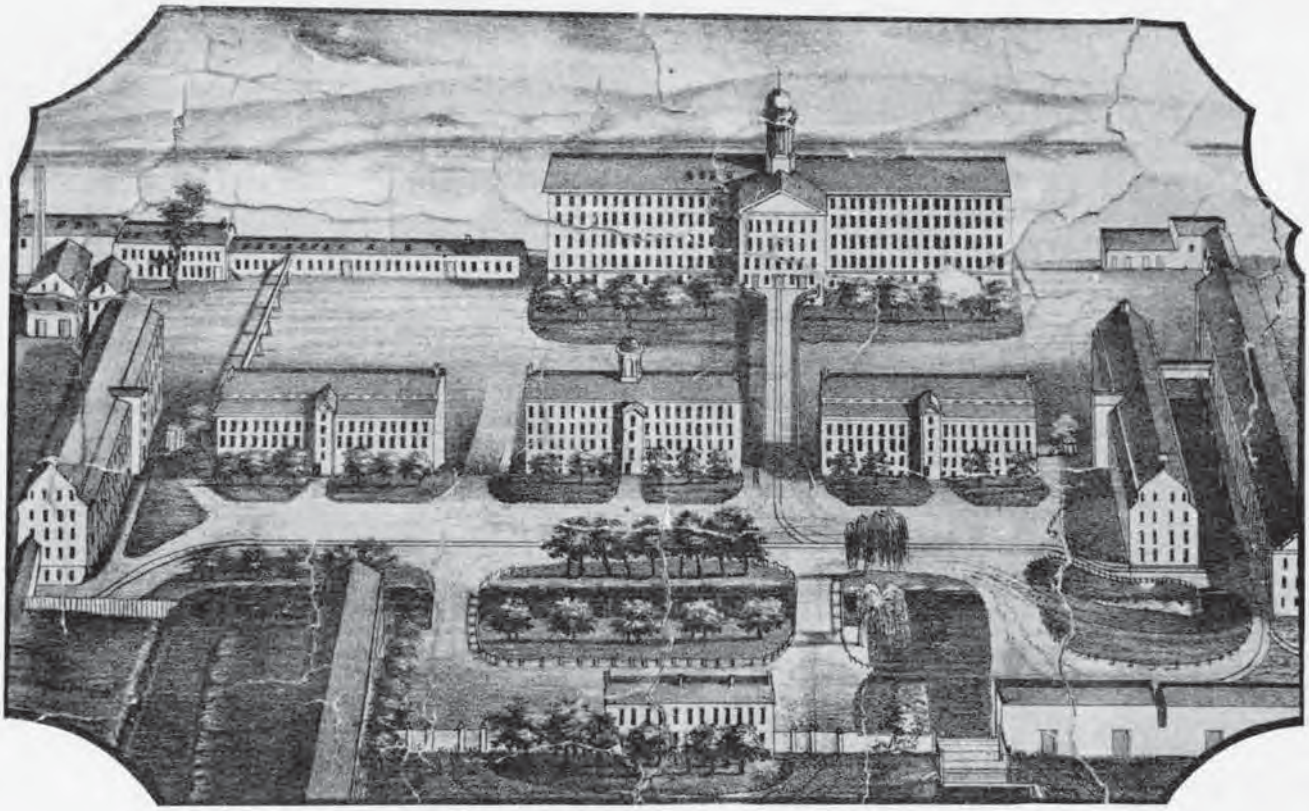

Figure 3-15 Millyard of Merrimack Manufacturing Company, 1850. From "Plan of the City of Lowell" by Sidney and Neff.

Figure 3-16 Boott Mills, 1850. From "Plan of the City of Lowell" by Sidney and Neff.

In 1845, the Proprietors of Locks and Canals initiated the Northern Canal construction. They capitalized the project by selling at auction the many undeveloped parcels of land they still owned throughout central Lowell, and also sold the Machine Shop to a new corporation, chartered as the Lowell Machine Shop. Nearly $500,000 were raised by these sales, approximately the amount spent to build the Northern Canal.

Agents for the Proprietors of Locks and Canals acquired lands and water rights in New Hampshire in 1845. The purpose of these acquisitions, and of the various dam building and channel development projects that followed, was to augment the flow of the Merrimack River in the dry summer months by using New Hampshire lakes as reservoirs.

After the Proprietors of Locks and Canals sold the Machine Shop and the undeveloped real estate, the corporation itself was purchased from its former shareholders by the textile companies for $600,000. It was reorganized into a service corporation whose sole function was to maintain and operate the canal system for the various companies. The Proprietors of Locks and Canals on Merrimack River's time as "The Shop that Built a City" was over. In this modified form, it began the construction of the Northern Canal in 1846, under the direction of J. B. Francis. Within two years, a channel 4,374 feet long, 100 feet wide, and 20 feet deep was built (Figure 3-17). Much of the canal had to be cut through bedrock, while the portion along the Pawtucket Falls was carried behind a high wall footed on ledge that was submerged beneath the river when the project began.

The building of the Northern Canal was the most dramatic engineering feat in the industrialization of Lowell. The course of the canal parallels the Merrimack River along the Falls, then turns inland just above the river's bend and runs southeast to meet the Western Canal. The Northern Canal supplied water power to the Suffolk, Tremont and Lawrence millyards, all formerly served by the Western Canal. The Northern Canal's waters reversed the direction of the flow of the western Canal at their junction, turning the older canal into a feeder back to the Swamp Locks basin. Under Moody Street a tunnel was constructed in 1847 connecting the Western to the Merrimack Canal, supplying additional water from the Northern

to the Merrimack Company's millyard. A smaller underground tunnel was built in 1848-49 connecting the Merrimack and Eastern Canals, to increase the water at the end of the latter canal where maintaining adequate water levels had previously been difficult.

Francis carefully evaluated the flow of water through the revamped system and on the basis of his findings the Locks and Canals Company was able to increase the number of mill powers sold to the corporations (for which an annual maintenance fee was received) from ninety-seven to one hundred thirty-six. Additional water was available for a set fee during the months when the Merrimack River ran high.

In the course of his study of the reworked canal system, Francis discovered what he felt was a considerable threat to the city. The construction of the new Northern Canal and its gatehouse, and a simultaneous widening of the abutments of the Pawtucket Bridge partially obstructed the flow of the Merrimack River over the Pawtucket Falls. Francis determined that in the event of flooding, these new obstructions would divert a destructive torrent down the Pawtucket Canal and into the center of the city. Between 1848 and 1850 he directed a complete rebuilding of the upper Guard Locks including a massive wooden guard gate that could be dropped against a flood. His calculations were questioned and the guard gate was derided as "Francis' Folly" until 1852, when the gate held back flood waters that exceeded any in living memory.

The increased water power gained by the construction of the Northern Canal was eagerly put to use by the mills. The Prescott Company built a weaving mill and a spinning mill in 1846, each over two hundred feet long. The Middlesex Company built a new mill in 1846 enabling it to double its production by 1849. Boott Mills began construction of No. 5 Mill in 1847 which stretched five hundred feet along the riverbank. No. 5 Mill was powered by turbines from the time of its completion in 1849, increasing the millyard's capacity by sixty percent. A new weaving mill and other buildings were erected by Lowell Manufacturing in 1848, to utilize the new Bigelow power loom for carpets.

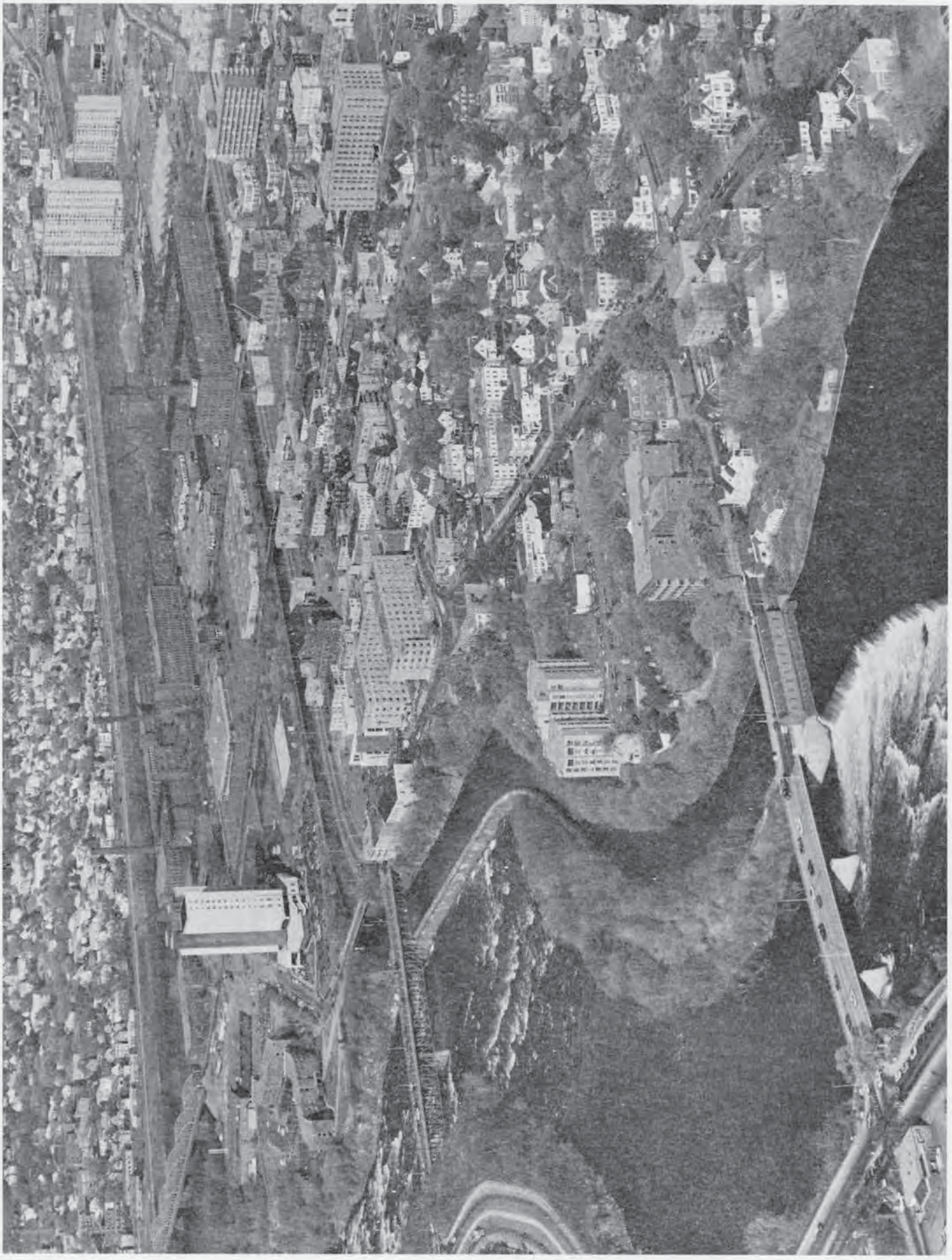

Figure 3-17 Aerial view of the Northern Canal, 1979.

Massachusetts Mills built a "Union Mill" in 1851 that linked two of its four original mills, and the Lawrence Company built a pair of connecting mills in 1854 and 1855. These connecting mills were all decidedly Greek Revival in style, each crowned by a gable roof treated as a broad pediment. Massachusetts Mills broke new stylistic ground in 1862 when its second connecting mill was built in the Italianate style, with segmental hoods over the windows and octagonal stair towers (Figure 4-8).

Corporation housing reflected the dramatic increase in scale as well. In the mid-1840s, the Merrimack Company replaced six of its wood-frame, two-and-one-half story double houses with one massive brick "New Block" three-and-one-half stories in height (Figure 3-39).

Reflecting the growth of the textile mills, the newly-independent Lowell Machine Shop underwent a major expansion in the late 1840s. Among its new products were steam boilers, which supplemented and eventually supplanted water power as Lowell's main source of motive power.

The major corporations and the canal system were not the only aspects of the city which grew substantially in the 1840-1865 period. In 1846, the same year "Whipple's Best Powder" was blasting out bedrock along the course of the Northern Canal, Oliver Whipple was rebuilding and lengthening his own canal on the Concord River. In its new form the canal generated about 500 horsepower. Rather than undertaking a major expansion of his own powder works, Whipple opted to rent mills along his canal to a variety of manufacturing enterprises and to sell water power to his tenants. A bolt factory, a print shop, carpet manufacturers, bobbin makers, dye houses, and others quickly established themselves in "Whipple's Mills." Whipple sold his powder works in 1855 to a bolt factory, but the thriving industrial community along the canal continued even after his active involvement ceased.

A new mill was built in 1854 by Belvidere Woolen Manufacturing Company on the east side of the river opposite the Middlesex millyard. Belvidere Woolen was incorporated only a year before, but its millyard had been the site of small mills since the 1810s. The new three-story brick mill measured only fifty-one feet by ninety feet.

The city's pattern of rapid population growth continued through the 1840s. The 1840 population of 21,000 swelled to 33,000 by 1850, exerting great pressure on Lowell's housing supply. When the Locks and Canals Company auctioned its real estate in 1845, the lots were snatched up immediately and almost as quickly built upon, mostly with houses for the burgeoning population. The area between Merrimack Street and the Boott Mills boarding houses, nearly vacant in 1841 (Figure 3-13), was solidly built by 1850 with churches, schools and houses, most of brick or stone. The city bought two sizable parcels northwest and south of the city center, designating them the North Common and South Common respectively. Housing rapidly surrounded them, along with a forbidding new jail and a courthouse building at the South Common.

A health report written by a Lowell doctor named Josiah Curtis in 1849 describes seriously overcrowded living conditions in the central area of Lowell. Curtis makes mention of both the Acre neighborhood and the Middle Street area as especially congested and unhealthful. Lowell's foreign-born inhabitants, a group constituting roughly one-third of the population by the mid-1860s, suffered from particularly poor living conditions.

Most of Lowell's early immigrants were Irish who continued to reside in the Acre around St. Patrick's Church. Much of that area had been unavailable for purchase before the 1840s, forcing the Irish to squat there in crude shelters. The Locks and Canals Company land sale of 1845 and a resolution of a decades-old dispute over land ownership finally put the Acre's house lots on the market. More substantial housing was quickly built, though overcrowding apparently remained a problem. The Irish community's increasing numbers as much as increasing wealth per capita may explain its ability to replace the wooden St. Patrick's Church of 1831 with a massive stone church begun in 1854.

Figure 3-18 "View of Merrimack Street, Lowell, Mass." in 1856.

Figure 3-19 View from the east along Merrimack Street, 1979.

The city's commercial districts along Merrimack and Central Streets followed the general trend toward larger buildings (Figures 3-18 and 3-19). Both of those streets were considerably built up before 1840, but after that date the redevelopment of lots began. In 1846, Boston investors built a new commercial block on the corner of Kirk and Merrimack Streets, replacing a brick structure previously on the site. The curved-corner Welles Block (175 Merrimack Street) resembles the commercial buildings of the 1830s in materials and general form, but differs from them in scale. The three stories of the Welles Block stand considerably taller, for instance, than the three-story Nesmith Block, built ca. 1836.

The Nesmith Building constructed ca. 1844 on John Street next to the corner Nesmith Block represented a bolder departure in both scale and style (Figure 4-14). Its taller three stories tower over the three of the corner block, and the building is Italianate in style rather than the familiar Federal/Greek Revival style. Perhaps for the first time on a Lowell commercial building, Italianate corner quoins, bracketed cornice, round-headed windows, and segmental-arched storefronts replaced the severe detailing, flat stone lintels, and trabeated granite ground floors of Lowell's earlier commercial buildings.

This shift in scale and in style is clearly illustrated by the first two "manufacturing laboratories" James C. Ayer built to house his prospering patent medicine business. The first, built in 1852 on Jackson Street (#28), was a brick structure of three stories, with an end-wall gable roof and flat granite lintels and sills above a trabeated granite ground floor. Ayer's business was growing so fast that by 1858-59 he built a new headquarters on Market Street across from the millyard of Lowell Manufacturing (#165, Figure 3-22). That building stands in marked contrast to the Jackson Street structure in scale, with its greater length and four-story height, and in style, with its Italianate cornice and flat roof, cast-iron storefronts, and segmental-arched windows with decorated brickwork caps. Those caps in particular were a hallmark of Lowell buildings, particularly industrial buildings, for decades.

Lowell annexed Centralville in 1851, prompting public purchase of the Central Bridge in the mid-1850s. The former Dracut neighborhood continued to be predominantly residential.

The city government was growing as well, and in 1853 a joint effort of the city government and the Boston and Lowell Railroad replaced the outgrown, original train depot at Dutton and Merrimack Streets with a much larger station. It was commonly called Huntington Hall, after one of the two public meeting halls it housed along with space for city government offices and the train station. It spanned the block between Dutton and Shattuck Streets, at Merrimack Street.

The city's and the corporations' growth slowed in the mid-1850s, when the Depression of 1857 disrupted the economic life of the whole country. In the decade between 1845 and 1855, the number of spindles operating in the Lowell mills had doubled from 200,000 to 400,00. In the next ten years, a relatively modest 50,000 spindles were added in the city. The effects of the mid-fifties downturn were also reflected in the 1860 census, which counted 36,000 Lowell residents. That number represented an increase of ten percent over 1850, compared to population growth of nearly fifty percent during the 1840s.

Lowell's population actually dropped between 1860 and 1865, falling to 31,000. The drafting or enlistment of young men into the army was one cause. Two Lowell soldiers, Luther C. Ladd and Addison O. Whitney, were the first casualties of the Civil War when they were killed in Baltimore in April, 1861. Another cause of Lowell's decline in population was that most of the Lowell textile corporations severely curtailed production or shut down entirely during the Civil War, once they ran out of their basic raw material, cotton from the American South. Ten thousand operatives were reportedly dismissed. Some of the corporations attempted at considerable expense to convert from cotton to woolen production, but these attempts were generally costly failures, at least in the short run.

Figure 3-20 View from the southeast in the Boott millyard, ca. 1870.

Several of the corporations used the war years to carry out major rebuilding campaigns in their millyards, demonstrating the corporations' pre-war profitability and their confidence in post-war recovery. As mentioned, Massachusetts Mills built a second connecting mill in 1862. Boott Mills closed down three times for rebuilding and improvements between 1861 and 1863. New construction in that millyard included connecting mills with new stair towers between both of its pairs of original mills, and a large new Cotton House (Figure 3-20). Upper floors were also added to a number of Boott buildings, including No. 5 Mill. Appleton added a fourth mill to its millyard in 1861. Both Suffolk and Tremont Mills took down their original mills in 1862, and rebuilt long new mills in their places.

Woolen mills flourished during the Civil War because of the continued availability of wool and the wartime need for woolen products such as blankets and cloth for uniforms. The Middlesex Company, the only major Lowell corporation originally to specialize in woolen goods, had collapsed financially in 1858 due to mismanagement and the Depression of 1857. Reorganized and recapitalized, largely by the drug manufacturer J. C. Ayer and Benjamin Butler, a Civil War general, the Middlesex Company built a large new mill and other buildings in 1862.

Belvidere Woolen found its site opposite Middlesex too constricted for expansion, and in 1862 erected a whole new complex further upstream on Whipple's Canal. Within the next two years, three new enterprises built woolen mills along Whipple's Canal. Charles Stott, Belvidere Woolen's agent, owned one of the companies, while the others belonged to Alfred Chase and L. W. Faulkner.

Another expression of confidence in the city's future was the chartering of the Lowell Horse Railroad Company in 1863. It inaugurated service in 1864 on four miles of tracks through the city streets, laid at an investment of nearly $70,000.

The post-war years fulfilled the expectations of a return to growth and productivity, and in the ensuing decades much of the historic fabric of present-day Lowell was built. The 1840-1865 period is also

well represented in the modern city, however, as described below.

Historical Resources

The Park and the District include seventy-eight structures built in the 1840s and forty-five built in the 1850s, reflecting the effect on construction of the Depression of 1857. Only twenty-seven buildings of the 1860s were inventoried, but these include many major industrial buildings.

The foundation of Lowell's continued expansion in the 1840-1865 period was improvements in the canal system, and the greatest of those, the Northern Canal of 1846-47, is the premier historical resource surviving from that period in Lowell. Its Gatehouse and Great River Wall are particularly handsome utilitarian constructions (Figures 3-17 and 4-33). The Francis Gate complex on the upper Pawtucket Canal is not an engineering masterpiece on the order of the Northern Canal, but the careful observation of the interaction of natural and man-made factors that prompted James B. Francis to build the Guard Gate exemplifies the foresight and the scientific methodology brought to his work on the canal system. The Moody Street Feeder, and its controlling Merrimack Gatehouse, both built in 1848, typify the increased complexity and efficiency of the revamped canal system.

The canal started by Oliver Whipple in the 1820s and expanded in 1845 is the District's most intact water power feature outside the main canal system. The present form of that canal, which runs north beside the Concord River and then turns ninety degrees west to parallel Hale's Brook emptying into that stream, is largely a product of the 1840s. Most of it is within the LHPD, but a portion near Hale's Brook is not.

Most of the structures built by the major corporations between 1840 and 1865 have been lost due to millyard redevelopment or to twentieth century demolition, but several typical examples do survive. Hamilton's Mill #4 of 1846 most clearly represents the new long mills first built in the 1840s. A top floor with segmental-arched windows was added in the 1880s, but the rest of the floors display granite sills and lintels. Unlike the rectangular lintels used in preceding decades,

these are slightly peaked. They also project forward from the wall plane, and rest on projecting granite blocks. All of these modifications are Greek Revival in flavor, and they contribute to a livelier wall surface than seen on mills of the 1820s and 1830s.

In the Boott millyard, the No. 5 Mill of 1847-49 still extends most of the combined length of the four original mills. Several of the alterations to that mill, including modification of its central pavilion and addition of an upper floor, probably were made during the Civil War. Conspicuous Civil War-era additions in the Boott millyard are the connecting mills between the pairs of original mills, and the wooden stair towers which flank those connector mills. One of those four towers has been removed, and the other three have lost their capping balustrades, but the clock and belfry atop the tower flanking No. 2 Mill remain a major landmark in the city. (Compare Figures 3-20 and 4-7.)

At the Lawrence millyard one of the two connecting mills (Mill No. 7) built in the mid-1850s still survives. Its Greek Revival detailing like that of the Massachusetts Mills' 1851 "Union Mill" (Mill No. 5), provides an interesting contrast to the other Massachusetts connecting mill (No. 6), built in 1862 with Italianate detailing. The Boott connecting mills of the early 1860s are rather Greek Revival in their heavy use of granite, but have decidedly Italianate stair towers.

The single Merrimack Company building that still stands dates from ca. 1860. The Yorick Restaurant on Dutton Street at (#91) Merrimack Street was built to house Merrimack Company employees. It originally contained three tenements or apartments and probably accommodated executives or overseers and their families.

The 1840-1865 period was one in which private and small corporate industrial enterprises grew in number and size. Structures representing a cross-section of these still stand in the LHPD. Some of these factories produced supplies used by Lowell's textile giants. One of these was D. C. Brown's handsome rubblestone Reed Factory that still stands on Church Street (#242) at the corner of Warren Street. It was built in

three stages between 1840 and 1853, for the manufacture of reeds, heddles, harnesses, and other power loom parts and accessories.

James C. Ayer's patent medicine business was unrelated to the textile corporations, unlike Ayer himself, who published criticisms of corporate mismanagement and made substantial investments in Middlesex and other corporations. All three of the buildings constructed for his business still stand, including the two already discussed which date to the 1850s. Twenty-eight Jackson Street of 1852 was subsequently raised a fourth story, and 165 Market Street of 1857, was lengthened by a few bays in the early 1860s (Figure 3-22).

The introduction of gas lighting was an event of considerable importance to mid-nineteenth century Lowell. Replacing smoky whale oil lamps, gas light improved health conditions in the poorly ventilated mills. The gas illumination of the city streets in 1850 was a source of civic pride. The gasworks on School Street north of the Pawtucket Canal were constructed in 1849. One of the two striking stone and brick buildings in that yard dates to ca. 1865. The headquarters of the Lowell Gas Light Company at 22 Shattuck Street, built in 1859, is a late example of Lowell's favorite rounded-corner form (Figure 3-21), updated through an increased use of decorative brickwork and decreased reliance on stone trim. The windows are segmental-arched with brickwork hoods, and the building is topped with an arched, corbelled cornice.

Only one of the Civil War-era woolen mills on Whipple's Canal still survives, Mill No. 2 (645 Lawrence Street) of the Belvidere Woolen Company (Figures 4-26 and 4-27). Built of brick in 1862, Mill No. 2 is conservative in its use of rectangular granite lintels. Except for the major loss of the mill's unusual gambrel-with-double-clerestory roof, which was replaced when an additional story was added in the 1880s,this modest-sized establishment is remarkably intact. The storehouse, mill, stair tower, and power house all still stand. The LHPD boundary extends through this complex, excluding the mill itself while including the others.

Figure 3-21 Lowell Gas Light Company, 22 Shattuck Street, offices of the Lowell Historic Preservation District Commission. Built 1859, photographed 1979.

Figure 3-22 J. C. Ayer & Co. Building, 165 Market Street, built ca. 1858, photographed 1979.

The number of commercial and institutional structures still extant within the LHPD from the 1840-1865 period is surprisingly small, though several of these structures are noteworthy. The reasons for this paucity are unclear, although the Depression of 1857 and the Civil War must be factors. In addition, the 1845 Locks and Canals Company land auction was more a spur to residential development than commercial, since few of the parcels were located on the main commercial streets.

The Wentworth Block, built ca. 1844, faces the intersection of Merrimack (#256) and Shattuck Streets with a curved corner. Its mansard roof was probably added following an 1865 fire. Down Shattuck Street from that building, The Lowell Institution for Savings Building of 1845 (18 Shattuck Street) was substantially altered in the early twentieth century and again recently, but it retains its Greek Revival cast-iron balcony and basic, twin curved-corner form. The Welles Block of 1846, has also been somewhat altered in the early twentieth century and recently, but its sweeping curved corner remains the boldest in Lowell.

The Nesmith Building presents dual facades on Merrimack (#65) and John (#25-35) Streets. The L-shaped plan cradles the corner Nesmith Block (Figure 4-4). The John Street side was built first in ca. 1844, and may have introduced Italianate motifs to Lowell commercial architecture. At least one of its original storefront arches survives, and more may exist beneath later coverings. The Merrimack Street portion, built about ten years later and linked behind the corner block to the John Street building, has lost half of its originally symmetrical facade, and the first and second floors have been substantially altered as well.

Two other commercial buildings of the 1840s are relatively reserved in their handlings of corner sites. Simpson's Block, now called the Kearney Square Building (1-5 Merrimack Street), occupies the short block between Paige and Merrimack Streets on Bridge Street. Built ca. 1847, its unadorned brick walls trace the angles of the intersections. Its most striking features are the rubblestone rear walls. One hundred two Central Street is a similar structure of about the same date. Called Martin's Building, it is brick

throughout. Its greatest asset is its site alongside the Pawtucket Canal, though a low storefront now bridging the canal hides this relationship.

The District includes a pair of schools and a pair of churches from the 1840s and 1850s. The Worthen Street Methodist Episcopal Chuch at 200 Worthen Street is now the Lowell Girls' Club. The church has been considerably altered since its 1842 construction but retains the basic form and some of the detailing typical of Lowell's wood-frame, Greek Revival churches. The west end of the Shrine of St. Joseph the Worker at 37 Lee Street was built in 1850 as the Lee Street Church, a Gothic Revival edifice in rubblestone with granite trim.

The little brick building at 138-140 Middlesex Street is the Elliot School of 1845, now nearly hidden by siding and wings (Figures 4-22 and 4-23). The Colburn School at 122 Lawrence Street is much more visible. Its simple, Greek Revival form is typical of Lowell public buildings of the 1830s and 1840s. Built in 1846, the Colburn is the oldest school in Lowell still serving its original function.

Among the houses in the LHPD built between 1840 and 1865, the ones located in the areas sold in the 1845 Locks and Canals Company land auction can be discussed as a distinct group. Before the sale, streets such as Worthen Street north of Broadway (then called Mechanics Street) and Middle Street were developed with individually owned houses. Two hundred eighty-four Worthen Street was built ca. 1840 for Erastus Douglass, a bobbin maker in the Locks and Canals Company sawmill and bobbin factory near the Machine Shop. A double house of brick with granite trim, it was owned and occupied by Machine Shop employees throughout the nineteenth century. At 222-224 Worthen Street next to the Methodist Episcopal Church there is another double house built of wood ca. 1850. With its broad facade gable and classical ornament around the entry, it is a residential version of its ecclesiastical Greek Revival neighbor.

Middle Street was another area that was built up with houses in the 1830s and 1840s, but a subsequent redevelopment in the 1880s and 1890s replaced almost all of them. The exception is a three-story brick

building at 194 Middle Street. Built ca. 1844 and owned by Charles Hovey, an apothecary with a shop in City Hall, it probably originally was rented as residences, though it was occupied by stores and small manufacturers' shops.

The land sale of 1845 touched off very rapid residential development in several areas. Both sides of Kirk Street from Merrimack Street to French Street were quickly built up, and on the east side several houses survive in various states of preservation. The most important and intact is the double house built in 1846 by the Boott and Massachusetts Mills to accommodate their agents. That site was actually purchased for those corporations shortly before the general auction. Designed by local architect James H. Rand, the house follows the long-established pattern favored for Lowell corporation-owned residences, consisting of the end-wall gable form with twin parapet-linked chimneys and rectangular stone sills and lintels. In this case, the status of the occupants was acknowledged by the generous proportions, the use of newly popular brownstone rather than granite, and such details as the broad stone enframements of the entries.

South of the Agents' House on Kirk Street are two more brick blocks built after the 1845 sale and before 1850. Forty-five to forty-nine Kirk Street consists of three dwelling units, rather than two, but adopts the same general form as the Agents' House of end-wall gable roof, twin, linked chimneys, and two-story height. Twenty-one to twenty-nine Kirk Street, a far more damaged row, contained six dwellings. Only the northernmost two remain in residential use with the rest of the row serving as storage space for a nearby department store. Originally the northernmost three units were three stories tall and flat roofed, and the southerly trio were two-and-a-half stories tall with an end-wall gable roof. Nearby on Paige Street (#29-31), two units of a row built soon after the land sale exemplify a modest version of brick houses of that time.

Away from the central Kirk-John Streets area, most of the land sale houses which remain are more modest wooden structures, though the double house at 39-41 Moody, built before 1850, is a substantial

brick structure. More typical is the story-and-a-half wood-frame house at 44 Race Street, built soon after 1845, and a double two-story house at 120 Cabot Street, also built of wood at about the same time. Both are Greek Revival in their facade gable form, and they bear vestiges of ornament characteristic of that style. The Race Street house is one of a trio of similar cottages, the remainder of which stands just outside the LHPD boundaries.

As mentioned, the land sale was only one spur to development in the Acre. Settlement of the long-standing legal dispute over the ownership of the area made numerous lots available for purchase and improvement. Some houses along Suffolk and Adams Street (Figure 4-13) remain from the development that followed. On Marion Street, just north of Broadway Street, a story-and-one-half Greek-Revival cottage faces a low shed across a granite-paved driveway. That house, the shed, which was cut down from a similar cottage, and the paving are all that visibly survive of Donohoe's Court which was built ca. 1847-1852. It contained fifteen dwelling units in four buildings. The extant remnants symbolize the achievement of the Irish immigrants as they worked their way out of the terrible conditions of the early Acre.

One of the potentially most significant archeological resource within the LHPD from the 1840-1865 period is the site of Donohoe's Court in the Acre. Above-ground only half of one of four buildings and the cut-off remnant of another still stand. However, the other structures were removed only in recent years, and none of the site has been redeveloped. The building of the Court in the late 1840s and early 1850s perhaps eradicated any remains of earlier huts which might have stood on the site, but recovering domestic remains of even mid-nineteenth century vintage would add to our knowledge of the daily life of Lowell's Irish settlers. Such information could be compared with Robert Schuyler's findings on boarding house sites.

Other potential archeological sites dating to the 1840-1865 period are more difficult to assess. The Belvidere Woolen Manufacturing site on the east bank of the Concord included a mill built in the 1850s which was demolished in the twentieth century, but

as mentioned in the discussion on the preceding period, the degree and condition of remains on the Belvidere Woolen site are uncertain. The pitted parking lot over the former Middlesex millyard is a clearer indication of potential subsurface remains which must include the footings of the No. 2 Mill built there in 1862. The Prescott millyard was primarily a product of 1840s development, but the conspicuous fragment of a building which forms the retaining wall on the Concord River side of that site is a remnant of the 1911 Power House. Other remains of that yard may survive beneath the parking lot pavement.

On Whipple's Canal the sites of the Civil War-era woolen mills were redeveloped in the 1880s. The American Bolt Company bought one of Whipple's powder mill buildings and converted it for its own use. The building still stands, but American Bolt's additions are in ruins. The site may contain remains of early powder production as well as early bolt manufactury.

Figure 3-23 Detail of "Birds Eye View of Lowell" in 1876, by Bailey and Hazen.

THE INDUSTRIAL CITY MATURES: 1866-1893

History

The Lowell cotton mills were quick to resume full production following the Civil War, and the city began again the kind of rapid growth that characterized its early decades. After the wartime low of 31,000, the population reached nearly 41,000 by 1870. The next decade brought the largest increase recorded for any ten years before or after, a jump of almost 19,000 to nearly 60,000. Growth in the 1880s was also substantial, with over 77,000 residents recorded in the city in 1890.

Some of the increases in population were tied to the substantial annexations of this period. Three annexations in 1874 more than doubled the city's acreage. Two hundred acres of Belvidere were annexed from Tewksbury. Chelmsford gave up over 1,000 acres at the west side of Lowell, including Middlesex Village at the head of the defunct Middlesex Canal. The largest annexation added over 2,000 acres that had been in Dracut, including both Pawtucketville and more of Centralville. Another section of Belvidere was annexed to Lowell in 1888.

While this pattern of rapid growth is familiar in Lowell's history, there were three important changes taking place in the post-war city. First, the work force of the mills was changing from a group mainly composed of young women from New England, who worked in Lowell to earn cash wages for a few years, to a permanent operative class made up largely of immigrants. These immigrants had no nearby families and farms to which they could return in times of layoffs and wage cuts. The Irish first came to Lowell in relatively small numbers in the 1820s to work as laborers. Refugees of the potato famine swelled the ranks of the Irish in Lowell in subsequent decades, and by the 1840s there were Irish women working as operatives in the mills. The Yankee operatives remained in the majority until the Civil War. However, by 1863 two thirds of the births in Lowell were described as "of foreign origin" reflecting both the size of the immigrant community (perhaps as large as one-third of the population) and the large component of unmarried women workers in Lowell's native-born population.

Writing in 1856 the Lowell chronicler Charles Cowley stated that a great virtue of the city was that it had no permanent operative class, that..."a majority of our operatives were not born as such, and do not die as such." When he wrote again of Lowell in 1868, Cowley already recognized "...that our operative population has become less migratory." Cowley was observing that many of the workers employed in the mills after the Civil War were French-Canadians, replacing Yankee operatives who went home when the mills shut down or reduced production during the war and did not return.

The French Canadian community was large enough by 1868 to purchase its own church, the former Lee Street Church off Kirk Street. The church was renamed St. Joseph's, and French-speaking Oblate Fathers made up the staff. Most of the French Canadians lived in a single, crowded district called "Little Canada," located north and west of the Lawrence millyard, within the great bend in the Merrimack River.

A second evolutionary change in the city's previous pattern of development was the wide adoption of steam power by the major corporations to supplement water power. A steam engine had been tried unsuccessfully in the Prescott millyard in the late 1840s, and steam power was successfully used at Lowell Manufacturing by 1848. After the war, steam was the power source that allowed the mills to continue to grow, and by 1885 steam engines supplied more horsepower to Lowell manufacturers than did water power.

The third key difference between the pre-war and post-war city was that, while the major textile corporations remained the dominant economic resource of the city through the nineteenth century, other industries, commercial interests and political forces came into their own, beginning with the incorporation of Benjamin F. Butler's Wamesit Power Company in 1865 and culminating in the dedication of the new City Hall in 1894.

If Kirk Boott was the most conspicuous figure in Lowell's initial development and James B. Francis the guiding spirit behind its continued growth in the 1840s and 1850s, Benjamin F. Butler symbolized post-Civil War Lowell. Son of a boarding house

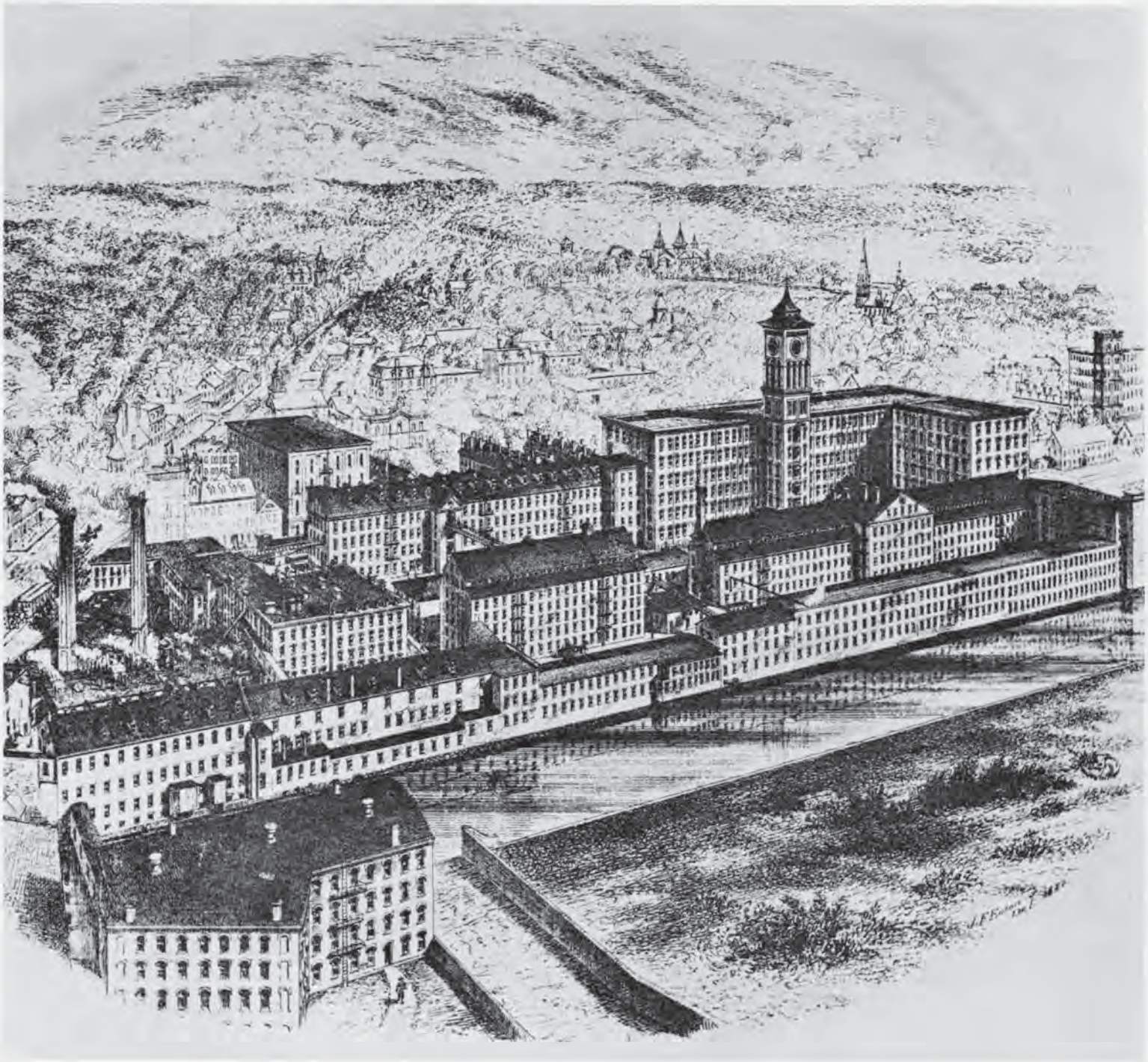

Figure 3-24 Hamilton Manufacturing Company, 1882.

keeper, he was a lawyer, militia officer turned Civil War general, major political figure in state, and occasionally, national politics, and a wealthy industrialist. Much of his success came through support of the labor force in their struggles with the established textile corporations. In 1865 Butler bought Whipple's Canal and most of the mill sites along it for the Wamesit Power Company. He participated in the chartering of the company, which could develop and sell steam and water power and lease mill sites as well as engage in manufacturing. A new surge of development began around the renamed Wamesit Canal. Butler owned major interests in at least two of the new factories, U. S. Cartridge Company and U. S. Bunting Company. His political connections brought in government customers for ammunition and flags and assured both enterprises of success.

The Hamilton Company led the way in post-war construction among the major corporations by erecting two large storehouses ca. 1868. The one between Jackson Street and the Hamilton Canal is 473 feet long, and features segmental-arched windows with Italianate brickwork hoods or caps, a motif followed throughout Lowell for most of the rest of the century (Figure 3-26). The other new storehouse was a ten-story brick pile on the south side of Jackson Street (Figure 3-24). Soon after, most of the millyards followed the Hamilton Company with major construction programs. New buildings or major alterations were started virtually every year between 1869 and 1884 in the Lawrence millyard. A four story, Italianate-style mill was built in 1870, probably as a knitting mill. The woolen products that had been a fiasco for the Lawrence Company and several other Lowell yards when attempted as mid-war conversions became a mainstay of Lawrence's production soon after the war. In the Lawrence millyard, as in all the others, new top floors were added to enlarge and update older mills. Octagonal stairtowers were also added, a striking feature of many Lowell millyards.

At Boott Mills, a large new mill was built in 1871, and another later in the decade. Boott had at least one steam engine by 1873, probably to help power the new mill. Massachusetts Mills made additions in the early 1870s that increased the spindles in that yard by nearly sixty percent between 1870 and 1876 and

almost doubled the 1870 figure by 1883. Steam power played a major role in that yard by the 1870s. At Lowell Manufacturing, a new Brussells Dye and Dry House was built in 1870.

The Suffolk Company and the Tremont Mills emerged from the war years in feeble condition. In 1871 controlling interests in both were purchased by Frederick and James Ayer. They combined the two yards administratively into one, and embarked on major building campaigns under the name of the Tremont and Suffolk Company.

Appleton joined in the general expansion with its large New Mill of 1873 built across Jackson Street from its main millyard (Figure 3-25). Steam engines freed this mill not only from the main yard, but also from the power island between the Hamilton and Pawtucket Canals. Applied on a grander scale this flexibility of location allowed by steam power helped wipe out the Lowell textile industry. As availability of waterpower declined in importance as a factor in the location of mills, other factors such as nearness to raw material, fuel and cheap labor became paramount, putting Lowell at a competitive disadvantage.

The 1872 depression briefly slowed construction throughout most of the city. However, the Lowell Machine Shop yard underwent a major expansion trying to keep abreast with orders for new machinery from mills retooling during the slowdown in production. Some other industrial construction went on in the 1870s, but most major projects were not underway until the 1880s. A major spur to development in several of the millyards in the 1880s was a joint project undertaken in 1882 by the city and several of the corporations to define the channel of the Merrimack. One of the results was that the riverside millyards were able to fill their portions of the riverbank, gaining new space for expansion. The Lawrence, Boott, Massachusetts, and Merrimack Companies all made additions on filled land in the 1880s or early 1890s. Several of the buildings Lawrence constructed in the 1880s had a peculiarly old-fashioned appearance because they used rectangular granite lintels, a feature popular in the first half of the century.

Figure 3-25 Appleton Company's "New Mill" on Jackson Street, built 1873, photographed 1979.

Figure 3-26 Hamilton Manufacturing Company's storehouse on Jackson Street, built ca. 1868, photographed 1979.

As the millyards were filling up, demolition preceded construction in several cases. In 1881 the Machine Shop took down its original Building #1 of the 1820s, and put a much larger new structure in its place. In 1882 the Machine Shop foundry rebuilt and enlarged. In the Lowell Manufacturing yard a Brussels Weave Mill was built in 1882 on a site where company-owned housing had stood. That company's elimination of housing for its operatives preceded the general trend in that direction by only about a decade. The Hamilton Company, which had even earlier eliminated a boarding house for a storehouse site, still had some underutilized space within its millyard, and built there a large new mill in 1881-1882. Its six-story height and even taller clock tower dominated one end of the millyard.

The smaller mills also rebuilt and expanded in the 1880s. Stirling Mills on the Wamesit Canal took down its ca. 1860-65 mill in 1880 and built a new and larger structure (Figures 4-24 and 4-25). A fire destroyed the neighboring Chase and Faulkner Mills in 1880. Faulkner rebuilt in 1881, and expanded onto the Chase site in 1887.

In 1885, a national census of industries indicated that steam engines were producing more horsepower for Lowell's mills than was water power by a margin of about 13,000 to 11,000. A single corporation, Lowell Manufacturing, had steam engines capable of producing 1,550 horsepower in 1882. Despite the cost of fuel and equipment, the availability of power in such quantity was irresistible to the expanding millyards.

While the millyards were erecting Italianate buildings by leaps and bounds, Lowell's commercial districts were also putting on a new face. The earliest among the post-war commercial buildings closely resembled the simple Italianate industrial structures, slightly enriched with the addition of bracketed cornices. The Richardson Block at 295 Dutton Street, built in 1870, and the similar Robbins Building at 102-110 Merrimack Street of about the same date (now Prince's Books and Office Supplies) illustrate the type. Greenwood Brothers Store at 573 Lawrence Street, built in 1872, explores more ornate possibilities with its mansard roof, cast iron storefronts and especially

its window trim, cornice decoration, and signboards of cast concrete.

Neither Lowell merchants nor the city fathers were content for long to build in their generally restrained pre-war manner or to merely hint at the decorative possibilities of the current architecural styles. When a large new schoolhouse was needed in 1870, George Meacham, a Boston architect, was employed to produce a Second Empire design. The Green School (408 Merrimack Street) was constructed in brick with bold granite trim. A bank building constructed at the corner of John and Merrimack Streets ca. 1870 was even more ornate than the Green School (Figure 3-27). Constructed of marble of various colors in the High Victorian Gothic style, it was called the Marble Bank.

Another building that led the way for Lowell's merchants was the Masonic Temple built in the center of the Merrimack Street business district (#134) in 1871 (at left in Figures 3-28 and 3-29). Hocum Hosford, a successful dry goods merchant, sponsored the building, which contained stores, Masonic meeting halls, and the City Library. Boston architect Nathaniel J. Bradlee designed the Second Empire style building (Figure 3-30), which was constructed with a granite facade and cast iron storefronts. Earlier Lowell buildings had used those materials, but never in such a richly decorative fashion.

The 1872 Depression slowed commercial construction, just as it did industrial. Several major new buildings within the Central and Merrimack Streets commercial areas marked the economic recovery of the mid and late-1870s. Central Street entered into its period of greatest prominence with the construction, in rapid succession, of a new train station for the Boston and Maine Railroad, built in 1876 (#238-254), the Fiske Building, erected ca. 1877 with elaborate cast iron decoration (#219), and the Appleton Block, a large High Victorian Gothic structure, built in 1879 (#166). All appear to be architect-designed, but none of the architects are known. Otis Merrill, a carpenter-turned-architect who later achieved local prominence with his design for the new City Hall, took an office in the new Fiske Building and may have been its architect.

Figure 3-27 "Marble Bank" at the corner of Merrimack and John Streets, built ca. 1870. From an undated stereograph.

Figure 3-28 View from the east along Merrimack Street, ca. 1884.

Figure 3-29 View along Merrimack Street, 1979.

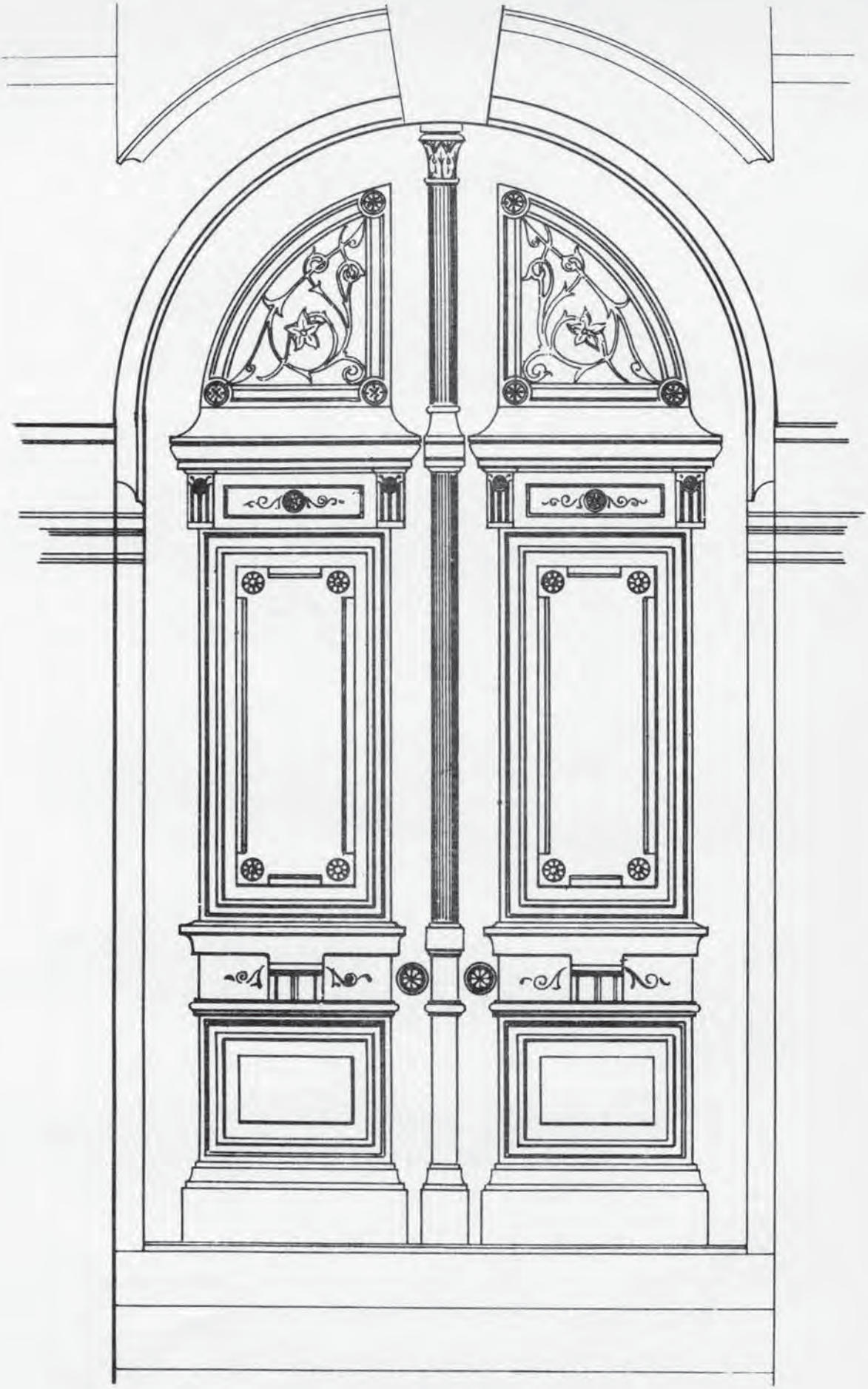

Figure 3-30 Detail for the doorway of the Masonic Temple (Hosford Building), drawn by Nathaniel J. Bradlee, 1871.

At the critical intersection of Merrimack and Central Streets, the brick, stone, and cast iron Wyman's Exchange was erected ca. 1880 to a four-story height (and raised to six stories ca. 1907-09). It replaced the original Wyman's Exchange, a daring building of ca. 1832 that used granite piers and lintels to achieve such open walls and large windows that local residents doubted its stability.

The 1880s and early 1890s brought more major new commercial structures than can be recounted. As in the millyards, earlier structures were sacrificed to clear sites, and in several cases boarding houses were demolished and their lots redeveloped with stores and offices.

The largest and most prominent of the commercial buildings of the 1880s is the Hildreth Building, constructed between 1882 and 1884 according to plans by Howe and Van Brunt, a prominent architectural firm from Boston. The Hildreth Building had a surface rich with brickwork and stone and metal ornament. It was the epitome of Queen Anne-style commercial architecture in the city. Most of the new construction of the 1880s and 1890s followed this stylistic lead, though on simpler buildings brickwork alone often provided all the decorative effects.

The Central Block, designed by Lowell architects Merrill and Cutler and built in 1881 between Market and Middle Streets on Central, was similar to Hildreth in scale and general style. The Bon Marché Building at 143 Merrimack Street built about a decade later in 1892 in a more restrained version of the same style.

Two areas that were almost wholly redeveloped with Queen Anne commercial buildings in the late 1880s and early 1890s were the northwest side of Dutton Street from Market to Broadway and all of Middle Street. Along Dutton Street many of the three and four-story structures were and are free-standing or semi-detached. On Middle Street, a fire in 1888 that destroyed the old firehouse gave impetus to the redevelopment. The Central Engine House was rebuilt in 1889 following a Romanesque Revival design by Merrill and Cutler. The handsome building itself, the protection it afforded, and the new street, Palmer, cut through to provide access from the firehouse to Merrimack and Market

Streets all encouraged the rapid redevelopment of Middle Street. Commercial and light industrial structures were built, arranged in two nearly solid rows of four and five-story structures, varying in the details of their fenestration and decoration but highly compatible in overall effect (Figure 4-5).

Most of Lowell's residential development in the 1865-1893 period occurred in the areas annexed in 1874 and 1888, entirely outside the LHPD. The Acre was the site of some new construction during this period, particularly along Broadway, which was extended west from Suffolk Street in the mid-1860s. The wood frame houses built shortly thereafter are either late Greek Revival or Second Empire in style, and each was designed to provide a number of dwelling units (Figure 3-31).

Another residential area within the LHPD that received quite a different kind of residential construction in this period was Pawtucket Street. There were houses along that road before Lowell was founded. In the 1870s and 1880s the scenic views of the river and the prevailing westerly wind, which blew the smoke of the mills away from this area, brought a new wave of house building to Pawtucket Street. West of School Street relatively modest frame houses for middle class occupants were built, while east of that line large houses and even mansions prevailed. Most pretentious of all was the Ayer Mansion, built in 1870 of brick and stone for Frederick Ayer from the designs of a Boston architect named Woodcock who had designed the Ladd and Whitney memorial obelisk on Monument Square. Smaller but still sizable wooden houses were built east of the Ayer Mansion along Pawtucket Street, such as #295 (Figure 3-33).

The growth of the city in area and population fostered plans for a larger city hall, both to accommodate the growing government and to provide an appropriate symbol of the prosperous city Lowell had become. In the late 1880s committees were formed, competitions were held, and eventually a design by the local firm of Merrill and Cutler was selected.

As the monumental Romanesque Revival structure was completed and dedicated in 1893, another severe depression disrupted the economic life of the city

and the country. In the years following that depression, the number and diversity of immigrants to Lowell greatly increased, and a new period in the city's history began.

Historical Resources

The structures built or substantially altered in the 1865-1893 period survive in such numbers within the LHPD that they establish the principal historical character of the area. Both earlier and later structures stand out as exceptions within this context of a late-nineteenth century city. There are ninety-three buildings dating from the 1870s in the LHPD, seventy-eight from the 1880s, and over one hundred built in the 1890s.

All of the standing millyards retain major structures from this period. Almost all the mills surviving in those yards from earlier periods were capped with upper floors and flat roofs between 1866 and 1893. The long Hamilton Company storehouse on Jackson Street, built ca. 1868, is an excellent example of the scale of post-Civil War industrial buildings, (Figure 3-26), and the attached Counting House translates the same motifs into a more human scale. Across Jackson Street and slightly to the west, the Appleton Company's "New Mill" of 1873 typifies the flexibility steam engines brought to the siting of mills (Figure 3-25). It also demonstrates the mill builders' tendency to concentrate decoration on the stair towers and the cornice.

Most of the Suffolk millyard, aside from the early Counting House and the surviving boarding house, dates from the 1860s, 1870s, and 1880s. The exterior face of the Lawrence millyard along Perkins Street is largely of 1870-1890 vintage, including the faintly High Victorian Gothic Counting House. Within the Lawrence millyard, most of the focal points such as the stair towers, octagonal chimneys and top floors date from the 1870s and 1880s. Most of the Lawrence buildings surviving from this period, and most in the other millyards as well, are simply decorated with brickwork hoods over the segmental-arched windows. Lawrence built several buildings in the 1880s in the pre-1850s manner with rectangular granite lintels, and the 1882 Warper Building (#16) and the 1883 Yarn Dyeing Building (#17)

are survivors from this anachronistic group.

Most of the exterior faces of the Boott millyard date from the 1870s and 1880s, and within the yard the four original mills and their connecting mills were all topped with Italinanate upper floors, ca. 1880. Boott's wooden stair towers and belfry date from just before this period, but the octagonal stair towers and chimney date from the '70s and '80s, as do Mills No. 6, 7 and 9, No. 1 Cotton Storehouse, and other structures and additions in the millyard. The Massachusetts Mills' yard is almost as indebted to that period as Boott, although that yard also contains some major structures built in the subsequent period.

The Lowell Manufacturing millyard contains several structures from the 1866-93 period and some major structures from the subsequent period, but no structures earlier than 1865. The Brussels Weave Mill of 1882, a long structure with one narrow end toward Dutton Street, is the most prominent of the Lowell Manufacturing buildings of this period (Figure 4-15).

Aside from the major millyards, several other industrial buildings and complexes of the 1865-93 period still stand in the LHPD. The Stirling Mills (also called Sterling) off Lawrence Street on the Wamesit Canal is an intact woolen mill complex, consisting of a mill, office wing, carbonizing building positioned over Hale's Brook, and storehouse. The major building, the mill, dates from 1880; the others range from a decade earlier to a decade later.

Two of Lowell's smaller mills of the early 1890s, the John Pilling Shoe Company at 33 Shaffer Street and the Whittier Cotton Mills at 50 Stackpole Street have new leases on life as residences for elderly people. The Pilling Mill has been rehabilitated and is occupied as the Francis Gatehouse Mill, while construction work continues on the Whittier Mills.

In many cases, structures within Lowell commercial districts that appear to be strictly commercial structures and are now used as such were built for light manufacturing purposes. A brick building at

50-56 Middlesex Street, decorated with a variation of Lowell's standard Italianate trim, was built ca. 1870 as the Hills Brothers Carriage Manufactury. The third of the Ayer patent medicine company buildings, built ca. 1886, stands at 176-190 Middle Street (Figure 4-5). Many of the Middle Street buildings originally combined light manufacturing and wholesale activities.

Commercial and institutional buildings of the 1866-1893 period dominate Merrimack, Central and adjacent streets. The Old Post Office at the corner of Gorham and Appleton Streets and the New City Hall with its companion Memorial Library on Merrimack Street stand at opposite ends of the commercial district within the LHPD, bracketing this area. All three are built of granite in a Richardsonian Romanesque style; all were completed in 1893. Between these somewhat homogenous bracketing buildings the structures of the post-Civil War years demonstrate the rich variety of styles and materials that characterized the period. The following discussion can mention only a fraction of those buildings.

Opposite the Memorial Library are the Green School (408 Merrimack Street) and First Congregational Church (#400), the former built in 1870 (and shorn of its high mansard roof following a fire in the 1960s), and the latter constructed in 1885. Both use red brick as their basic material, both are rather richly trimmed with contrasting stone, but the school makes use of granite and is Second Empire in style, while the church employs brownstone in the High Victorian Gothic style.

The Bon Marché Building of 1892 (143 Merrimack Street) and the Lowell High School nearby on Kirk Street (#30), the older, southern part of which was also built in 1892, introduce yellow brick to Lowell construction. The department store displays an eclectic mix of decorative motifs in a style best described as commercial Queen Anne, while the High School, appropriately enough, is a much more academic design based upon Classical and Renaissance motifs. The Masonic Temple/Hosford Building like the Green School, lost its mansard roof following a twentiety-century fire.

The Wyman's Exchange at the corner of Merrimack and Central (#9) Streets, built ca. 1880 in red brick with cast iron and light stone trim in a High Victorian Gothic style, must have dominated that intersection when first constructed. However, very soon thereafter that building lost its pre-eminence to the Hildreth Building, built on the opposite side of Merrimack Street (#45) between 1882 and 1884. Even though most of the rich carving of its brownstone trim has since spalled away, the Hildreth Building still dominates lower Merrimack Street with its great length and varied Queen Anne decoration. Two additional floors were added to Wyman's Exchange ca. 1907-09, perhaps in an attempt to re-establish the building's lost domination of the corner.

The foot of Merrimack Street at Kearney Square is anchored by the Runels (now Fairburn) Building (2-14 Kearney Square) and the Howe Building (#11), both products of the early 1890s. Prescott Street extends only a block from that intersection to Central. At its Central Street end are two four-story brick buildings that combine features of Italianate and Queen Anne styles. Called the Southwick (#66-82) and the Claflin (#58) Blocks, they were built ca. 1880. Both retain their original facade features to an unusual degree, including iron storefronts.

Along Central Street the major structures of the 1866-1893 period are McQuade's at #91 (originally the New Mansur Building, ca. 1885), the Appleton Block at #166 (1879), the Fiske Building at #219 (ca. 1877) and its neighbor Gray Furniture (originally Cook and Taylor's Building, 1884), the Rialto at #238-254 (formerly the Boston and Maine Railroad Station, 1876), and the Shedd Block at #295 (ca. 1883-1884). All are red brick buildings with trim of stone or cast iron. The 1870s structures represent variations on the exuberent High Victorian Gothic style, and all have lost cresting and pinnacles from their rooflines. The Boston and Maine Railroad, in fact, has lost two mansardic towers. The Central Street buildings of the 1880s employ brownstone trim and decorative brickwork in a Queen Anne manner.

Extending off Central Street Middlesex Street retains a number of brick commercial or commercial/residential buildings from the 1870s and 1880s. Middle

Figure 3-31
Michael Rourke Building, 174-180 Broadway Street, built ca. 1870-75, photographed 1979.

Figure 3-32
L. McFarlin House, 681 Broadway Street, built ca. 1870-75, photographed 1979.

Figure 3-33
Rogers House, 295 Pawtucket Street, built ca. 1873, photographed 1979.

Street consists almost exclusively of structures built between 1886 and 1893. Queen Anne features such as varied window size, shape and placement and decorative brickwork characterize both streets' buildings. An exception to the rule on Middle Street, in terms of both style and original function, is the Central Engine House at the corner of Palmer Street, which was built in 1889 in the Romanesque Revival style.

Elsewhere in the LHPD any list of characteristic 1866-1893 commercial and institutional structures should include the 1872 Greenwood Brothers Store at 573 Lawrence Street. Another is the Kirk Street School at 31 Kirk Street, built in 1881-1882, which provides a sharp contrast to the LHPD's other nineteenth century primary schools, the Green School on Merrimack Street and the Colburn School on Lawrence Street. The City Stables on Broadway at Fletcher was built in 1877 from plans by Otis Merrill, who a few years later prepared considerably grander designs for the new City Hall.

While the city as a whole abounds in residences built within the 1865-1893 span, the LHPD contains only a small sample. The main concentrations of these are in the Acre neighborhood, particularly along Broadway Street, and on Pawtucket Street. 174-180 Broadway Street, a multiple-family frame building in the Second Empire style, is typical of Acre houses built in the 1870s (Figure 3-31). Further out Broadway in the Francis Gate area #673, #676, and #681 are representative of the several small, single-family cottages built within the LHPD in that area (Figure 3-32). If the little cottages out on Broadway represent a step up the social ladder from the multiple-family blocks in the Acre, the larger and more richly decorated frame house at #415 Pawtucket Street, built for the family of an overseer in 1872, was up another step. This side-hall plan house, with its ornate doorhood and five-sided bay window, follows a very common Lowell form.

Many of the larger houses built along Pawtucket Street northeast of School Street in the 1870s and 1880s have been converted from residential to institutional or commercial use. Frederick Ayer's grandiose Second Empire mansion of brick and stone, built in 1870 is now the Franco-American School.

The large wood-frame Second Empire house at #295 Pawtucket Street, built a few years later for a banker and his family, is now a mortuary, as are other houses of the period along Pawtucket Street (Figure 3-33).

Indicative of Lowell's increasingly urban character in the 1866-1893 period was the construction of several brick apartment blocks, particularly along Middlesex and Appleton Streets. The Bancroft Block at 90 Appleton is a good example within the LHPD. Constructed in the early 1880s in the Queen Anne style, the block was originally built as an investment property for George Runels, a prominent Lowell businessman and one-term mayor.

The potential archeological resources within the LHPD from the 1866-1893 period mostly occur in sites previously mentioned. The Tremont and Middlesex millyards and the Machine Shop yard all underwent significant development in the period. The remains of those buildings could be expected to form a major component of the below-ground remains in those demolished yards. One site within the LHPD that was developed almost exclusively in the second half of the nineteenth century is the Faulkner millyard on the Wamesit Canal. The two woolen mills built there during the Civil War, probably on the sites of earlier powder mill buildings, both burned in 1880. Within that decade a single, larger mill complex was built on the combined yards. Woolen goods were manufactured there until the 1930s, and in 1937 the complex was demolished. As with all historic archeological resources, the significance of potential finds on the Faulkner site must be evaluated in terms of the information they might yield that could not be gained from other sources. In this case both the mills that burned in 1880 and the complex that replaced them are quite well documented in terms of building size, use, materials, and locations, and a purposeful archeological study of the site would need to address other questions.

MULTILINGUAL LOWELL: 1894-1923

History

When writers in the first two decades of the twentieth century wrote of the changes Lowell was then undergoing, the word they often used to describe the city was cosmopolitan, not so much in the modern connotation of sophisticated, but rather in a more literal sense of being not limited by national boundaries. In their places of birth Lowell's citizens certainly were cosmopolitan; Frederick Coburn wrote in 1920 that one could ask directions of a dozen successive passers-by on the street, and hear replies in a dozen different languages, none of them English.

Lowell's population increased by one quarter between 1890 and 1900, from 77,000 to 95,000, with many immigrants among that number. The physical area of the city also grew, with a 1906 annexation of 1,000 acres from Tewksbury, along the eastern side of Lowell. By 1910 the city had 106,000 residents, and in 1920 the population of Lowell reached its peak, at nearly 113,000. Lowell's mills also continued the relentless expansion characteristic of their entire history, with a work force made up largely of the diverse immigrants. The mills' annual production of textiles, like the city's population, reached its highest point around 1920, but events of the preceding years foreshadowed the disaster that was to strike almost all the major textile corporations by the third decade of the twentieth century.

The city had seen a decided increase in labor disputes in the late 1880s, but the economic Panic of 1893 threw so many out of work that no one holding a job was likely to risk it. George Kenngott, a Lowell minister and sociologist who published a useful, though biased social study of the city in 1912, linked the increase in labor strife to the "newer immigrants" who were flooding the city, but it is equally true that the corporations used new groups of immigrants to break strikes by earlier residents and that language barriers made labor organizing difficult.

By the first decade of the twentieth century Lowell's immigrants included representatives of at least forty countries, but the largest new groups were Greek,

Polish, Portuguese, and European Jewish from several countries. All started settling in Lowell in sizable numbers in the 1890s, though the major influx of Greeks, by far the largest of the new groups, came in the first decades of the new century.

Like the Irish and the French-Canadians who had preceded them, the new groups tended to settle in concentrated areas. The Acre, by then largely under Irish-American ownership, became the primary settlement of the Greek population, and dozens of coffee houses lined its principal streets, particularly Market Street to the west of Dutton Street. The Greeks adhered to a pattern common to many immigrant groups, in that young men arrived well in advance of women or whole families. Of the eighteen hundred Greeks in Lowell in 1900, only about fifty were women. The coffee houses were the center of Greek social life, and above many of them were rented rooms. In the early years most of these were overcrowded, poorly maintained and grossly unsanitary. Health problems, particularly tuberculosis, were rampant.

Many of the Polish settled in Centralville, particularly along the banks of the Merrimack River around Lakeview Avenue. The Portuguese, who mostly came from the Azores or Cape Verde Islands rather than from Portugal itself, were concentrated south of the Central Street business district.

Of Lowell's 1900 population of 95,000, only about a fifth were native-born of native parents, and many of those were descendents of the Irish immigrants who arrived in Lowell before 1850. At least partially because of the influx of non-English speaking immigrants, most of the corporations divested themselves of their company-owned housing in the mid-1890s. Before that time, several of the corporations had demolished a boarding house or two to clear the way for expansion, but the divestiture in the 1890s was concerted and nearly complete. It extinguished the last aspect of the paternalistic "Lowell Experiment," which in most ways had been discarded once the work force was no longer young women from New England. Two principal reasons were cited by mill agents for selling the apartments provided to the better-paid employees and the operatives' boarding houses. Among the more skilled employees, there had been a

trend to reside away from the mills, in the outlying neighborhoods of their social peers. The boarding houses, on the other hand, were becoming increasingly difficult to manage according to their rather strict regulations and dormitory-style bedrooms because of the increasing diversity and demands of the operative population.

The Machine Shop retained its housing into the 1920s, and some of the Lawrence Company and Tremont and Suffolk Company boarding houses remained in corporate ownership until ca. 1910. Most of the tenements and boarding houses were in private hands by 1900. Some were quickly demolished, but most were rented out, under increasingly crowded conditions. Around 1900 Saiman Sirk, a Boston investor who bought many of the boarding houses from Boott, Merrimack and other companies, extensively remodeled two Boott boarding houses, joining them together into an apartment building called the Sirk Block (now called Surf's Building).

Other aspects of Lowell's development were also quick to reflect the wave of immigration. The new immigrants built churches when they had barely settled into the city, just as the Irish had built St. Patrick's in 1831 and the French-Canadians had purchased the Lee Street Church and made it St. Joseph's in 1868. The most prominent of the new churches was the Greek Orthodox Holy Trinity, completed in 1908 in the center of their settlement, just across the Western Canal from St. Patrick's.

Housing development and redevelopment also reflected the growth of the population and the movement away from the company housing. The 1,000 acres annexed from Tewksbury in 1906 are all outside the LHPD. Inside the District Clare Street was laid out in the early 1890s and almost wholly built up by 1900 with single and double houses and a few larger blocks (Figure 4-32). Litchfield Terrace, a few blocks west of Clare Street, was laid out and built with several small Colonial Revival cottages around 1910 as an investment by a Lowell dentist. On the east side of Perry Street in Belvidere a group of simple, two-family houses was developed under one ownership around the turn of the century.

While these developments were dispersing the city's population and providing an increased supply of small, single-family houses, the portion of the Acre within the LHPD was undergoing considerable redevelopment to larger structures to accommodate more people. "Triple deckers" with three dwelling units on three floors were the smallest of the new buildings, and frame structures up to five stories tall were built (Figures 3-37 and 4-13). Most of this building post-dated 1906, and probably reflected the ability of the Greek community to afford better housing.

A change in industrial business practices was to precipitate sweeping changes in Lowell. In 1893, the charter of the Massachusetts Mills was changed to allow the corporation to do business outside the state. Production of coarse white goods was immediately transferred to mills in Lindale, Georgia, where in 1896, 1898, and 1902 the company built new mills.

Steam power had freed the mills from the need to locate near great falls of water and southern sites had advantages over the older northern ones such as proximity to supplies of cotton, availability of cheaper labor and newer mills. As the Middlesex Canal was used to deliver the ties and engine parts of the Boston and Lowell Railroad that superseded it in the 1830s, some of the earnings of the Lowell mills went to build their southern competitors, protecting the investors but speeding the demise of Lowell as the "City of Spindles."

The mill buildings and the canal system could not be moved south, of course, and they represented a vast investment. Most of the corporations therefore modernized their millyards in the 1894-1923 period. The founding of the Lowell Textile School in 1895 by several mill owners and officers was another attempt to keep Lowell competitive, by training skilled workers in the areas of textile mechanics, chemistry, engineering, and design.

The most dramatic of the modernization campaigns occurred at the Appleton Company, which virtually rebuilt its millyard between 1898 and 1919. Directing the effort was Alexander Cumnock, one of the founders of the Lowell Textile School. He had

Figure 3-34 Massachusetts Mills Storehouse C on Bridge Street, built 1910, photographed 1979.

served as the Boott agent for thirty years before becoming the Appleton treasurer in 1898 at the age of sixty-eight. He switched the production of the millyard from sheeting to finer goods, and directed twenty years of rebuilding that left within the main millyard only a few fragments of the nineteenth century structures. Most of the Cumnock-era buildings were built of simple utilitarian design, with wide, segmental-arched windows and little or no decorative trim (Figures 4-20 and 4-21).

The old Lowell Manufacturing Company millyard was also considerably rebuilt in the early years of the twentieth century. Lowell Manufacturing was the first of the original group of Lowell textile corporations to go out of existence when Bigelow Carpet Company bought it out in 1899. Bigelow Carpet embarked on a sizable rebuilding campaign building the new weave mill which constitutes the northern face of the millyard in 1902. In 1905-6 the original 1829 Cotton Mill was replaced with a six-story worsted mill, and all of the buildings along the Pawtucket Canal were rebuilt between 1909 and 1911. Bigelow Carpet had further rebuilding plans, but scrapped them in 1914 and relocated its Lowell operations to Thompsonville, Connecticut. The millyard was leased by U. S. Cartridge Company during the First World War, was vacated in 1920, and was the first of the major millyards to be sold piecemeal.

The other millyards made some improvements during the 1894-1923 period, and further corporate changes were made as well. The Lawrence Company sold its secondary millyard east of the Western Canal to the Tremont and Suffolk Company in 1896 and turned solely to the production of knitted goods. Some new construction followed between 1905 and 1910 including Mill #12, a brick and frame structure that stood on the former site of the millyard's clock tower.

The Hamilton Company built one of the largest Lowell mills of the early twentieth century, choosing metal-frame construction rather than reinforced concrete, which was coming into favor in Lowell during that period. Mill #7 was raised in successive stages in 1911 and 1919 and finally measured 653 feet by 135 feet. The premier example of the new reinforced concrete construction was Massachusetts Mills'

ten-story Storehouse C, built in 1910 (Figure 3-34).

In 1911-1912 the Lowell Machine Shop merged with three other firms to form the Saco-Lowell Shops. The new company built reinforced concrete buildings on the foundry yard in 1920 and across Dutton Street on the sites of former company housing in 1923. As the last major buildings erected by one of the eleven Lowell corporations, they mark the end of an era.

Beyond the main corporations, similar consolidations and improvements took place. The Faulkner Mills on Wamesit Canal were incorporated in 1897 and then absorbed into the American Woolen Company in 1899. Frederick Ayer of Lowell was the president and a founder of American Woolen, which set out in the late 1890s to consolidate as much of the woolen industry in this country as it could. Elsewhere on the Wamesit Canal new mill buildings were erected early in the century by the Wamesit Power Company and leased to industrial clients. Waterhead Mills operated in a brick and wooden mill near the head of the power island formed by the Wamesit Canal, (900 Lawrence Street, rear). Further north just off the canal, U. S. Cartridge built new brick mills (685 Lawrence Street) after a severe explosion damaged its previous structures in 1903. Both of those complexes used brick construction, but consolidated the load of the building on thickened piers, which allowed wider segmental-arched windows to be opened between the piers. This modified masonry-bearing form of structure was widely used in other New England textile centers around 1900 but seldom appeared in the main Lowell millyards.

Some new structures were built in the commercial/industrial district along Merrimack and Central Streets between 1894 and 1923, but not in numbers matching the activity of the preceding period. A 1911 description of the city suggested that Lowell had few major office buildings because the control of its major enterprises was centered in Boston. The tallest building in the city at that time (and for many decades thereafter) was built for a local company, the Lowell Sun newspaper. Its ten-story tower was built in 1910 (8 Merrimack Street), designed by Boston architect Clarence H. Blackall (Figure 3-35).

Figure 3-35 Lowell Sun Building, as it appeared when built in 1910.

Figure 3-36 Lowell Memorial Auditorium, as it appeared when built in 1923.

The Sun Building was the exception rather than the rule, for only a few of the commercial and institutional buildings of the early twentieth century exceeded the scale established in the preceding years. The 1922 addition to the Lowell High School with its considerable length overwhelmed the original 1892 building. The Memorial Auditorium was built in 1923 of appropriately monumental scale (Figure 3-36). More typical of the period was the Bradley Block in 1912 on Central Street (#135-187). The site was purchased from the Hamilton Company, whose print works had been an industrial intrusion on commercial Central Street since the 1830s. The long Bradley Block is only two stories tall, and like the conversion of the Boston and Maine Railroad Station to a New England Telephone office in 1896 and a movie theatre in 1915, it represented a decline in the intensity of use of the site. The railroad had relocated to a new depot on Middlesex Street beyond Thorndike Street in 1894, removing the Central Street stations' original function less than twenty years after it opened.

These breaks in Lowell's previous pattern of expansion did not yet apply to population growth, largely due to continued immigration from Europe. By 1910 the census recorded over 106,000 in the city, of whom only one-fifth were native born of native parents. The 1920 census recorded almost 113,000 residents, a total not exceeded since that date.

The purchase of Lowell Manufacturing by Bigelow Carpet, and the exodus of Bigelow from the city in 1914 marked only the beginning of an accelerating pattern that touched all the major mills within the next few years. The Middlesex Company leased a major portion of its manufacturing space to the Ipswich Hosiery Company in 1913, and when that lease was renewed in 1918 Middlesex ceased manufacturing textiles; its sole business became the leasing of space in its millyard. The closings or major reductions in operations that affected the rest of the major Lowell textile corporations and most of the minor ones as well came in the 1920s, within the next period discussed.

Historic Resources

The Appleton and the Lowell Manufacturing/Bigelow Carpet millyards contain the greatest concentrations of industrial buildings of the 1894-1923 period within the District. Appleton demonstrates the challenges of rebuilding a millyard within a constricted, pre-determined site. The Lawrence, Massachusetts, and Boott millyards also contain structures or additions dating from that period. Massachusetts Mills' Storehouse C, built on former boarding house sites on Bridge Street in 1910 represents a new generation of mill buildings in its great height and length, and its reinforced concrete construction (Figure 3-34). Virtually the only Lowell Machine Shop/Saco-Lowell buildings that survive are the two reinforced concrete structures built in the early 1920s. Hamilton's Mill #7, built in two campaigns in 1911 and 1919, still occupies one whole side of that yard, facing mills built in the 1840s and 1880s.

Aside from the main millyards, factories of the period survive in various states of repair on the Concord River. The brick portion of the Waterhead Mills stand and is used as a furniture store (900 Lawrence Street, rear), but the wooden part burned down decades ago. This mill is quite unusual in its use of English bond brickwork. The U. S. Cartridge buildings on the opposite side of Lawrence Street (#685) suffered a major fire in recent years, but still present intact facades to Lawrence Street. A non-textile related industrial structure of considerable interest is the Father John's Medicine building on Market Street (#73-91). When the medicine manufacturer moved to that location in 1920, three distinct buildings stood on the site. The present unified facade was based on the design of the original central building, and was extended across the fronts of the two other buildings which otherwise were left intact.

The tall Sun Building of 1910 (Figure 3-35) and the long Bradley Block of 1912 (now the Saab Building) both still stand, representing two dimensions of 1894-1923 commercial building. The Colonial Building of 1906, facing Wyman's Exchange across Central Street at 24 Merrimack Street, is another prominent example of the period. The Neo-Classical Union National Bank Building of 1924, with granite facades

Figure 3-37 View of the west side of Adams Street, between Lagrange and Broadway Streets in the Acre neighborhood, November 1979.

on Merrimack (#61) and John Streets (#39) is comparable in scale to the adjacent Nesmith Building of the 1840s and 1850s which it imitates in plan (Figure 4-4). The Lowell Five Cents Savings Bank (36 John Street), built in the early 1920s opposite the John Street facade of Union National, is similar to the other bank in style but is built of brick with stone trim.

The Strand Theatre of 1917 still stands at 128-136 Central Street and is the last surviving major downtown movie theatre. Much of its ornate cast-ceramic marquee on Central Street is hidden behind a white metal screen. Several important public buildings of the period remain. An important city landmark, the Old City Hall, was transformed from a public to a commercial building in 1896 by means of a thorough, Colonial Revival-style remodeling. Lowell Trade High School on John Street (#64) at Paige Street retains its original exterior appearance (Figure 3-42) while the massive addition of 1922 to the main High School on Kirk Street dwarfs the original portion. The Memorial Auditorium built by the city in 1923 beside the Concord River on East Merrimack Street (#50) still serves as the terminus of that end of the central business district (Figure 3-36).

The LHPD contains several small areas developed with houses in the 1894-1923 period. Clare Street retains all of the original buildings from its initial development in the 1890s and early 1900s (Figure 4-32). Litchfield Terrace, a much smaller group, still has all seven of its houses, built ca. 1910. North of the Merrimack River, half-a-dozen larger houses built in the 1910s and early 1920s stand above the V.F.W. Highway. Both their view of Pawtucket Falls and their Colonial Avenue addresses (#22-92) predate the Highway. Within the Acre frame residential blocks built in the first decades of this century are the most common predominant building type (Figures 3-37 and 4-13). The four-story, wood-frame Panagiotopoulos Building at 172-178 Adams Street, built ca. 1900-1905, and some of the small, two-story houses along Marion Street between Lagrange and Broadway Streets represent two extremes within this period and type.

No archeological sites of potential significance dating primarily to the 1894-1923 period were identified within the LHPD.

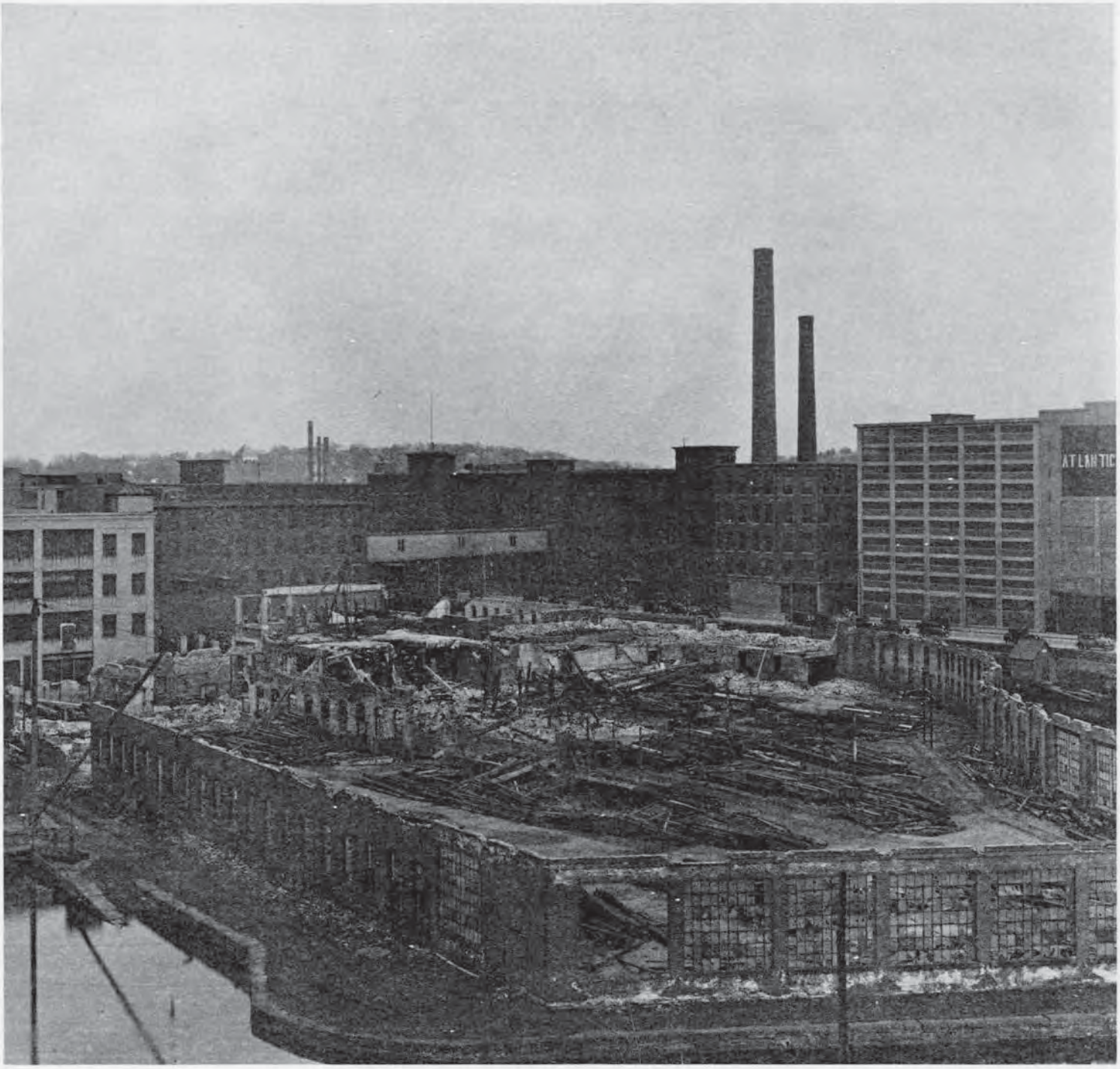

Figure 3-38 View of the foundry of the Lowell Machine Shop during demolition, ca. 1932.

COLLAPSE OF THE LOWELL TEXTILE INDUSTRY: 1924-1969

The Bigelow Carpet Company's abandonment of the Lowell Manufacturing millyard in 1914 and the end of Middlesex Company's production of textiles in 1918 initiated the dissolution of Lowell's textile industry. The Boott Mills and the Merrimack Company remained in operation on a reduced scale into the 1950s. For most of Lowell's textile corporations, however, the 1920s were the decade of the general collapse. In 1920, the Lowell historian Frederick Coburn could still optimistically write in his History of Lowell:

> There were those who in 1890 forsaw a shrunken village where once spindles had been counted by the hundreds of thousands. Such catastrophes rarely befall, and Lowell has shown the energy and adaptability characteristic of American municipalities. It has stood up under competition; it has yielded to no "fell clutch of circumstance."

Ten years later, the city was not "a shrunken village," but its population had fallen by a full 12,000 to just over 100,000, and its major corporations were dissolved, or operating at a reduced scale. The Hamilton Company halted production in the early 1920s, and by 1930 the millyard was owned by Marden and Murphy, "Industrial Liquidators." They demolished the last of the Hamilton boarding houses in 1934 and razed the Print Works in 1935-36. The Appleton, Massachusetts, and Tremont millyards had all ceased production by 1929 and sold their equipment, and in the 1930s Merrimack Manufacturing bought the Tremont millyard and razed its buildings. Saco-Lowell Shops closed the Machine Shop yard in the late 1920s, and most of it was razed in the 1930s (Figure 3-38).

The Lawrence Company was purchased in 1926, and much of the millyard was then sold off piecemeal between 1927 and 1939. The Suffolk millyard continued to operate under new ownership into the 1930s, then it too was closed in 1936. The Middlesex Company, which had not produced textiles since the 1910s, finally was liquidated in 1946, and the remaining mill buildings were demolished in 1956. The Merrimack Company operated in reduced fashion and with reduced buildings until a reorganization in 1952, then closed

shortly thereafter. Much of its millyard and housing survived into the 1960s (Figures 3-39 to 3-41), then were demolished.

The Boott Mills remained in operation through the 1940s, with as many as 1,200 operatives employed, up from a Depression low of 725. Cotton manufacturing continued until 1956, when the millyard began to be rented to a variety of smaller manufacturing concerns.

The smaller textile mills suffered fates similar to the major establishments. The Faulkner Mills were producing until about 1932, then were demolished in 1937. Stirling Mills ceased textile production in the mid-1930s, and has rented space to manufacturers since that time. Belvidere's two millyards were separated by a reorganization in 1914, and neither of the two yards produced textiles through the 1920s.

The little new construction that occurred within the District in the 1930s was government-sponsored. A new Post Office was built on East Merrimack Street in 1930-31, a Neo-Classical design of gray granite, with an entablature and balustrade of matching gray terra cotta. It stands between the Concord River and the Eastern Canal, on land formerly occupied by a Massachusetts Manufacturing building. An annex to the Trade High School was built in 1939 at the corner of John and French Streets (Figure 3-42). The architect was Harry Prescott Groves, who had designed the original Trade High School next door in 1900.

Perhaps the most significant of the Depression-era building campaigns was the construction of the North Common Housing Project in 1939 and 1940. Much of the northern part of the Acre was razed for this project, portions of which are within the LHPD Boundaries.

The city's population increased by about 1,000 between 1930 and 1940, reaching just over 101,000. A decline of about 4,000 was recorded by the 1950 census, and by 1960 the population had dipped to 92,000, almost 3,000 below the 1900 figure. By 1960, some of the decline must be attributed to increased ownership of automobiles, and the accompanying trend toward suburbanization.

Figure 3-39
Merrimack Manufacturing Company's "New Block" boardinghouse row on Dutton Street, built ca. 1845, photographed 1960.

Figure 3-40
Merrimack Manufacturing Company boardinghouse on Dutton Street, built ca. 1822, photographed 1960.

Figure 3-41
Proprietors of Locks and Canals "Grist Mill" on French Street at the foot of Anne Street, built in 1883, photographed 1960.

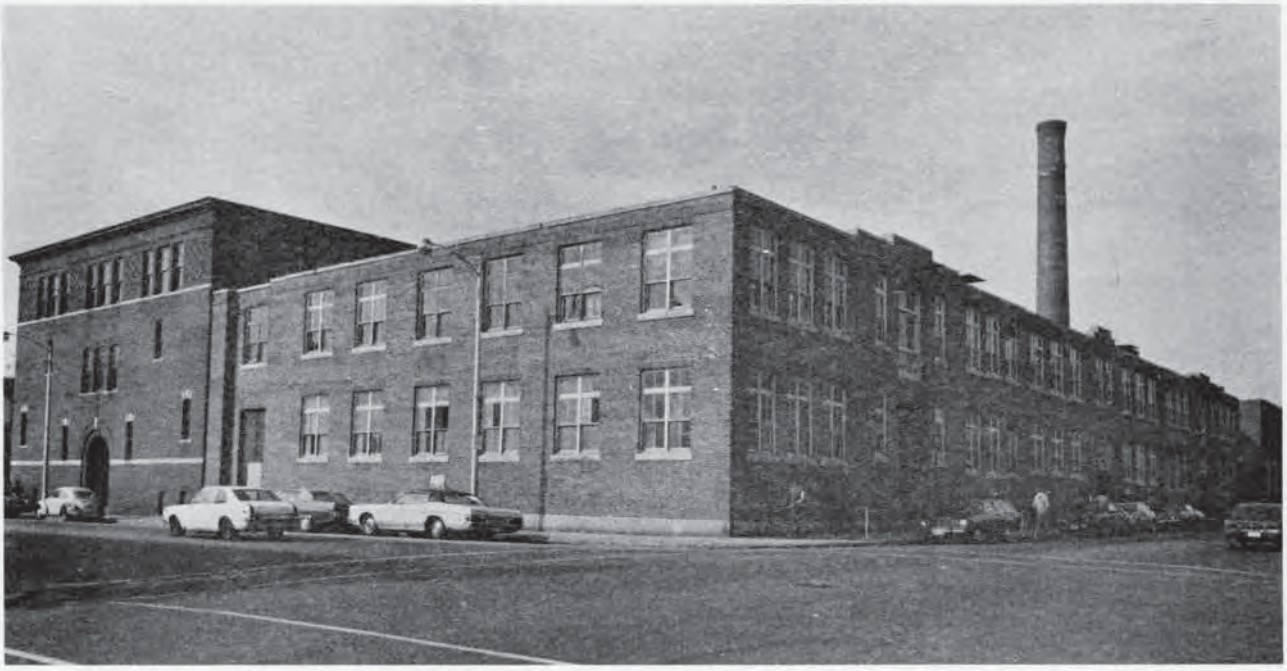

Figure 3-42 Lowell High School Annex, John and French Streets, built in 1939, and the old Trade High School (left) built in 1900. Photographed 1979.

Figure 3-43 View from John Street of the Cherry and Webb store, remodeled in 1953, photographed 1979.

Lowell's development in the 1924-1969 period is symbolized not by buildings, but by parking lots from which buildings were removed. Within the business district, new construction was rare, although projects involving remodeling, refacing, or adding and subtracting stories were (and are to the present day) fairly common. The Cherry and Webb Store at the corner of Merrimack and John Streets incorporates portions of at least three early buildings behind its 1953 metal facade, including whatever remnants of the "Marble Bank" that had survived earlier remodelings (Figures 3-43 and 3-27). No matter what the external appearance of a building in the central Lowell area, it is wise to suspect the existence of older building fabric within.

If the characteristic legacy of the 1924-1969 period in Lowell is the parking lot, a corresponding debt must be acknowledged for the preservation of the vast quantity of historic resources that did survive. The canal system, seven of the eleven major millyards, whole neighborhoods of nineteenth century houses, a central business district rich and varied with historic buildings, and countless other irreplaceable historic resources were not demolished. On these resources and on the "energy and adaptability" of Lowell's citizens described by Coburn in 1920, the revitalization of Lowell will be based.

REVITALIZATION OF LOWELL: 1970 to present

The demolition of the Merrimack Company millyard and boarding houses in the early 1960s confirmed a local conviction that Lowell was on a wrong course, that the city was destroying those features that make Lowell a special place. By the early 1970s, initial planning and demonstration projects based on Lowell's unique historic resources were underway, supported by the Model Cities Program and other agencies and foundations. In 1971, the non-profit Human Services Corporation was established in support of the goals of using the city as an educational resource, enhancing its environment, and pursuing economic revitalization through the preservation and presentation of Lowell's historic resources. Also toward these ends, legislation was introduced in Congress in 1972 and 1973 to create an Urban National Cultural Park in Lowell. Also in 1972, the City Council passed a resolution designating the cultural park concept as the basis of local planning efforts. A tangible result was the commitment of substantial funds to park-oriented revitalization efforts, totalling $12 million between 1975 and 1978.

In 1973, the state authorized the City Hall Historic District Commission. It was empowered to review all exterior changes to buildings within the designated District.

The publication in 1973-4 of Lowell Urban Park, a product of the Human Services Corporation, helped crystalize the planning effort. The Commonwealth of Massachusetts authorized the Lowell Heritage State Park in 1974, with goals of preserving Lowell's historic resources and fostering their appreciation and enjoyment by the public. In 1975 Congress established the Lowell Historic Canal District Commission and charged it with preparing a plan for the preservation and interpretation of Lowell's historic resources. Published in 1977, the report of this commission, together with the cooperative efforts of the National Park Service, the Department of the Interior, and Paul Tsongas (first as Congressman from the Lowell district, then as a Senator) produced the legislation that Congress approved in 1978 and President Carter signed into law. Designated Public Law 95-290, "An Act to provide for the establishment of the Lowell

Figure 3-44 View of the Lowell National Historical Park office on Merrimack Street in the Welles Block, 1979.

National Historic Preservation District. Both of these entities took active form in Lowell during 1979. (Figure 3-44).

These public efforts have had a private counterpart in restoration and rehabilitation projects, particularly in the central business district. In some cases aided by a facade improvement grant from a fund established by local businesses, owner-occupants as well as developers have rehabilitated many structures in recent years, and work is underway on several others in 1979.

Lowell has survived, and has found in its past the means to prosper again. The challenge it faces lies in maintaining a strong local voice in the discussions of the city's future.

CHAPTER FOUR

PATTERNS OF RESOURCES, PATTERNS OF USE: THE PARK AND THE DISTRICT TODAY

The task of coalescing the information on the 895 properties recorded by the inventory into a comprehensive picture of the Park and the District resembles the challenge Humpty Dumpty presented "all the king's horses and all the king's men." The preceding chapter adopted a chronological approach to that task. This chapter focuses on the present-day Park and District and describes how the historical resources relate to one another and to current patterns of land use and activity in Lowell.

Twelve more or less discrete areas within the LHPD can be identified. These do not necessarily correspond to neighborhoods within the city as a whole, since the Park and District boundaries apply their own organization, based largely on the canal system, to the city. The factors which determine these twelve areas are geographic divisions, patterns of activity and land use, and concentrations of historic resources. Fewer, larger areas could have been described, but a "finer grained" approach was chosen to permit discussion both of major concentrations of resources in central areas, and of historical features important to lesser-known parts of Lowell. The twelve areas are outlined on a fold-out map at the end of this chapter.

AREA 1--CENTRAL BUSINESS DISTRICT

The Central Business District (CBD) is preeminent within the Park and the District for its present-day vitality and its rich historic fabric. This area extends from the Memorial Auditorium on the east, along Merrimack Street to City Hall and the Memorial Library on the west, and from French Street on the north to Market Street on the South. Middle, Palmer, and Shattuck Streets south of Merrimack, and

John, Paige, Lee, and Kirk Streets north of Merrimack are within the CBD. It is a busy area of stores, banks, restaurants, and private and governmental offices but also includes numerous underutilized structures. There is an encouraging trend in the area toward rehabilitation and fuller occupancy rates. In addition, a number of buildings are undergoing conversion to subsidized housing, under the auspices of the Section 8 Program of the Department of Housing and Urban Development.

The heart of the CBD and the heart of the city is Merrimack Street, Lowell's "Main Street." It is lined by a varied collection of commercial and institutional structures, dating primarily from the nineteenth century. Red brick is the predominant material, but granite, yellow brick and Lowell's characteristic rubblestone construction are also represented along the street.

The most prominent landmark on Merrimack Street is the "New" City Hall, which with its companion Memorial Library was completed in 1893 (407 and 415 Merrimack Street, respectively). When City Hall was built, Monument Square was a fitting forecourt to the impressive granite building (Figure 4-1). Among the buildings enclosing the Square in 1893 were a leading hotel, a train station, a large new office building, and some handsome houses owned by the Merrimack Manufacturing Company. Of those buildings only a single house still stands, and the modern Square is primarily a wide traffic intersection (Figure 4-2), flanked by open lots or low buildings including a self-service gas station and a tire store and automobile repair shop. The City Hall and the Library are by no means without neighboring historic structures, however. Across Merrimack Street are the Bank Block of 1826 (#350-376), the First Congregational Church of 1884 (#400, now the Smith Baker Center), and the Green School of 1870 (#408). This diverse row of buildings is characteristic of the variety that is a delight and a strength of the CBD.

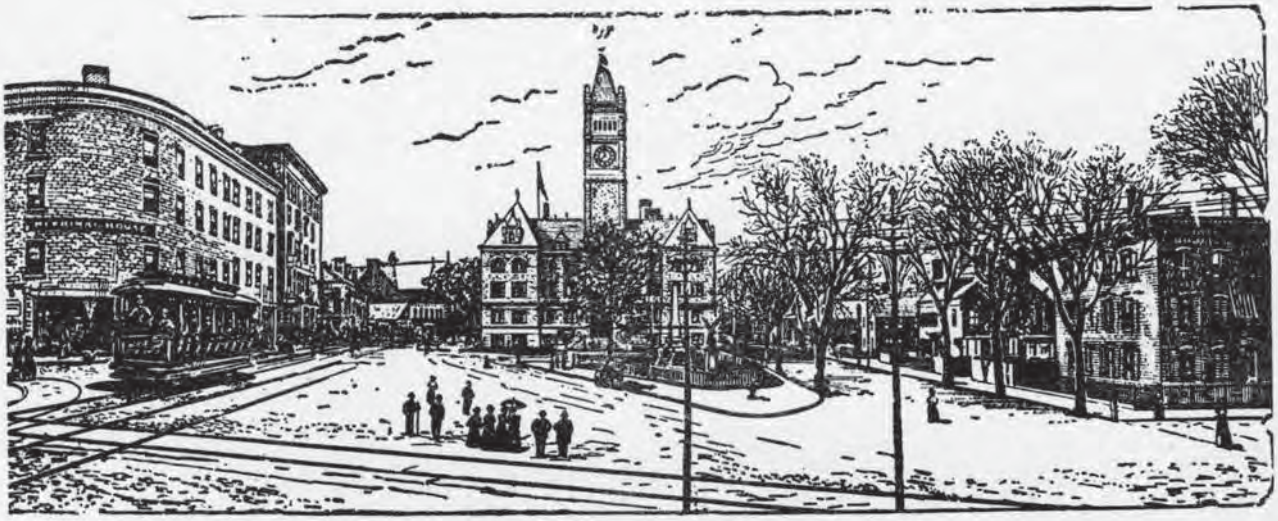

Figure 4-1 View of Monument Square from the east, ca. 1895.

Figure 4-2 View of Monument Square from the east, 1979.

Across the Square from City Hall a pair of mid-nineteenth century structures beside the Merrimack Canal serve as reminders of the industrial foundation on which the city was built, as does the canal itself. It was dug in 1822 to power the mills of the Merrimack Manufacturing Company. A restaurant now occupies the brick structure that same company built ca. 1860 as housing for employees (91 Dutton Street). In front of the restaurant is the Merrimack Gatehouse on the bank of the canal. Since 1848 the gatehouse has controlled the flow of water into the Merrimack Canal from the Moody Street Feeder, an underground tunnel off the Western Canal.

On the other side of the canal, a pair of major Lowell landmarks face one another across Merrimack Street. On one side are St. Anne's Church and Rectory (237 Merrimack Street and 8 Kirk Street, respectively), built in the mid-1820s. St. Anne's is distinctive on predominantly commercial Merrimack Street for its clearly ecclesiastical form, gray rubblestone material, and spacious, fenced lawns. Adding to the openness of the churchyard is the adjacent Lucy Larcon Park and the Merrimack Canal. Across Merrimack Street from St. Anne's Old City Hall (#226) retains its original Greek Revival scale and basic form. The 1829-30 building underwent a Colonial Revival remodeling in the mid-1890s which changed the windows and applied considerable new decoration to the building.

East of St. Anne's and the Old City Hall Merrimack Street is walled in by solid ranks of commercial structures. On three key intersections there are early buildings with rounded corners, a favorite Lowell motif. The Wentworth Block (#256) of ca. 1844 stands on the Shattuck Street corner, modified by the addition of a mansard roof. The Welles Block (#175) of 1846 occupies the corner of Kirk and Merrimack Streets, and the Nesmith Block (#83) has stood at Merrimack and John Streets since the mid-1830s. A sample of the eclectic group of buildings on Merrimack Street also includes structures of the 1850s--the "New" Nesmith Building of ca. 1850-56 (#65); the 1860s--the Robbins Building occupied by Prince's Books (#102-110); the 1870s--the Masonic Temple of 1872, now called the Hosford

Building (#134 and Figures 3-28, 3-29, and 3-30); the 1880s--the Hildreth Building of 1882-4 (#45) and Wyman's Exchange of ca. 1880 (#60); and the 1890s--the Runels/Fairburn Building of ca. 1892 and the Howe Building of ca. 1894 (both on Kearney Square at the foot of Merrimack Street). Early twentieth century buildings important to the streetscape are the Colonial Building of 1906 (#24) and the ten-story tall Sun Building of 1910 (#8 and Figure 3-35), the first Lowell skyscraper and the only one in the CBD. No other Lowell street has so many historic structues representing such a comprehensive range of styles and dates.

Merrimack Street's greatest strength lies not in its individual structures, however, but rather in the vibrant streetscape they form as a group. The long block between Central and Palmer Streets is particularly well composed, with the granite facade of the Hosford Building near its center flanked by ranges of brick buildings. The cohesiveness of the block could be considerably enhanced by a sympathetic rehabilitation or refacing of the Executive Building at #100 (Figure 4-3). Its present blue and pink metal and glass facing was installed in the early 1960s over two nineteenth century buildings. A re-exposure of these structures, if possible, or else a more compatible new facing would constitute a substantial contribution to the whole CBD.

Another significant Merrimack Street group wraps around the corner of John Street, and extends east towards Bridge Street (Figure 4-4). The corner Nesmith Block presents a curved facade to the John and Merrimack Streets intersection. Two other structures with twin facades on Merrimack and John Streets wrap around the ca. 1836 Nesmith Block. The "New" Nesmith Building has lost half of its Merrimack Street facade (#65, built ca. 1850-56), but retains all of its oddly asymmetrical John Street front (#35-35, built ca. 1841-50). On the John Street side one of the original arched storefronts is still visible and others may survive beneath the glass and metal panels. The other "wrap-around" building was constructed for the Union National Bank in 1924, and displays Neo-Classical granite facades on John Street (#39)

Figure 4-3 View from John Street to the south side of Merrimack Street, 1979.

Figure 4-4 View of the Nesmith Buildings at the corner of John (left) and Merrimack (right) Streets, 1979.

Figure 4-5 View east on Middle Street, 1979.

and Merrimack Street (#61). Completing this Merrimack Street group is the Hildreth Building (on the far right in Figure 4-4). In scale and materials it is a fitting culmination to this diverse collection of buildings. This group would be enhanced by a re-exposure of the red brick and granite trim of the corner Nesmith Block and a restoration of the stuccoed facades and John Street storefronts of the wrap-around Nesmith Building. Two one-story storefronts and a vacant lot separate the Hildreth Building from the corner Simpson Block (1-5 Merrimack Street) at Bridge Street. Sensitive new construction of three or four-story height could bridge the gap between the Hildreth and the corner building and make of the whole block a richly varied, cohesive urban design.

Even some of the discordant notes along Merrimack Street are nineteenth century in origin. The block between Kirk and John Streets has three and four-story buildings at either end, then steps down to one-story storefronts at mid-block. Historic views of the street show that the present jagged profile of this block replicates the late nineteenth century outline, and many of the modern-looking buildings may have older cores.

Not all the historical buildings in the CBD are located on Merrimack Street. Middle Street was largely redeveloped in the 1880s and 1890s, and since that date has retained most of its four and five-story brick structures. These now comprise the most homogenous and concentrated street of nineteenth century commercial structures in the city (Figure 4-5).

Other streets in the CBD have suffered more recent redevelopment and more extensive demolition, and only scattered historic structures survive. On the north side of Market Street, between Central and Dummer Streets, the key historic buildings are three industrial structures-- the Father John's Medicine Building at #91, a 1920 reworking of three earlier structures; the J. C. Ayer and Company patent medicine factory at #165, built ca. 1858-9; and the Gates Block at #307, a leather belting factory built in 1881.

North of Merrimack Street, important institutional structures and fragments of mid-nineteenth century residential development are the major historical features of the underutilized northern edge of the CBD. The old portion of the Lowell High School on Kirk Street (#30, built in 1892), the Shrine of St. Joseph the Worker on Lee Street (#37, built in 1850 and enlarged in the 1870s), the former Kirk Street Primary School (#31, built in 1881, now the AHEPA Center), and the old Trade High School at the corner of Paige and John Streets (64 John Street, built in 1900), are the major structures in that area. They all remain in institutional use. The smaller residences along Kirk and Paige Streets are less well-preserved, but serve as important reminders of the original residential component in this neighborhood. The most significant of the houses on these streets is the double house built in 1846 for the agents of the Boott and Massachusetts Mills (Figure 4-6), but that structure is more properly included with the industrial area north and east of the CBD.

AREA TWO--BOOTT AND MASSACHUSETTS COTTON MILLS

The Boott and Massachusetts millyards north and east of the CBD comprise a distinct area of historic importance and future promise for the city. The agents' house at 63-67 Kirk Street (1846) and the Massachusetts Mills boarding house at 28-56 Bridge Street (ca. 1840) can properly be included in this area. Lowell has lost almost all of its company-owned housing, increasing the significance of these remaining structures.

The feature that historically linked and still joins the Boott and Massachusetts millyards is the Eastern Canal. The mills retain their historical relationship to this canal, drawing its water to drive electrical generating turbines. The massive granite blocks of the wall of that canal in front of the Boott yard, and the swiftly flowing waters themselves are conspicuous historical assets of the Boott/Massachusetts area.

Both millyards are among Lowell's most intact, retaining major original buildings and typical later structures and alterations (Figures 4-7 and 4-8). The four original mills in each yard

Figure 4-6 Massachusetts and Boott Cotton Mills Agents' House, 63-67 Kirk Street. Built 1846, photographed November 1979.

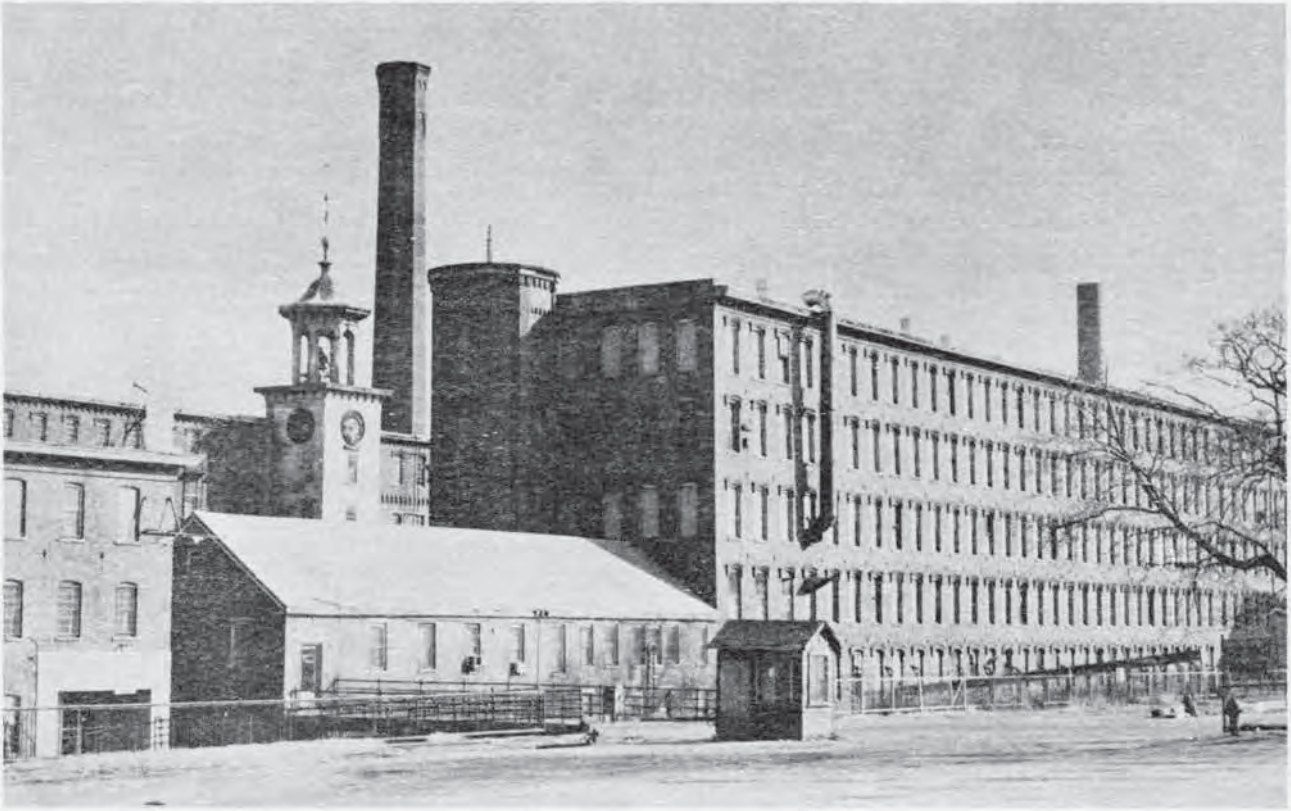

Figure 4-7 View of Boott Mills from the west,1979.

Figure 4-8 View of Mill No. 1, Massachusetts Cotton Mills, 1979. Right and left sections built 1839-40, center section 1862, left stair tower 1872.

have been linked into longer units and increased in height, but are still clearly discernable (Figures 3-9, 3-10, 3-16, and 3-20). These additions to the first mills, and the extensive later construction surviving in both yards testify clearly to the continuous growth and increasing scale of the Lowell mills in the nineteenth century. The millyards are still busy places, with a variety of industrial and commercial tenants occupying nearly all the habitable space, but both also have empty buildings in need of rehabilitation.

Due to the size of their structures and their riverbank locations, these two mills are major visual landmarks of central Lowell when seen from the north, east, and southeast. Their clock and stair towers and chimneys are particularly prominent and positive contributors to the Lowell skyline.

AREA THREE--LAWRENCE AND SUFFOLK MILLS

Northwest of the Boott Mills, beyond the former site of the Merrimack Manufacturing Company, is another major industrial area of the Park and the District. It includes the razed Tremont millyard and the Lawrence and Suffolk mills. The Northern Canal runs through this area, and South of the canal there is a handful of houses within the LHPD. The character of this area both north and south of the canal is determined by a combination of significant historic structures, vacant lots disrupting the historic development patterns, and new construction which is generally incompatible with the older buildings in material and scale.

The most important historical features of the area are the broad Northern Canal and the Western Canal into which it flows, and the Suffolk and Lawrence millyards. Most of the Suffolk structures date to rebuilding projects of the Civil War period and later (Figure 4-9), although three important earlier buildings do survive. The Counting House, 561 Suffolk Street at the entrance to the yard was built in 1831 and extended in 1844, and is little changed since then,

except for the loss of its dormers. To the rear of the yard off Cabot Street (#199) is one of the very few extant Lowell boarding houses, built in 1831-2, and converted to industrial uses in 1904 (Figure 4-10). Across the Northern Canal from the main millyard, another row of formerly Suffolk-owned housing still stands at 111-131 Cabot Street. This two-and-one-half story brick row was built ca. 1845-50, probably to accommodate skilled workers and their families in separate "tenements" or apartments.

Two modern-day occupants lend further importance to the main portion of the Suffolk millyard. The nascent Lowell Museum uses Suffolk mill buildings to house its interpretive displays on the history of the city. Elsewhere in the yard, Wannalancit Textile Company represents living history, producing textiles with the most traditional equipment of any mill in the city. This operation is a significant asset to the Park, and its continuation should be a LNHP goal.

The other major millyard in the area, that of the Lawrence Manufacturing Company, is the largest of the standing millyards (Figure 4-11). It retains structures dating from the 1830s to the early twentieth century in a complex pattern indicative of the almost unceasing growth of the Lowell mills in their first century. Like all of the major millyards, Lawrence now contains underutilized buildings, but the mills are by no means idle and the yard can still count textile manufacturers among its occupants.

The most unique structure of the Lawrence Manufacturing Company buildings is the Agent's House, standing outside the main yard at 119-121 Hall Street (Figure 4-12). Built in 1833, its construction of rubblestone with granite trim is not unusual in Lowell, but these materials were infrequently used by the major corporations. Its scale, even as a double house, is also grander than most of the known agents' houses in Lowell. The house has served as the Lowell Day Nursery since the 1920s.

Figure 4-9 View inside the Suffolk Manufacturing Company millyard, 1979.

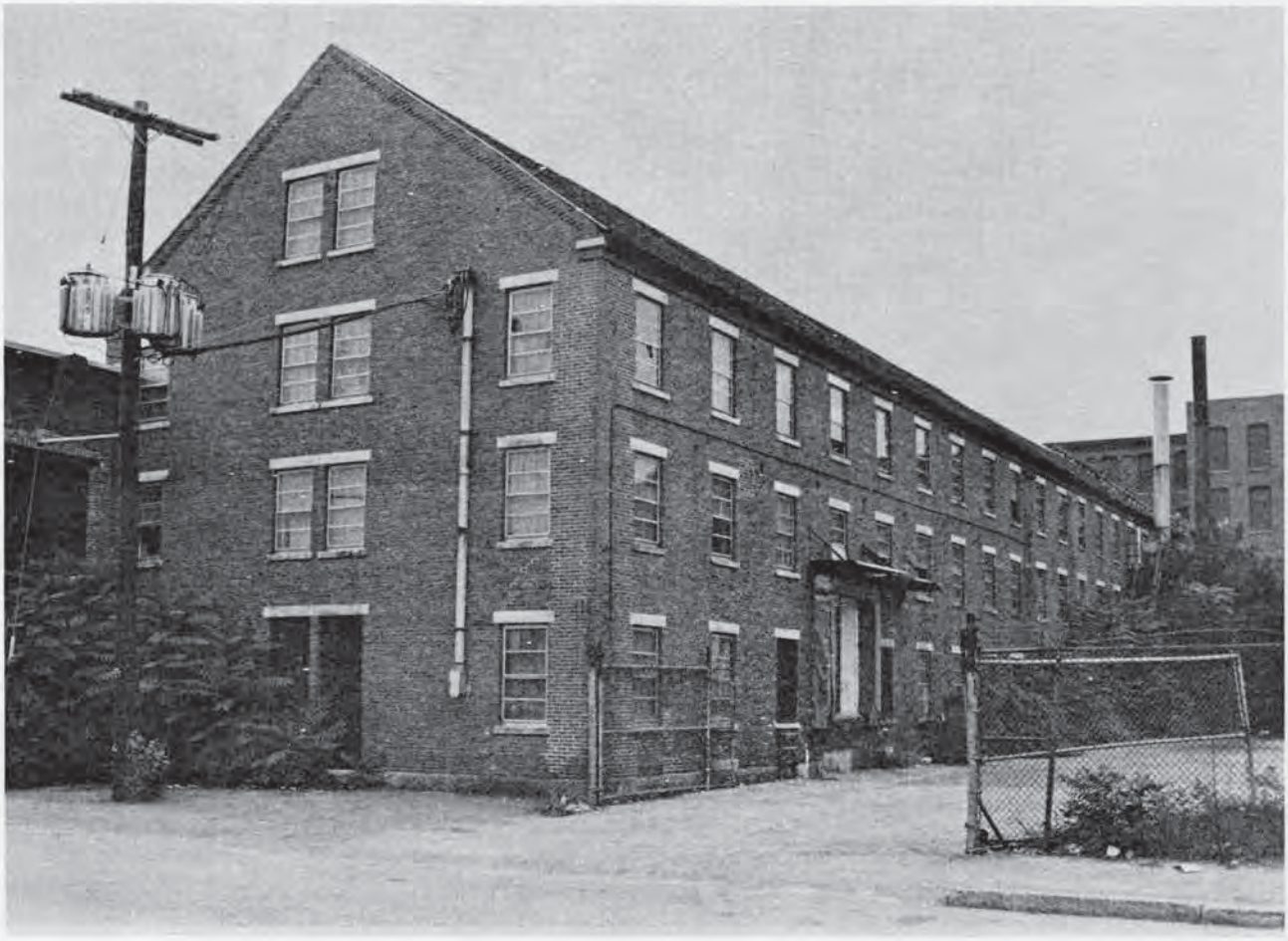

Figure 4-10 View of the Suffolk boarding house on Cabot Street, built 1831-32, photographed 1979.

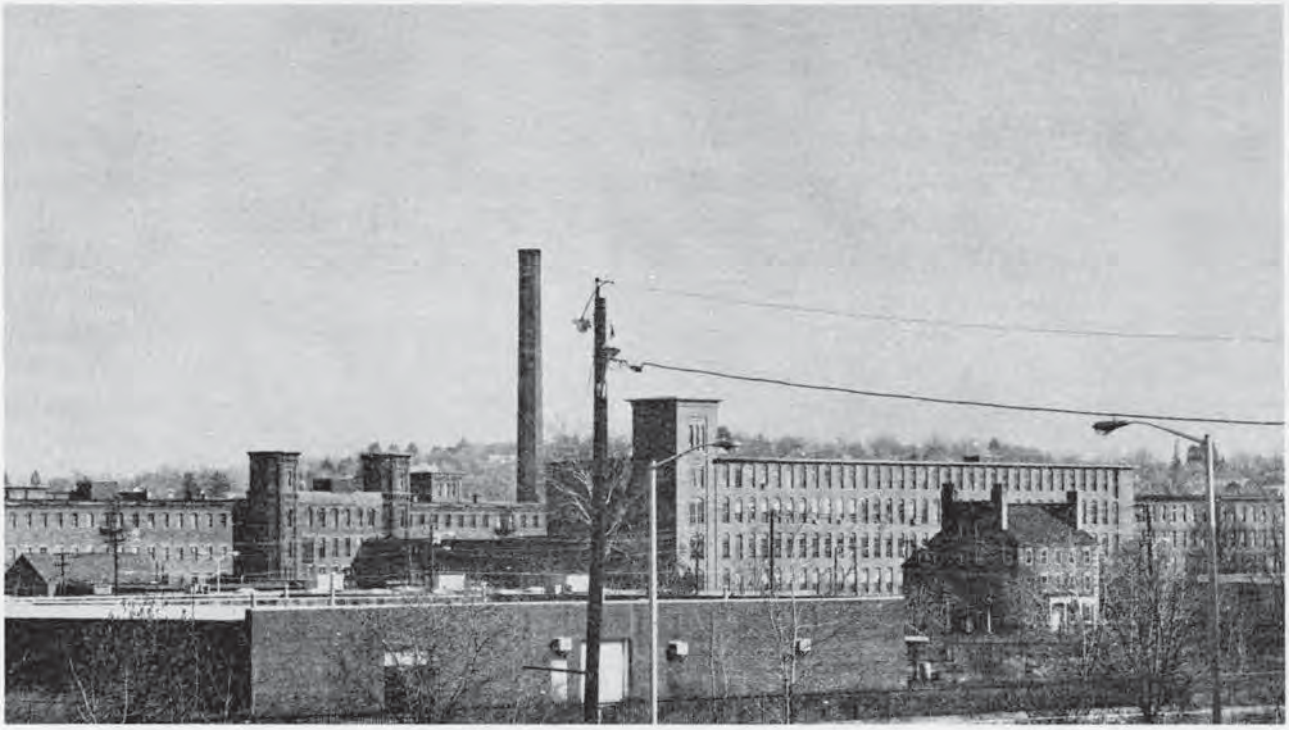

Figure 4-11 View of the Lawrence Manufacturing Company from the west, 1979.

Figure 4-12 Lawrence Agent's House, 119-121 Hall Street, built 1833, photographed 1979.

The Tremont millyard is a potential resource of the Lawrence/Suffolk area. Razed in the 1930s, the yard has not been redeveloped and could provide a site for an interpretive excavation of a major millyard, exposing foundations, waterways and other features of a water-powered textile factory not visible in the intact millyards.

Relatively recent events have altered the way the Lawrence/Suffolk area relates to the city. The replacement in the 1960s of narrow Ford Street with the wide French Street Extension has isolated this industrial district. In addition, the demolition of the Merrimack yard and of the secondary Lawrence yard that stood southeast of the Western Canal removed the middle from Lowell's "Mile of Mills", creating a wide gap between Massachusetts and Boott on the southeast and Lawrence on the northwest. Viewed from the Centralville side of the river, however, even this broken "Mile" is an awesome expression of the scale of Lowell's industrial enterprise.

AREA FOUR--THE ACRE

The Acre neighborhood is south of the Lawrence-Suffolk industrial area and west of the Central Business District. It is one of the very few areas included within the LHPD primarily for its historic importance as a residential section. Irish laborers pitched their tents and built their huts here in the first decades of Lowell's development. By mid-century more substantial houses accommodated a predominantly Irish populace. Towards the end of the nineteenth century and in the early twentieth, Lowell's growing Greek population settled in the Acre, eventually gaining ownership of most of the houses. In recent years, Hispanic immigrants have perpetuated the Acre's traditional function as Lowell's entry neighborhood.

The Acre historically included lands south of Market Street and north of Broadway on both sides of the Western Canal, and the area south of Broadway to Fletcher Street. Most of the northern portion of the Acre was redeveloped in the late

1930s as the North Common Public Housing Project. A few of the structures of that early public housing project are included in the LHPD, bordering the Western Canal. Adjoining the project buildings and facing each other across the canal are two monumental churches, symbolic of the two major historic groups to settle in the Acre and testaments to their deep religious faiths. The Irish Catholic community built St. Patrick's between 1853 and 1874, replacing with stone their original wooden church. Greek immigrants built Holy Trinity on the east bank of the canal between 1906 and 1908, less than a decade after the first substantial influx of that group into Lowell.

The southern portion of the Acre was not included in the North Common project. That area bounded by Cross, Fletcher, and Suffolk Streets is one of the most historically important and currently endangered residential areas in the LHPD. None of the original settlers' huts still stand, but the small houses that replaced them are represented (77 Adams Street, ca. 1845 and One Marion Street, c. 1851), along with much larger multi-family residences built in the later nineteenth century (236-246 Broadway and 28-30 Marion, both ca. 1870) and the still larger buildings constructed to house Greek immigrants in the early twentieth century (172-178 Adams Street, ca. 1900-05). Figure 3-37 illustrates a group of late nineteenth and early twentieth centurey houses in the Acre, while Figure 4-13 includes houses dating to the mid-nineteenth century.

Historic accounts of living conditions in the Acre in the 1830s, 1850s, and 1900s sound warnings of overcrowding and poor health conditions that still apply today. The combined forces of neglect, vandalism, and arson are now solving the problem of the Acre in a fashion that serves neither the residents nor the historic character of the city. During the time in which this inventory was conducted, at least seven nineteenth or early twentieth century structures were demolished in the Acre, and those removed in the last few years bring the recent total to well over a dozen. As long as abandoned buildings represent a fire

Figure 4-13 View of the east side of Adams Street between Lagrange and Broadway Streets, in the Acre, 1979.

hazard that threatens neighboring, occupied structures, this aggressive demolition must continue, but without a general reversal of the current trend there will soon be no Acre.

AREA FIVE--GREATER DUTTON STREET

The roughly triangular area framed by the Western Canal, the Pawtucket Canal, and Market Street was originally developed with major industrial complexes and related housing northwest of Dutton Street. The area retains some of its historic industrial structures and is still an important industrial center of Lowell. Some historic houses survive along Worthen Street, and Dutton Street has a fine row of nineteenth century commercial buildings.

The canals which enclose this area are some of its most important historic resources (Figure 4-14). The canals fan out from the main Pawtucket Canal to the scattered mill sites, and at the center of the fan is the Swamp Locks, the heart of Lowell's two-tiered waterpower system.

Within the spreading fan were key industrial complexes. The most important among these, the Lowell Machine Shop yard at the junction of the Merrimack and Pawtucket Canals, was demolished in the 1930s. Most of its yard is now used for parking, or as sites for low, modern industrial buildings. A few late Machine Shop structures still stand, and one, the large reinforced concrete structure at 305 Dutton Street, has certain symbolic importance. Built by the Machine Shop (then the Saco-Lowell Shops) in 1923, it is the last major building erected by one of the eleven, main-line Lowell corporations.

A far more intact complex of late nineteenth and early twentieth century industrial buildings stands at 491 Dutton Street. It housed the Kitson Machine Shop, once the world's largest producer of cotton-picking machinery. The buildings are now occupied by the Pellon Corporation, which also has modern buildings in the former Machine Shop yard.

The most historically important of the extant industrial complexes in the Dutton Street area is the millyard of the Lowell Manufacturing Company, located off Market Street between the Merrimack Canal and Pawtucket Canals. Lowell Manufacturing originally produced both cloth and carpets. In the late nineteenth and early twentieth centuries, the Bigelow Carpet Company owned and operated these mills. The Lowell Canal which supplied waterpower to the millyard was an open channel until ca. 1910, when it was covered over. Several buildings have been removed along Market Street, and all of the surviving structures date from the post-Civil War period through the early twentieth century. Most notable among these are the Brussels Weave Mill of 1882 (Figure 4-15), and the #2 Weave Mill (1902) along Market Street. The latter constitutes a major industrial presence along one side of the Central Business District, and terminates the important Shattuck Street vista from Merrimack Street.

Along Dutton Street opposite the Lowell Manufacturing Company is a fine group of late-nineteenth century brick structures. The earliest among them is the Italianate Richardson Block, built as a grocery store and residential block in 1870. Most of the rest of these two, three and four-story buildings were constructed in the late 1880s and early 1890s to house stores or small manufacturing establishments. They provide a useful comparison to the larger structures of similar purpose and style along Middle Street.

At the north end of this block, separated by a wide vacant lot from the nineteenth century structures, is Haffner's Gas Station and Lubritorium (215 Dutton Street). Built in 1935 and since diluted in impact by the loss of its matching canopy over the pump area, the gas station is incompatible with its neighbors in style or scale, but nevertheless is an interesting representative of its own period. The same firm operates another "period" gas station just outside the LHPD, on Appleton at South Street.

Paralleling Dutton Street to the northwest is Worthen Street, which contains a small, diverse

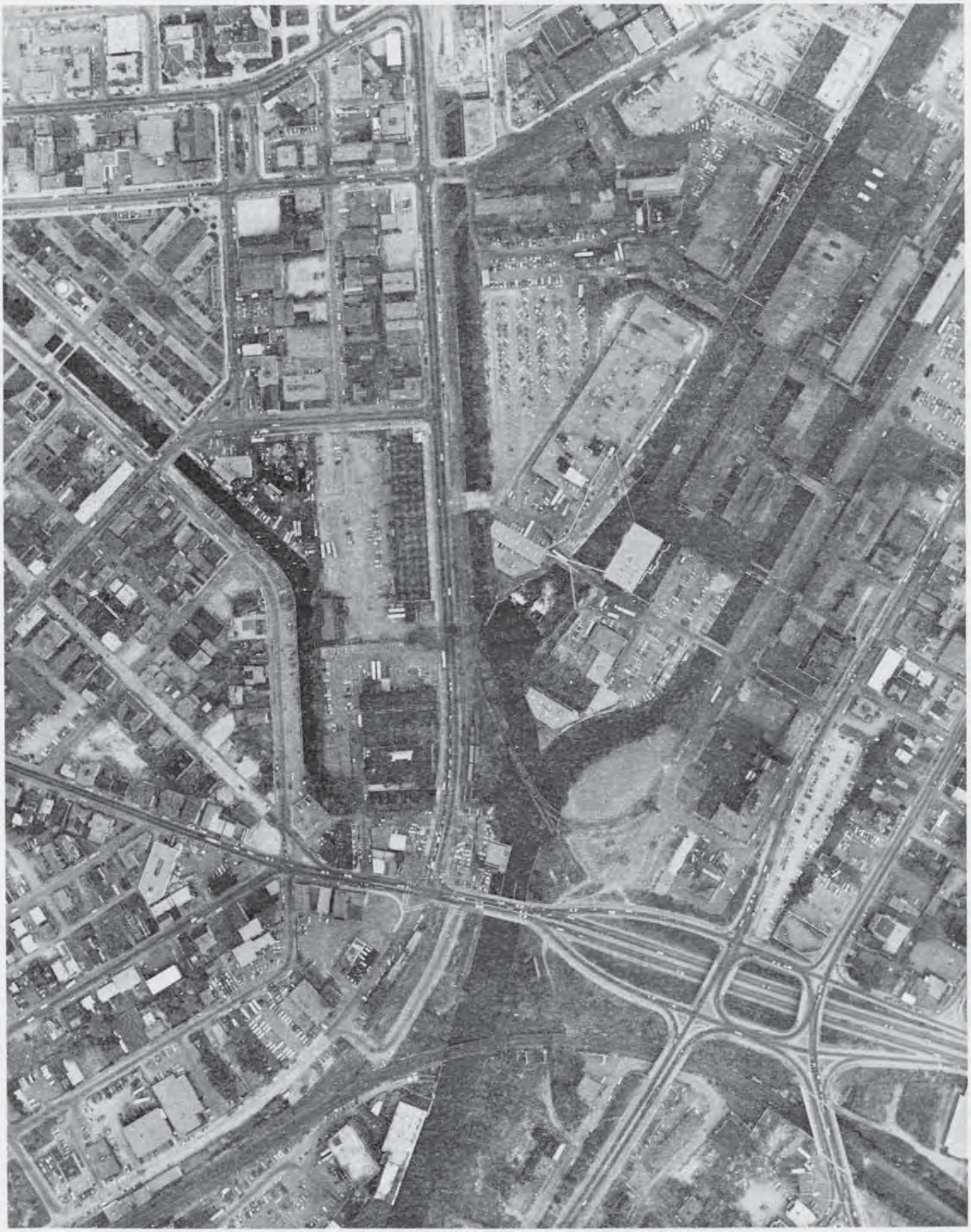

Figure 4-14 Aerial view of the central portion of the Lowell canal system, 1979. Swamp Locks are at center, and Pawtucket Canal extends from bottom center to upper right. Hamilton Canal branches to the right, Western to the left. Merrimack Canal is at top center.

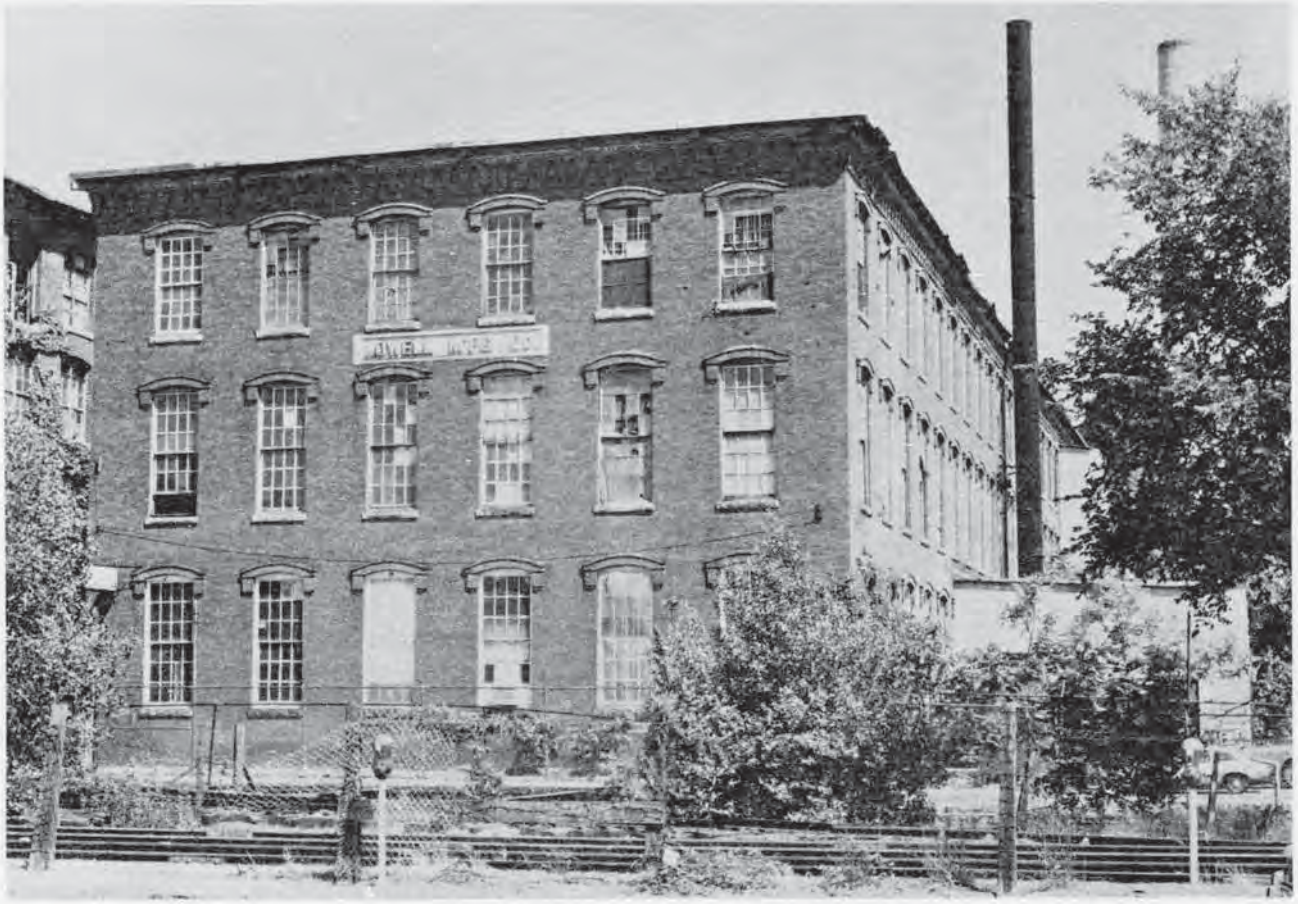

Figure 4-15 Brussels Weave Mill #1 of the Lowell Manufacturing Company, facing Dutton Street. Built 1882, photographed 1979.

Figure 4-16 Douglass House at 284 Worthen Street. Built ca. 1840, photographed 1979.

group of residences related to the nearby industrial sites. Pre-eminent among these is the wood-frame Moody-Whistler House, built in the mid-1820s for Paul Moody, the first superintendent of the Machine Shop. Now the headquarters of the Lowell Art Association, the house is best-known as the birthplace of James McNeil Whistler, the avant-garde nineteenth century artist. His father, Captain George Whistler, was more important in Lowell's history. He was the Chief Engineer who directed the Lowell Machine Shop's production of locomotives during the infancy of railroads in America. Across the street from the Moody-Whistler House are two wood-frame Greek Revival buildings, one originally the Worthen Street Methodist Episcopal Church (#200, built in 1842 and now the Lowell Girls' Club) and the other a double house (#222-224, built ca. 1850). Contrasting with that pair in style and materials is the brick double house at 284 Worthen Street, built in 1840 for a Machine Shop employee (Figure 4-16).

AREA SIX--GREATER CENTRAL STREET

The roughly counter-clockwise course of this discussion leads next to the Greater Central Street area. The portion of Central Street within the LHPD is a commercial area closely related to the Central Business District, but historically and in its present character it asserts a distinct identity. The short length of Prescott Street is part of this area on the north, as is Gorham Street on the south and the Old Market House on Market Street on the west.

The historic structures of this area are fewer in number than those of the CBD, and Central Street shows more intrusions and losses than Merrimack Street, but among the area's historic buildings are some of great interest. On Prescott Street, the adjoining Southwick Block and Claflin Building (#58 and #66, respectively, both erected ca. 1880) are among the city's most conspicuous and intact commercial blocks of that period, retaining even their cast iron storefronts. Both are only partially occupied and are in need of the most careful kind of rehabilitation.

Similarly, the Old Market House, just off Central at 40 Market Street, has the least altered exterior of Lowell's major institutional structures of the 1830s, and should be rehabilitated and returned to productive use. The vacant Strand Theatre's Central Street facade (#128, built in 1917) is mostly hidden behind a metal screen, but the extravagance of the visible terra cotta ornament is more than matched by the interior decoration.

The Old Mansur Block at 101 Central Street (Figure 3-12) and the New Mansur Building at #91 (now McQuade's) provide a clear illustration of the changes in style and scale commercial structures underwent between the 1830s and 1880s. If the proposal is carried out to open up the Central Street views of the Pawtucket Canal by the removal of #111 and of the building south of 104 Central, the view of the south end wall of the Old Mansur Building with its characteristics double, parapet-linked chimneys will also be enhanced. However, in evaluating that proposal careful consideration should be given to maintaining the visual continuity of the wall of facades along Central, since the street has been flanked with solid rows of buildings since the 1840s, when the first shops were built on platforms over the canal. Replacement of the buildings over the canal with elements which suggest a continuous opacity, such as heavy, cast iron fences, might achieve the dual purpose of providing a canal view and maintaining the integrity of the block faces when viewed in perspective up and down the street.

Two High Victorian Gothic buildings on Central Street were once among the finest examples of that style in Lowell. Both are now in need of assistance. The Appleton Block of 1879 (#166) has lost its original storefronts and the pinnacles, pediments, and cresting that enriched its roofline. However, the decorative brickwork and polychromatic trim that remain on the body of the building are arguments for removal of the metal screen and paint which conceal the main facade of the structure. The Boston and Maine Depot of 1876 at 238-254 Central Street has also lost towers and cresting that originally enlivened

Figure 4-17 View of the Central Street block between Middlesex and Jackson Streets, 1979.

Figure 4-18 Sketch of Central Street, suggesting a new building at #241.

its roofline, but it is unique as Lowell's only surviving historic train station. Both the structure and the street would profit by a more sympathetic display of its surviving features.

The west side of Central Street opposite the old B. & M. Depot contains one of the city's architecturally richest and most diverse commercial groups (Figure 4-17). At the Middlesex Street end is the Union Building (1-5 Middlesex Street and 249 Central Street), a curved corner building erected ca. 1830. It was originally about twice as long on Central Street and the remaining portion has undergone numerous evolutionary changes, including the installation of a cast iron storefront and alteration of the gable roof to a mansard. The Union Building retains its essential simplicity, however, especially when compared to the Fiske Building of ca. 1877 (#219) at the other end of the block. Like the Appleton Block and B. & M. Depot, this High Victorian Italianate structure has lost its original storefronts and roofline cresting, but with its cast iron cornice and window trim, it is still the most exuberant Victorian building in the city. Adjacent to the Fiske Building, Cook and Taylor's Building (Gray Furniture,#231) of 1884 demonstrates the rapidity of changes in architectural fashion in late nineteenth century Lowell, countering Fiske's highly decorated style with more restrained brownstone and copper ornament in the Queen Anne style.

The adjacent structures on Middlesex and Jackson Streets add to the visual and historic richness of this block. The Union Building is abutted by a small handsome Italianate building (9 Middlesex Street) constructed of brick in 1877 for Eli Hoyt, manufacturer of Hoyt's German Cologne. The Fiske Building abutts 28 Jackson Street the first factory James C. Ayer built (in 1852) to manufacture patent medicine, which in turn adjoins the small, brick, Greek Revival building (#32) which housed David Dana's brass foundry as early as 1832.

The universal use of red brick and the gradualness of the shifts in scale maintain the compatibility of this stylistically diverse concentration of historic buildings. The block does suffer one severe intrusion, however, the Saab Annex at 241 Central Street. In style, scale, and materials, the Annex clashes sharply with the rest of the block. That property is an excellent example of an appropriate site for new construction in an historic streetscape. Figure 4-18 illustrates how a sensitively designed new building could mend this block.

The individual and group strengths of the Central Street area do not end with the Union-Fiske block. The much altered J. J. Turner's Hotel at #278 is the oldest building in the area, dating to 1825, and recalls the early concentration of hotels on Central and nearby streets. Further south on Central Street, the Queen Anne-style Shedd Block of 1883-84 (#295) looms over the small shop beside it, built ca. 1830 (now Helen's Hair Haven, #289-291). On Gorham Street, which continues the line of Central Street where the latter curves slightly eastward in front of the B. & M. Depot, a visual terminus to the LHPD is provided by the Old Post Office at the corner of Appleton Street. That gray granite, Richardsonian Romanesque building (89 Appleton Street) is similar in material and style to the City Hall and Memorial Library, and opened the same year, 1893.

The Old Post Office does not quite complete the list of major historic resources scattered throughout the Greater Central Street area. Cater-cornered across the intersection from the Post Office is a trio of masonry buildings, all constructed ca. 1830 (Figure 4-19). The northernmost, a two-story brick building, was originally a tailor's house (#62). The central building, highly unusual in Lowell for its early construction of ashlar granite, was built as a double house (#72-76). The blocks of its facade are finely dressed, while the side walls are rock-faced. The southernmost brick structure, a full three stories tall, was built as the Lowell Hotel (#80). Nowhere else in the LHPD is there such a concentration of commercial/residential structures from Lowell's earliest period of

Figure 4-19 View of 62, 72, and 80 Gorham Street (left to right), all built ca. 1830, photographed 1979.

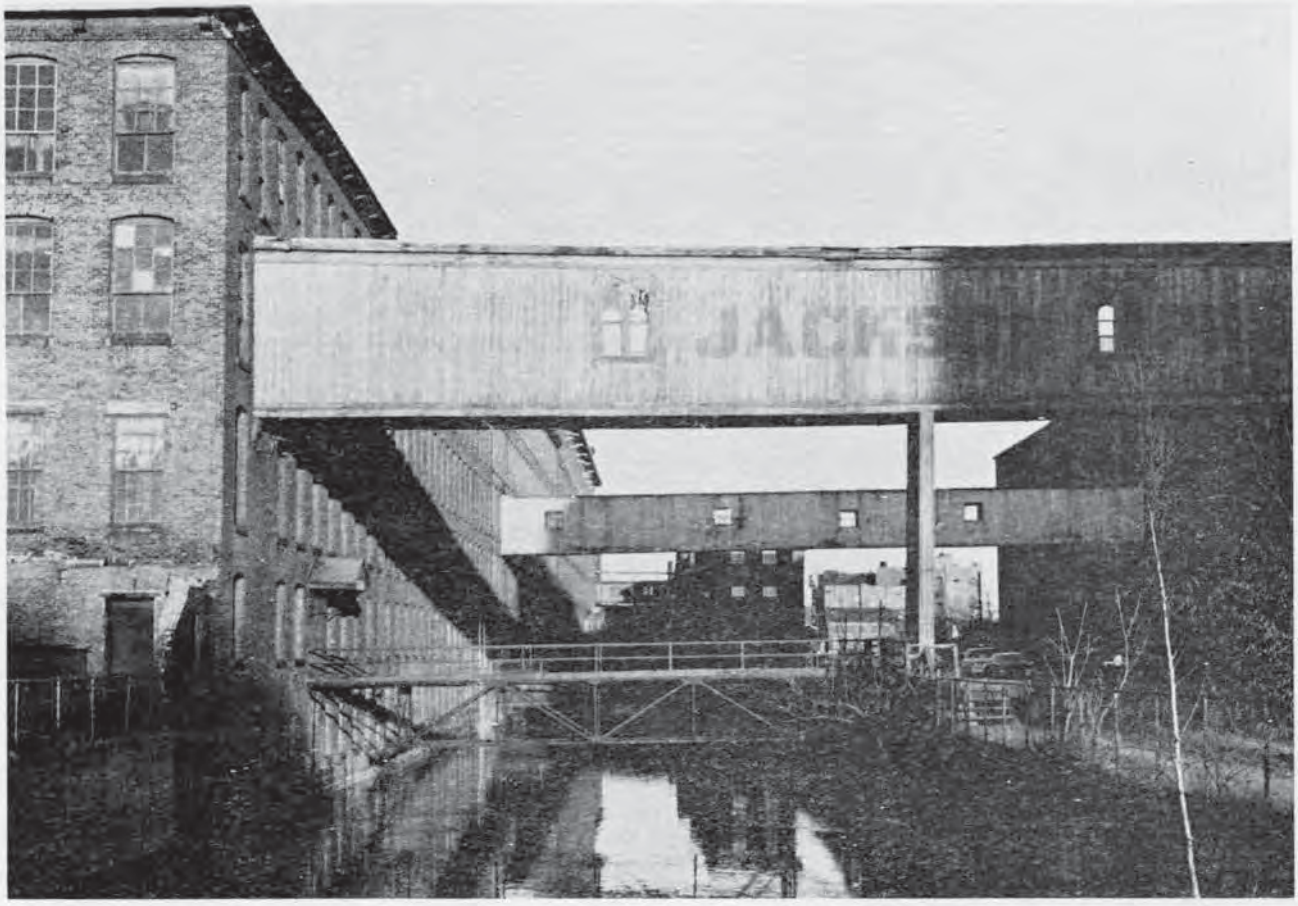

Figure 4-20 View of Appleton mills along the Hamilton Canal, 1979.

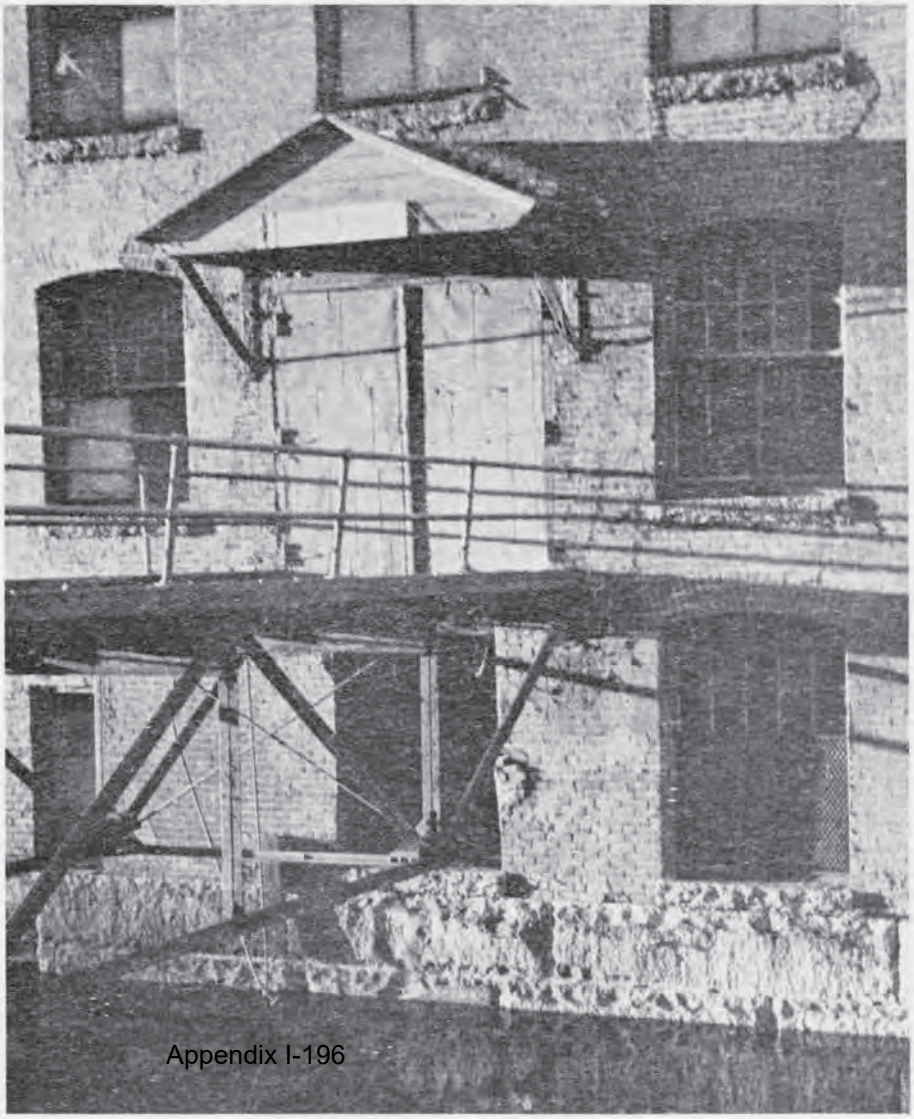

Figure 4-21 Detail of Mill #4, Appleton Manufacturing Company, 1979.

development. All three retain most of their original exterior fabric, providing a unique opportunity within the District to preserve and rehabilitate a mutually reinforcing group of very early structures.

The Greater Central Street area has close ties to two other portions of the LHPD not yet discussed--the Middlesex and Jackson Streets area to the west, and the lands along the Concord River to the east and the south. The former area is physically and historically more closely related to the Central Street commercial area, and will be discussed first.

AREA SEVEN--MIDDLESEX-JACKSON STREETS

The Middlesex-Jackson Streets area contains industrial, commercial and residential structures plus important elements of the canal system and a few important examples of institutional buildings. The area is bounded on the north by the Pawtucket Canal, on the west by Thorndike Street, on the south by the edge of the district between Middlesex and Appleton Streets, and on the east by Central Street. The LHPD boundaries quite properly make an excursion along the south side of Appleton to include an important early row house there (Figure 3-11).

Forming the foundation of this area, historically and visually, are the Appleton and Hamilton Manufacturing Company mills on the power island between the Pawtucket and Hamilton Canals. These parallel canals form the purest manifestation of the ideal power island arrangement in the city. The 473-foot length of the ca. 1868 Hamilton storehouse (Figure 3-26) dominates the eastern end of Jackson Street, and Appleton buildings line both sides of that street toward its western end (Figures 4-20 and 4-21).

Both yards have lost their early buildings and all of their housing, but the remaining buildings include some of the best examples of Lowell industrial structures from certain periods. Hamilton's Mill #4 is the most intact mill of the mid-1840s surviving in the city, and that company's Counting

House and long storehouse on Jackson Street typify the wave of construction following the Civil War. The Appleton yard was almost entirely rebuilt in the first two decades of the twentieth century, but the company's "New Mill" of 1873 on the south side of Jackson Street was retained, and is a sterling example of a steam powered mill of the 1870s (Figure 3-25). The two long bridges that link the Appleton buildings on Jackson Street to the main millyard across the canal are particularly prominent features of this industrial landscape.

The north side of Middlesex Street originally was lined with the boarding houses of the nearby mills. Industrial expansion and sale to commercial developers eventually eliminated the boarding houses, and now that side of the street is a mix of parking lots and commercial/residential structures, mostly of late nineteenth century vintage.

The south side of the street has a similar blend, except for the central block between Elliot and South Streets, where three significant earlier structures fill the block. At the center is the Free Chapel (#150), long the home of the Ministry-at-Large, which attended to the secular as well as religious needs of Lowell's poor for nearly a century from the 1840s through the 1930s. The Queen Anne-style facade was added to the building in 1882 (Figure 4-22). From the sides and rear, the main body of the 1829 brick structure remains visible (Figure 4-23). It was originally constructed by the Hamilton and Appleton Companies to provide a schoolhouse for the children of their employees. East of the Free Chapel is the Elliot School (#140), built by the city in 1846 as a primary school. The small brick structure is now somewhat hidden by side wings and changes to the facade (Figure 4-22). At the west end of this group is a structure with a brick ground floor and wood-frame second floor (#160-170) built ca. 1848. It was occupied by grocers and a brewery through most of the nineteenth century. These three buildings are reminders of the boarding houses now gone from Middlesex Street, for all three provided services to the residents of the houses.

Figure 4-22 View of 140 Middlesex Street (the Elliot School, center) and 150 Middlesex Street (the Free Chapel, right) from the northeast.

Figure 4-23 Rear view of the Free Chapel and the Elliot School.

The Coburn Block on Appleton Street (#100-126) was not company-owned when it was built ca. 1832-34, but the Hamilton Company bought the whole row in the mid-1840s for employee housing. It was sold back into private ownership during the Civil War. Two of the original eight units of the two-and-one-half story row were lost behind a new facade in 1921, and a third received a mansard roof sometime earlier, but the majority of the row is still intact (Figure 3-11). It presents a fascinating combination of materials and styles with its brick facade, rubblestone side and rear walls, Federal-style elliptical-roofed dormers and rather bold use of granite trim, suggesting Greek Revival influence. A portion of the row is vacant, and prompt action should be taken in support of this unique early residence.

Just east of the Coburn Block, the Bancroft Block (90 Appleton Street) illustrates a multi-unit residence built fifty years later (ca. 1881-85). Only in its use of red brick does it identify with the earlier row, differing sharply in scale and style.

AREA EIGHT--CONCORD RIVERBANKS

The last five areas of the LHPD described in this chapter are primarily buffer zones for waterways important to Lowell's development. In some of these areas, the waterpower features are the principal historical resources, but several include additional assets. The largest and most varied of these areas extends south along both sides of the Concord River, and contains notable examples of industrial establishments that developed separately from the main Lowell corporations. The area also adds a few important residential, institutional, and commercial structures to the LHPD.

The east bank of the Concord is in the Belvidere neighborhood, but the LHPD boundaries do not extend into the historically prestigious residential sections traditionally associated with Belvidere. Aside from some developer's houses of the 1890s on Perry Street (#54-68) and some fragments of industrial complexes, especially tanneries, on the same street, that portion of the area adds

little to the visible historic fabric of the LHPD. Of greater historical interest are various structures on the west bank of the river, and the two nineteenth century stone-arch bridges that span the Concord at Church and Rogers Streets (built 1857-8 and 1884, respectively). Just north of the Church Street Bridge is the rubblestone factory D. C. Brown built in the 1840s. He manufactured reeds, heedles, and other power loom accessories for sale to the textile corporations.

There is a larger and more autonomous industrial zone at the southern extremity of the Concord River area. Just south of Hale's Brook, Oliver Whipple established in ca. 1821 a gunpowder mill off what is now Lawrence Street. He powered the mill with his own canal off the Concord River. In the 1840s, he expanded the canal to provide waterpower to a number of industrial tenants. In the 1860s, the Wamesit Power Company further expanded the canal to power larger factories that manufactured woolen goods, carpets, gunpowder, and other products. One of Whipple's early stone buildings and all or parts of four other factory complexes stand within the LHPD. More importantly, the Wamesit Canal itself, the heart of Whipple's alternative to the main Lowell canal system, still exists (Figure 4-25). It parallels the Concord for over 1,500 feet, then turns westward under Lawrence Street and empties into Hale's Brook, using the stream as its tail-race. This whole complex of river, stream, canal, and mills is of major importance, particularly for the contrast it provides to the main Lowell system.

Among the complex's individual components, the rubblestone powder mill building is probably the earliest industrial structure surviving in the city (Figure 3-3). Abandonded and open to the elements, it warrants prompt protective action. Two complete woolen mill complexes survive along the canal. The Stirling Mills (576 Lawrence St.) stand behind the powder mill on the bank of the river, a site of considerable natural beauty (Figures 4-24 and 4-25). The main mill building dates to ca. 1880. Considerably earlier and more visible to the passerby on Lawrence Street is Belvidere Woolen Mill No. 2 on the banks of Hale's

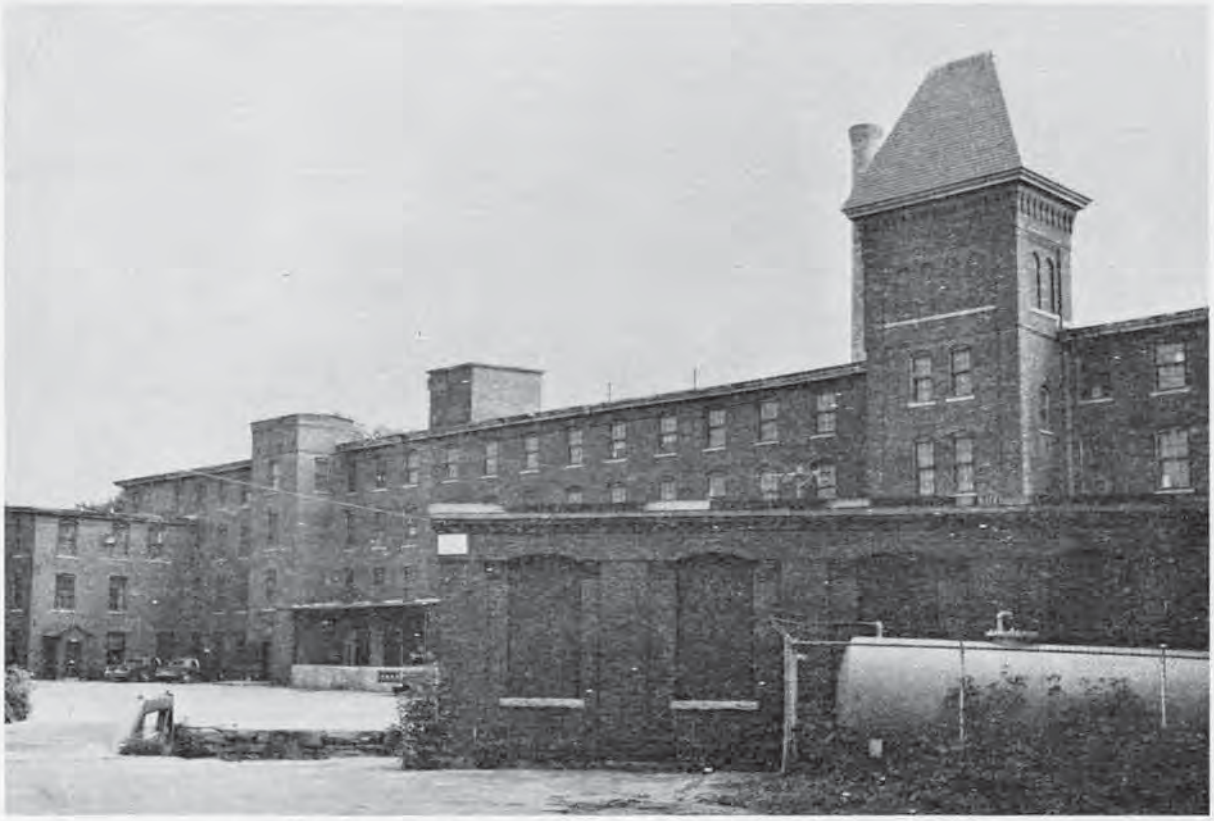

Figure 4-24 Stirling Mills, built ca. 1880, photographed 1979.

Figure 4-25 View of the Wamesit Canal behind Stirling Mills, 1979.

Figure 4-26 Belvidere No. 2 Mill, 645 Lawrence Street, built ca. 1863, photographed 1979.

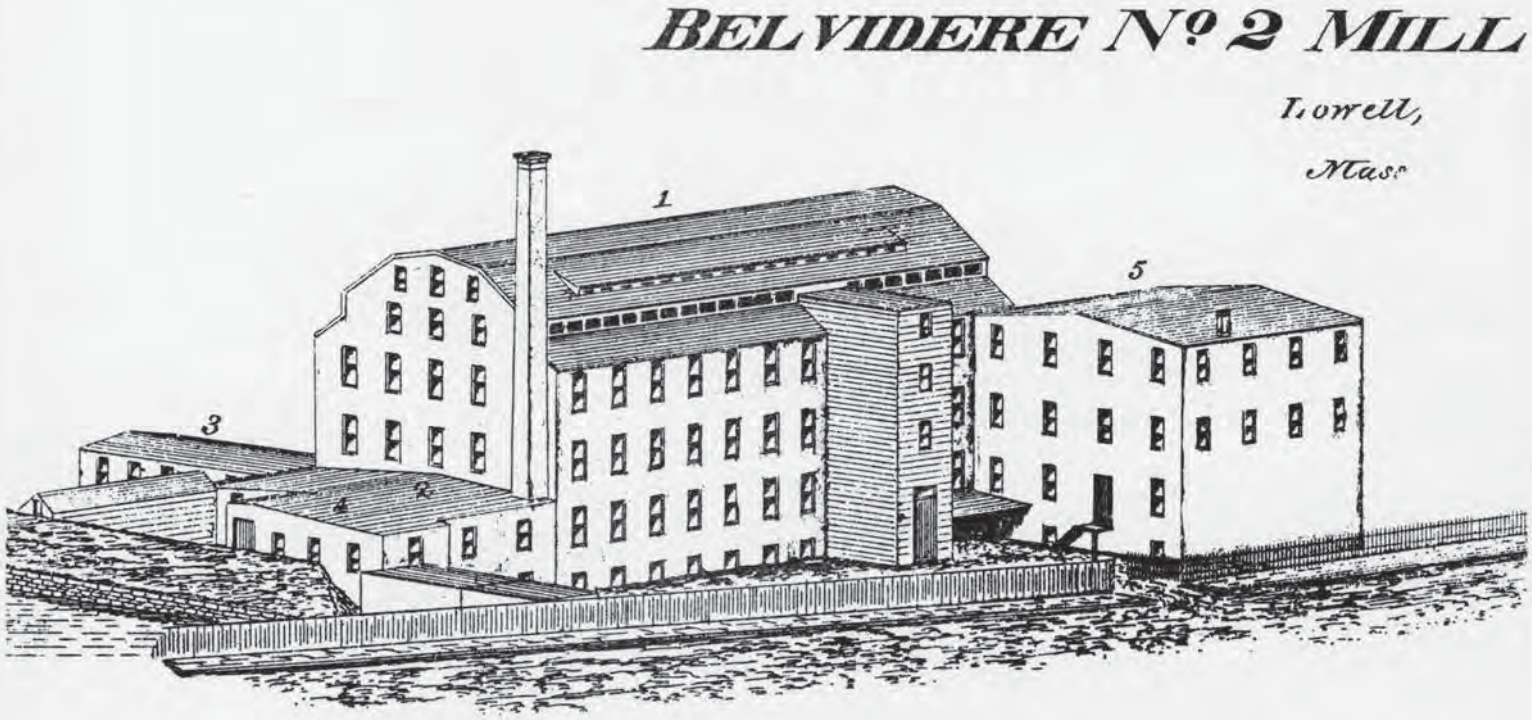

Figure 4-27 Detail of an 1880 insurance survey of Belvidere No. 2 Mill.

Brook (#645). Built ca. 1862, this complex retains its original mill, storehouse and stair tower, and its early power house (Figures 4-26 and 4-27) Inexplicably, the last three structures are within the LHPD boundaries, while the mill itself is just outside the line. Also excluded from the LHPD is the northern end of the Wamesit Canal, where it enters Hale's Brook.

Two other partial mill complexes off the Wamesit Canal are notable as examples of early twentieth century masonry construction techniques. Just south of Belvidere No. 2 at 685 Lawrence Street are two structures built ca. 1910 by the U. S. Cartridge Company. Although reduced in length by a recent fire, they remain Lowell's best demonstration of brick-pier industrial construction. The walls between the piers are given over almost entirely to wide, segmental-arched windows. The Waterhead Mills at the south end of the Wamesit Canal power island were also built ca. 1910. The main structure (900 Lawrence Street, rear) is also of brick-pier construction, but the use of English bond brickwork may be unique in Lowell.

The historic houses of the Concord River area serve as representatives of the greater wealth of such houses in Lowell outside the District. Some of these are as close as the west side of Lawrence Street, and others are not much further away in the Chapel Hill neighborhood and around the South Common. Within the District, the house at 48 Lawrence Street is more interesting for its historic occupants than for its present appearance. Luther Lawrence, the second mayor of Lowell and brother of the textile magnates Amos and Abbott Lawrence, built the house ca. 1831, and resided there until his death in 1837. From 1842 until 1875, Tappan Wentworth lived in the house, and his alterations probably brought it close to its present form. Wentworth was prominent in Lowell as a lawyer, investor, and politician, and served a term in Congress.

South of the Lawrence-Wentworth House, the Colburn School of 1848 (122 Lawrence Street) is a far less altered structure. It continues to serve its original function, and is the oldest schoolhouse in the city to do so. The historic houses further south on Lawrence Street more often sheltered workers from the various Concord River factories than employees of the factories and stores in central Lowell. 202 Lawrence Street is a Greek Revival cottage, built ca. 1840. 224-228 Lawrence (ca. 1870)links together two small, mansard-roofed cottages into a double house with U-shaped plan. 310-326 Lawrence, a five-unit wood-frame row house, was built ca. 1870, and like #224-228, it accommodated workers from the adjacent mill at Massic Falls. An anachronistic house at 8 Clarks Court was built ca. 1834-7 by and for a carpenter who worked at Whipple's Powder Mills.

The Concord River area also contains one of the LHPD's most unique and intact small commercial buildings, the Greenwood Bros. Store at 573 Lawrence Street (Figure 4-28). Located near the Wamesit Canal and its factories, it was built as a grocery store in 1872. The store retains its cast iron storefront and cast concrete trim, a decorative material seldom seen in the LHPD.

Before discussing the other areas, another historical building related to the Concord River area deserves mention, even though it is a few hundred feet outside the District, west of its southernmost end. Oliver Whipple's own house still stands on Moore Street at the corner of South Whipple Street. Whipple was the main developer of the industrial complex in that area and a major manufacturer of gunpowder in his own right. He was also a substantial figure in Lowell's civic affairs. His house dates from the 1820s, and is particularly interesting for its long rear wing. That feature, shown on maps as early as 1832, appears to have been built as a series of tenaments, presumably for some of Whipple's employees. If so, this arrangement is in sharp contrast to the hierarchical separation practiced by the major Lowell corporations in housing the various industrial classes.

Figure 4-28 Greenwood Brothers Store, 573 Lawrence Street, built 1872, photographed 1979.

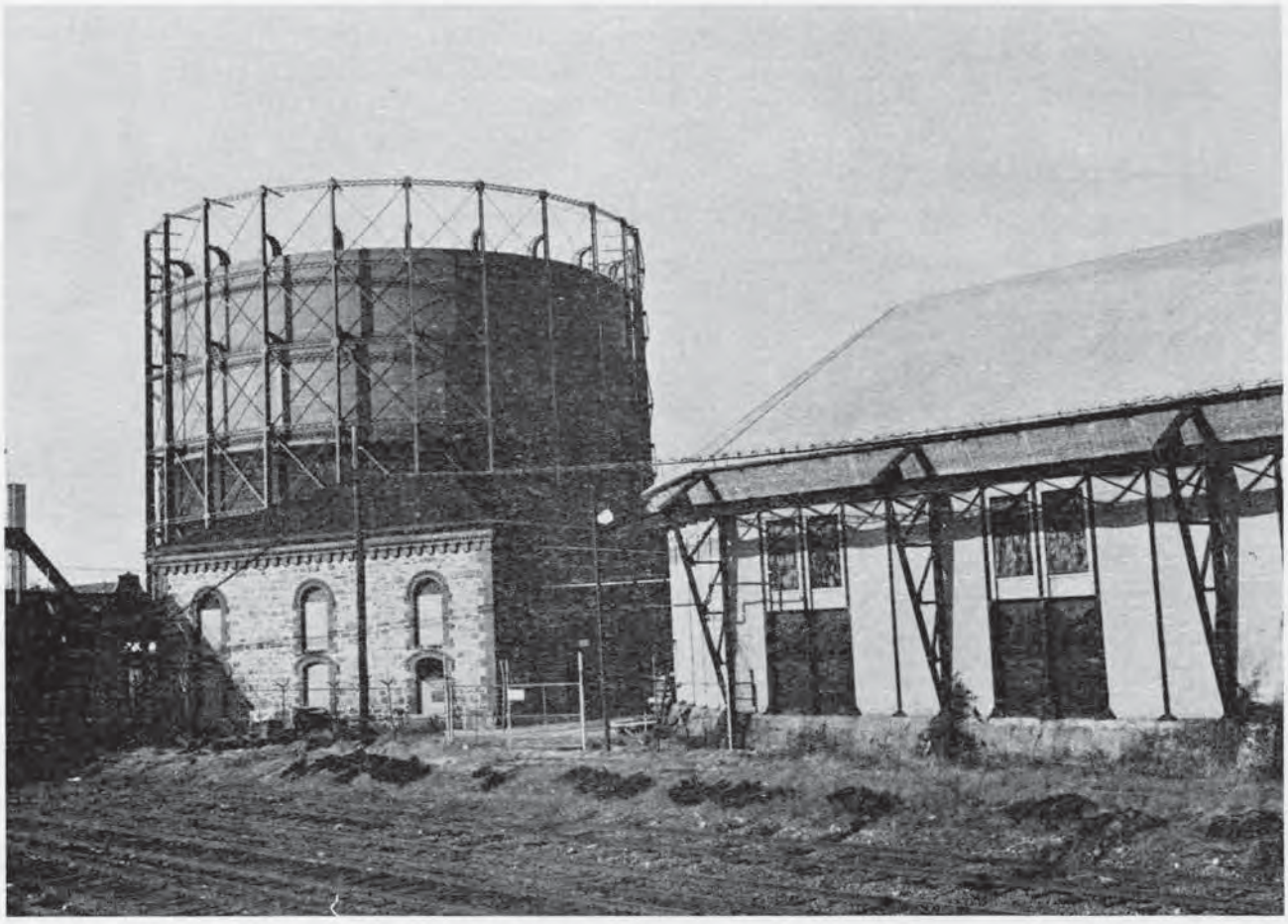

Figure 4-29 View of the gasworks of the Lowell Gas Light Company, 1979. The Coal Pocket (right) was built ca. 1901, the Purifying House (left) ca. 1870.

AREA NINE--MID-PAWTUCKET AREA

The Pawtucket Canal curves south, east, and north from Broadway Street toward the Swamp Locks, and that portion of the canal and the sections of the LHPD bordering it constitute the ninth area in this discussion. The broad canal itself is the major cultural resource of this area, but a few historical structures are scattered along its banks. On the south side, two former hotels stand in the shadow of the ramp that carries Middlesex Street over Thorndike Street. The Howard House at 533 Middlesex dates to the 1830s, and is similar to the Lowell Hotel at 80 Gorham Street in Area Six (Figure 4-19). Adjoining the Howard House is the old St. James Hotel (#543), an Italianate structure of the 1880s. It accommodated travelers from the railroad station which stood just across Middlesex Street.

On the north bank of the canal, Joan Fabric Company operates a plant in a group of late nineteenth and early twentieth century mill buildings on Western Avenue near Thorndike. From the start, operations in these buildings ran on steam rather than waterpower from the Pawtucket Canal, for they stand above the canal's first fall at Swamp Locks. The long, low structure at 275-285 Western Avenue was built by the Lowell and Nashua Railroad as a freight depot in the 1870s. At Western Avenue and School Street, the gasworks of the Lowell Gas Light Company include a pair of very handsome stone buildings trimmed with red brick. This combination of materials reverses the standard order of nineteenth century Lowell construction. One was built ca. 1865 as a machine shop, the other ca. 1870-75 as a purifying house. Beside them is the gaswork's Coal Pocket, an unusual building in plan and structure. The narrow, oval-shaped structure is over 400 feet long, and was constructed ca. 1901-05 in a manner that leaves much of the steel frame exposed.

Like the Concord River area, the mid-Pawtucket area stands close to some notable historical resources that are just beyond the LHPD boundaries. The triangular area north of Dutton Street and west of Fletcher Street contains several small nineteenth century industrial establishments, some

built of Lowell's characteristic rubblestone. They represent the broadened industrial opportunities steam power, and later electricity, brought to the city.

Also north of Dutton Street is a potential historical resource of quite a different kind. Six wooden cottages line a small street called Wamesit Court, each a mere story-and-one-half tall. The three cottages on each side of the court are linked together by lateral wings between the houses. Circumstantial evidence suggests that these cottages were early workers' houses moved to this site in the mid-nineteenth century from the Lowell Manufacturing Company's millyard. If that hypothesis is correct, Wamesit Court contains workers' housing of a type rare in Lowell even when they were built ca. 1828.

AREA TEN--FRANCIS GATE

Like the preceding area, the major historical resources of the Francis Gate area relate to the canal system, but here the most significant resources of the area are fairly concentrated rather than diffuse. This tenth area includes the canal and its adjacent lands from Broadway to Pawtucket Street.

The area is generally residential in character, but its two most prominent features are the Francis Gate complex on the canal, and the adjacent John Pilling Shoe Factory, which was recently converted to housing. The Gate complex includes a navigational lock, a gatehouse to regulate the normal flow of water (Figure 4-31) and James B. Francis' ingenious Guard Gate (Figure 4-30), designed to protect the heart of the city from floods. Ridiculed as unnecessary when completed in 1850, it successfully contained a record flood just two years later. The area around the Francis Gate complex and along the canal of the river is now a state park, but the dilemma of providing access while restraining vandalism has not yet been solved.

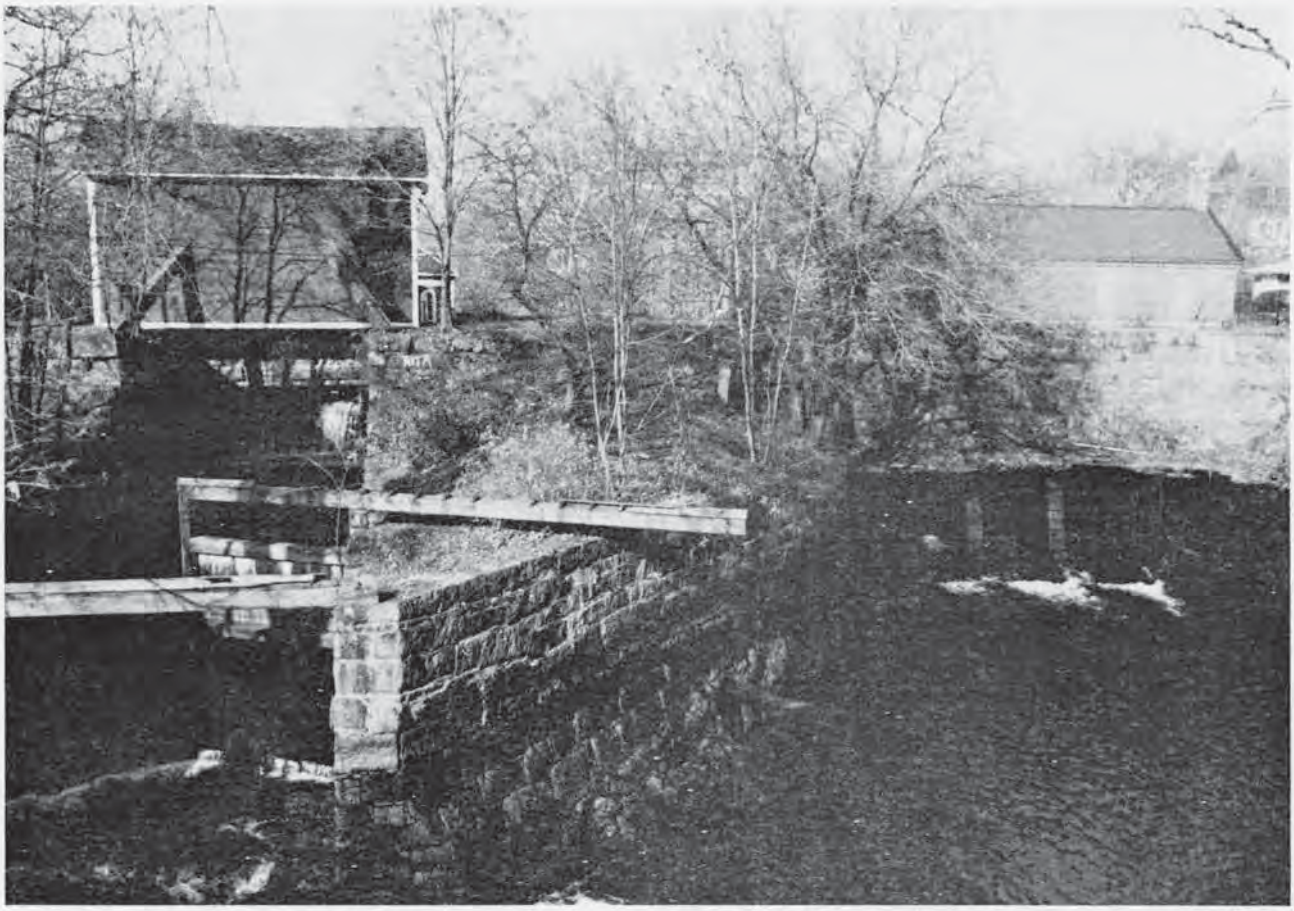

Figure 4-30 View from the south of the Francis Gate complex, 1979. At left is the navigational lock and the Francis Gate, at right the Guard Dam and its gatehouse.

Figure 4-31 View of the Francis Gate complex from the northwest, 1979. At left is the gatehouse to the Guard Dam, at right the lock gatehouse.

Figure 4-32 View up Clare Street from the south, 1979.

The Francis Gate area also contains some of the LHPD's best examples of certain periods and forms of residential development. The short stretch of Broadway Street within this area contains a half dozen small frame houses characteristic of the expansion of Lowell's residential areas in the 1870s. Clare Street was uniformly built with frame houses between 1895 and 1905 (Figure 4-32). Most were first owned and occupied by Irish-American working men and their families. Litchfield Terrace on the west side of the canal is a much smaller residential development of even more modest frame houses, built ca. 1910.

AREA ELEVEN--PAWTUCKET FALLS

The Pawtucket Falls on the Merrimack River, the natural feature that drew prehistoric and industrial man to Lowell, dominates the eleventh area of the LHPD. This area includes both banks of the river from the head of the Pawtucket Canal on the west to Textile Avenue on the east. The man-made structures that harness the falls--the Pawtucket Dam and Northern and Pawtucket Canals--are the most prominent historical features of this area, along with the Northern Canal Gatehouse (Figure 4-33) and the Great River Wall that carries that canal along the falls (Figure 3-17). The area also contains several significant historic houses, since the land around the falls on both sides of the river has traditionally been favored as a residential district. Among these houses are both the oldest and the grandest in the LHPD.

The oldest house in the District is the Spalding House of 1761 (383 Pawtucket Street). Indisputably the grandest is the Frederick Ayer Mansion of 1876 (335 Pawtucket Street). Both are on the south bank of the river, and like many of the houses along Pawtucket Street, both now serve institutional purposes. The Spalding House is a house museum and the headquarters of a D.A.R. chapter. The Ayer Mansion, along with substantial rear additions, houses the Franco American School. The Second Empire house at 295 Pawtucket Street, built ca. 1873 for a banker and his family, has been converted into a mortuary, as have several

other large houses along this street. The Old Stone House (267 Pawtucket Street), built of rubblestone in 1824, has been a tavern and hotel, mansion (of James C. Ayer, Frederick's brother), charitable home for young women and children, and is currently a residential hall for nuns from the nearby St. Joseph's Hospital (Figure 4-34).

The north bank of the Merrimack River remains residential in character. Three brick houses on Riverside Street (#22, #26-28, and #52) are the most notable ones in that section. They were built in the 1820s and 1830s, when that area was still West Dracut.

Further east, on a fine site on Colonial Avenue overlooking the falls, a half dozen houses (#22-92) built in the early twentieth century provide a middle class comparison to the more modest houses of Litchfield Terrace in Area Ten.

AREA TWELVE--CENTRALVILLE

The final area within the LHPD to be discussed extends between the Aiken Street Bridge and the Hunts Falls Bridge on the north bank of the Merrimack River, in the Centralville neighborhood. Centralville is rich in nineteenth century houses of various styles and dates. However, only a single side of a single street (Lakeview Avenue) is included in the LHPD, along with the V.F.W. Highway which blocks this neighborhood from the riverbank. Nonetheless, the street does contain a sampling of modest frame houses dating from most decades of the nineteenth century after 1840.

The key resource of this area, however, is not what is contained within it, but rather what can be seen from it. Lowell's nineteenth century "Mile of Mills" on the south bank of the Merrimack (Figure 4-35) was broken by the demolition of the Merrimack Manufacturing Company's mills and of the secondary Lawrence millyard (Figure 4-36). Nevertheless, the view from Centralville of the Massachusetts, Boott, and Lawrence yards and the city behind them remains the clearest comprehensive image of Lowell as the "City of Spindles."

Figure 4-33 View from the southwest of the Pawtucket Falls and the Northern Canal Gatehouse, 1979.

Figure 4-34 Old Stone House, 267 Pawtucket Street, built 1824, photographed 1979.

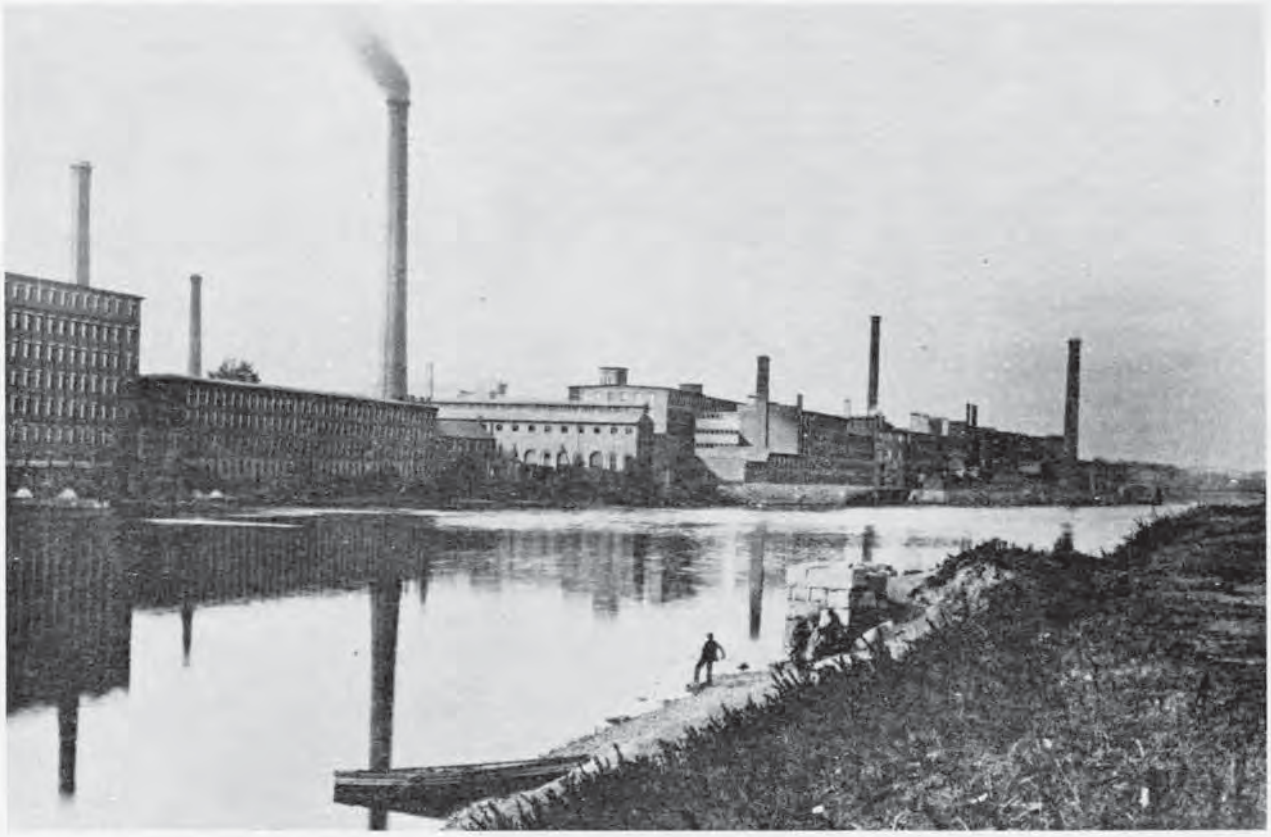

Figure 4-35 View from east across the Merrimack River to the Merrimack Manufacturing Company (left) and the Lawrence Manufacturing Company (center and right), ca. 1895.

Figure 4-36 View from the east of the Boott Mills (left and center) and of the apartment towers on the site of the Merrimack Manufacturing Company (right), 1979.

The Park and the District encompass most of Lowell's historic waterpower features, large industrial complexes, and commercial center. The majority of these historic resources is concentrated in the central areas identified as One through Seven in this discussion, but the far-flung portions of the LHPD make substantial contributions. Lowell is fortunate to retain not only the main elements of its nationally significant industrial development, but also much of the nineteenth century city--inside and outside the Park and the District--that supported and was supported by the mills. Each enriches and provides context for the other. The magnitude of the Lowell Cultural Resources Inventory gives testimony to the scale of the Park and the District and to their wealth of resources, but the fourteen volumes should not obscure the truth that it is the city as a whole that is Lowell's real historical resource.

MAP OUTLINING TWELVE AREAS DISCUSSED IN CHAPTER FOUR.

SOURCES FOR THE INVENTORY

Lowell is a richly documented city. The inventory project drew upon historic data in over a dozen collections, but by no means exhausted the available sources. Much more can and should be learned about Lowell's built environment, and hopefully the inventory will provide a reliable foundation for that work. The following list of sources is arranged in the approximate order of the frequency with which they were used in preparing the inventory.

SPECIAL COLLECTIONS, ALUMNI-LYDON LIBRARY, UNIVERSITY OF LOWELL

Special Collections is the broadest-based repository of information on the history of Lowell. The comprehensive collection of maps and atlases, city directories, illustrated handbooks and guides, and other published materials gathered there was the most important source of historic information in carrying out the inventory. The maps and atlases provided the basic historic information on every property, and the directories were almost as frequently consulted.

Of similar importance is Special Collection's picture file of prints, photographs and other graphic materials related to Lowell, including many images on deposit from the Lowell Historical Society and the Lowell Museum. Filed separately are approximately four-thousand photographic negatives (and prints) exposed for the Proprietors of Locks and Canals, primarily showing canal and industrial features in the first half of the twentieth century. Together with the well-illustrated histories, guidebooks, yearbooks, and the like published in the late nineteenth and early twentieth centuries, a remarkably complete composite picture of Lowell's historic appearance, particularly in the late nineteenth century, can be formed.

Other Special Collections resources valuable to the inventory were the document file on Lowell people, places, corporations, and buildings; architectural and engineering drawings and millyard insurance surveys, mostly deposited by Locks and Canals; and

the collection of manuscripts, dissertations, and other research works on Lowell topics. The cooperation and active assistance of the Special Collections staff made these extensive holdings all the more useful.

PROPRIETORS OF LOCKS AND CANALS ARCHIVE, BOOTT MILLS, LOWELL

The Proprietors of Locks and Canals private archive at the Boott Mills is the best source of historic plans and drawings related to Lowell's power canal system and to the major industrial enterprises that used it. The archive also contains some Locks and Canals Directors' records and other invaluable documents. Lowell was initially a city built for industry, and this industrial archive contains unique sources related to the development of the town and city as a whole, particularly manuscript maps.

The broad scope of the inventory prevented an in-depth analysis of most of the very specific information available in the Proprietors of Locks and Canals archive. That repository should be an important point for further research on the canals and the major industrial sites.

Boott Mills is an active business, yet its staff was consistently generous in assisting the inventory team.

Memorial Library, City of Lowell

The city library's reference collection of Lowell histories, directories, maps, and atlases is very extensive, and includes a copy of the 1936 atlas of the city not found at Special Collections. A unique strength of this library is its exhaustive microfilm collection of Lowell newspapers, accompanied by a WPA-prepared index. The Memorial Library staff frequently advised the inventory team on specific research questions.

Registry of Deeds for the Northern District of Middlesex County

Lowell researchers are fortunate to have county registry of deeds records available locally.

The breadth and time frame of the inventory effort prohibited investigation of the title history of most properties, but the registry was consulted on many key parcels. Of particular interest were several detailed building contracts discovered in the course of title research, dating from the 1830s through the 1850s. A focused search for and analysis of such documents would tell much about early building practices in Lowell.

City of Lowell, Various Departments

The records of at least four city departments were consulted in the preparation of the inventory. The City Engineer's plates were used to determine current ownership of property. Other records and plans related to public works were not utilized, and represent a source for further research.

The Buildings Office has an index of permit applications dating from 1906 to the present, and the documents themselves are available from 1924 to the present. These records can be very informative as to date, cost, materials, and other particulars on new construction, alterations, and demolition projects. The index is arranged by street name and date of application, but not by numerical address. Locating a permit of unknown date for a property on a long and active street (e.g., Merrimack Street) can be quite time consuming, and could only be done for a few particularly important buildings which raised questions that could not be answered from other sources.

The Assessor's Office assisted in determining the tax status of various properties. Other resources, such as annual property valuation books arranged by owner and address, were not used on the inventory, but could be useful in tracing alterations to specific properties.

The files of Division of Planning and Development's Neighborhood Analysis Project provided photographs of several properties demolished recently, particularly in the Acre neighborhood. Another resource is the Division's collection of photographs of areas affected by urban renewal projects.

Other Sources

The inventory team's less extensive use of other repositories of historic Lowell information more accurately reflects the constraints of the project than the potential usefulness of those sources. The Manuscript Collection at Baker Library of the Harvard Business School has an extremely extensive collection of business records from many of the major Lowell corporations. A brief examination of the material on a single company confirmed that detailed information on the construction and operation of the mills can be uncovered in these records. Like the Proprietors of Locks and Canals' archive, the Baker Library represents a major source for further research on industrial Lowell.

The Merrimack Valley Textile Museum in North Andover includes considerable Lowell material in its library. This is a particularly useful source on the many industrial enterprises in Lowell other than the major corporations, such as the mills on the Concord River. The inventory team was able to devote few hours to the Museum's library, but the very helpful staff there made it time very well spent.

The Lowell Museum's files were consulted on several subjects, particularly concerning immigrant groups. In the course of the inventory, the Museum deposited its photographic file with Special Collections at Alumni-Lydon Library, and several images in that file contained information important to the project.

The Boston Athenaeum's collections include several architectural drawings for Lowell buildings, and an exquisitely detailed manuscript map of Lowell dated 1835. Both the drawings and the map warrant further examination.

The library of the Society for the Preservation of New England Antiquities has the largest and broadest collection anywhere of historic photographs related to New England architecture. The material in the collection on Lowell is extensive. Particularly useful to the inventory were the many stereographs of nineteenth century Lowell scenes.

The Massachusetts Historical Commission's records of archeological sites was consulted for the inventory

and this report. The Commission also provided the National Register of Historic Places nomination forms prepared for the Middle-Merrimack Streets, the Locks and Canals, and the City Hall Historic Districts. The Massachusetts State Archives provided some maps consulted in the course of the project. The State Department of Corporations and Taxation has a useful index to the charters and charter changes of all Massachusetts corporations.

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Lowell

Locks and Canals Historic District, Lowell, MA
Joe Orfant, 1975
CDA, 50 Arcand Drive, Lowell
looking south at the sluiceways gatehouse at
the Francis Gate site
photo #5 of 6

Middlesex Co. Mass.

APR 6 1976

AUG 13 1976 DOG

Middlesex Co. Mass.

Lowell

Locks and Canals Historic District, Lowell, MA
Joe Orfant, 1975
CDA, 50 Arcand Drive, Lowell
looking north on Suffolk Street to the Suffolk Yard on the left, the Lawren ce County House in the background, and the Tremont Yard on the right

photo #4 of 6

APR 6 1976

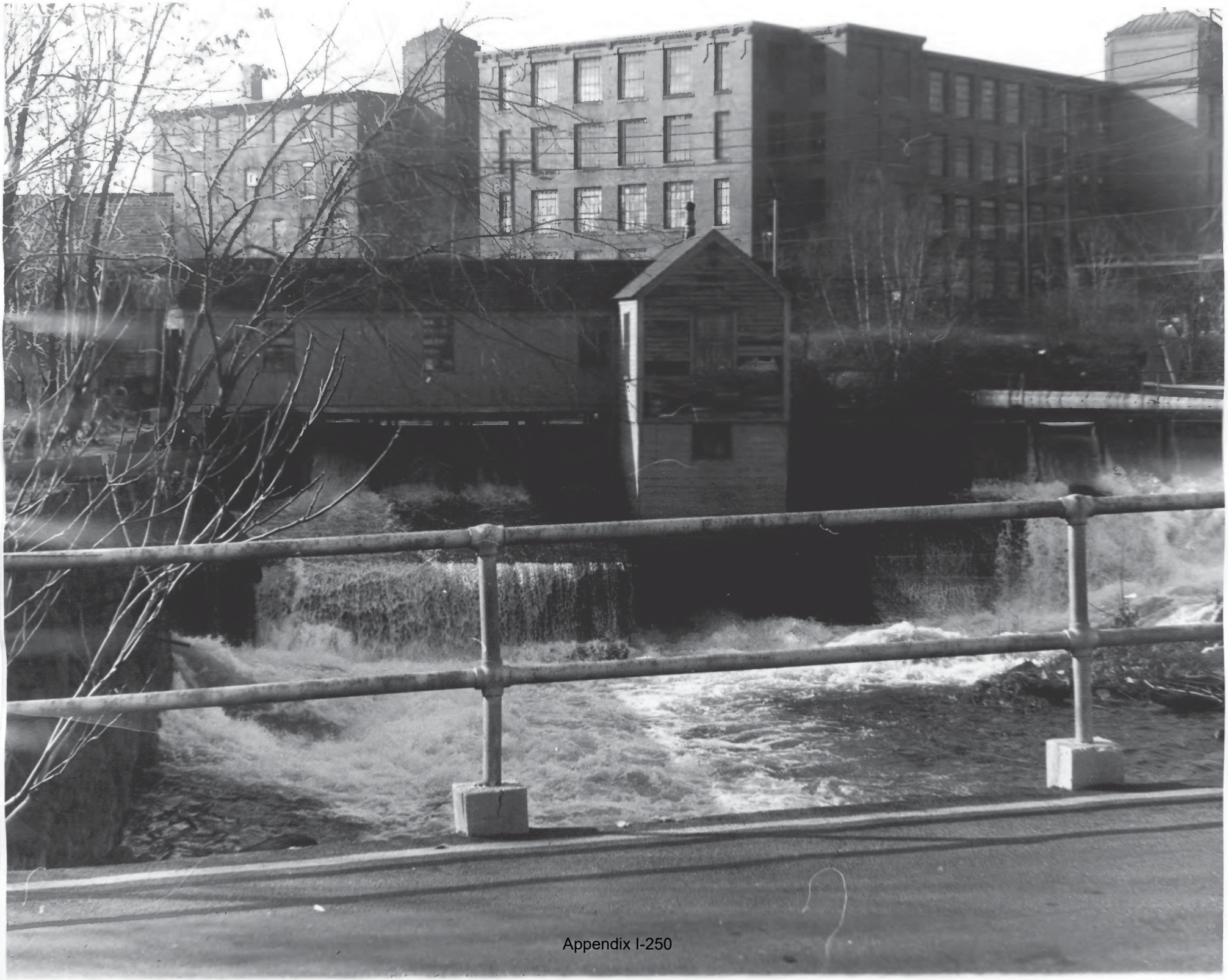
Middlesex Co. Mass.

AUG 13 1976 DOG

Lowell

Locks and Canals Historic District, Lowell, MA
Joe Orfant, 1975
CDA, 50 Arcand Drive, Lowell
looking north from French Street Extension to
the Tremont Gatehouse and the Suffolk Yard
on the left
photo # 3 of 6

Middlesex Co. Mass



Lowell

Locks and Canals Historic District, Lowell, MA

Joe Orfant, 1975

CDA, 50 Arcand Drive, Lowell

looking southwest at the Swamp Locks Dam and Sluicway, in the Background is the 1890 plant of the Lowell Machine Shop

photo #2 of 6

Merrimack Co, Mass.

APR 6 1976

AUG 13 1976 DOG

Lowell

Locks and Canals Historic District, Lowell, MA
Joe Orfant, 1975
City Development Authority, Lowell, MA
looking northeasterly from the O'Donnell Bridge
at the Northern Canal and the Canal Walk
photo #1 of 6

Middlesex Co., Mass.

APR 6 1976

AUG 13 1976 DOC

Lowell

Locks and Canals Historic District, Lowell, MA
Joe Orfant, 1975
CDA, 50 Arcand Drive, Lowell
looking northwest from Broadway at the
Western Canal
photo #6 of 6

Guidelcast Co. Mass

APR 6 1976

AUG 13 1976 DOE

LOWELL LOCKS & CANALS HD
Photo credit: AASLH

LOWELL LOCKS & CANALS HD
Photo credit: AASLH

LOWELL LOCKS & CANALS HD

Photo credit: AASLH

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Photo credit: AASLH

LOWELL LOCKS & CANALS HD
Photo credit: AASLH

LOWELL NATIONAL HISTORICAL PARK

SUBJECT: The Solomon, Jade Pagoda, and Old City Hall buildings.

DATE:

1979

PHOTO CREDIT: Shepley, Bulfinch, Richardson and Abbott.

INFORMATION:

East and North elevations.

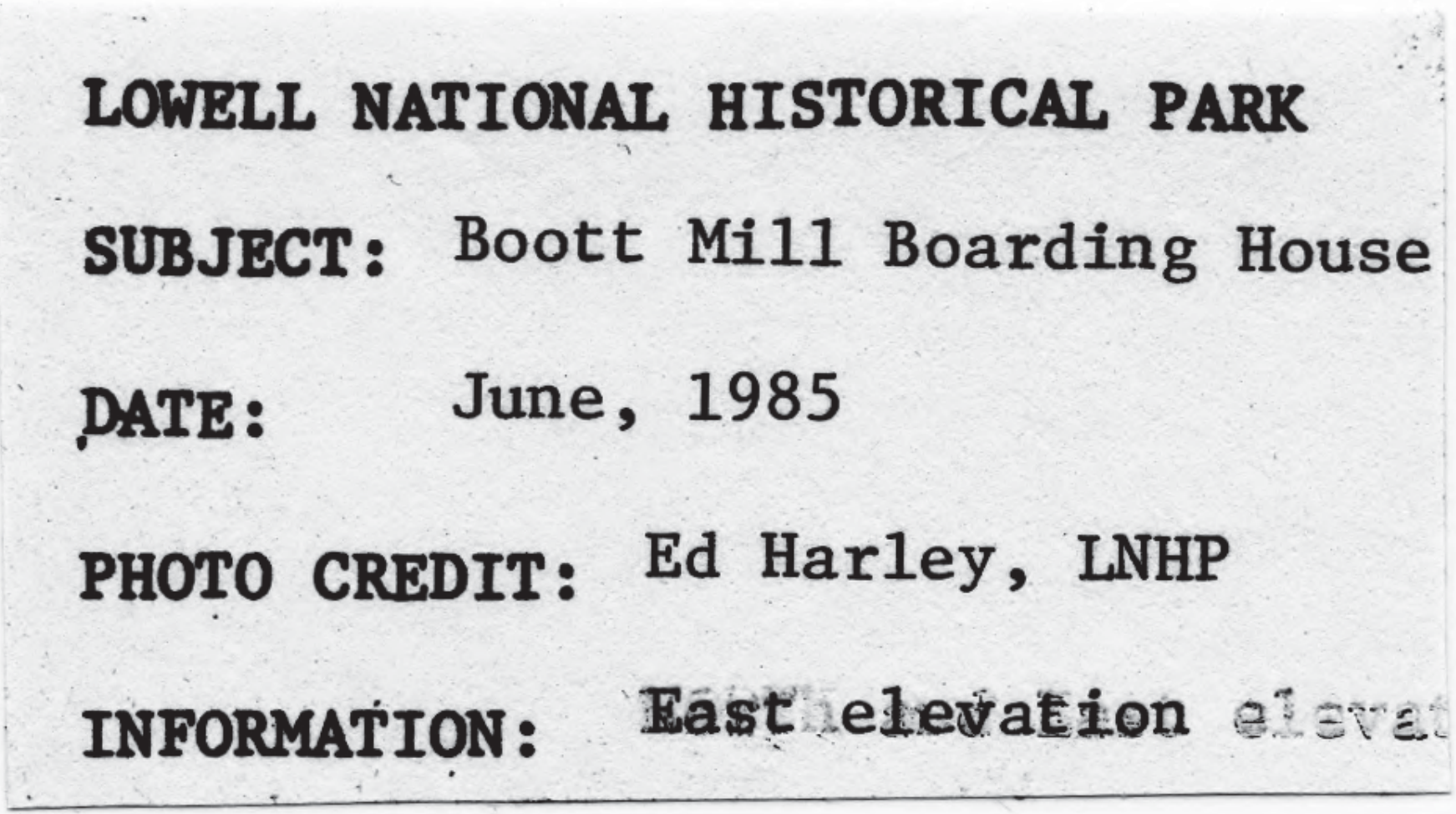
LOWELL NATIONAL HISTORICAL PARK

SUBJECT: The Kirk Street Agents' house.

DATE: June, 1985

PHOTO CREDIT: Ed Harley, LNHP

INFORMATION:
West and South elevations



LOWELL NATIONAL HISTORICAL PARK

SUBJECT: Boott Mill and Counting House.

DATE: June, 1985

PHOTO CREDIT: Ed Harley, LNHP

INFORMATION:
South elevation. Counting House is on left side of photo. Building #6 Boott Mill is on right side of photo.

LOWELL NATIONAL HISTORICAL PARK

SUBJECT: Suffolk Manufacturing Company

DATE: May, 1984

PHOTO CREDIT: James Higgins

INFORMATION: South and East elevations

LOWELL NATIONAL HISTORICAL PARK

SUBJECT: Lowell Manufacturing Company

DATE: June, 1985

PHOTO CREDIT: Ed Harley, LNHP

INFORMATION: North and West elevations.

LOWELL NATIONAL HISTORICAL PARK

SUBJECT: Dutton Street Parking Lot.

DATE: June, 1985

PHOTO CREDIT: Ed Harley, LNHP

INFORMATION: Picture taken facing North towards the Lowell Manufacturing Company.

LOWELL NATIONAL HISTORICAL PARK

SUBJECT: Moody Street Feeder Gate house

DATE: 1979

PHOTO CREDIT: Shepley, Bulfinch, Richardson and Abbott.

INFORMATION:
East elevation overlooking the Merrimack Canal.

Document Content(s)