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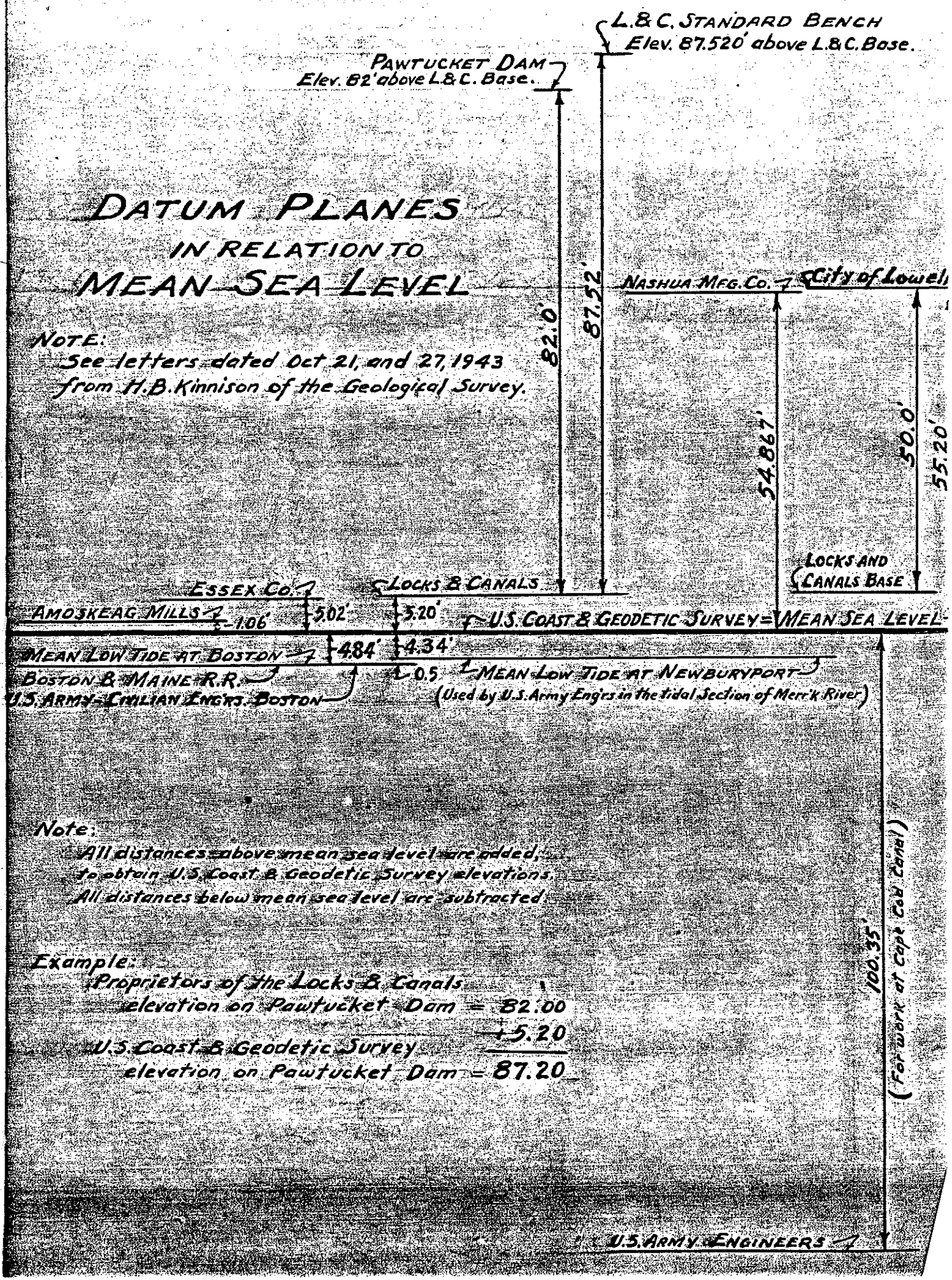


Note:
All distances above mean sea level are added,
to obtain U.S. Coast & Geodetic Survey elevations.
All distances below mean sea level are subtracted.

Example:
Proprietors of the Locks & Canals
elevation on Pawtucket Dam = 82.00
+5.20
U.S. Coast & Geodetic Survey
elevation on Pawtucket Dam = 87.20

Relation of Datum Planes

Massachusetts

Town of Orange	+435.52
Town of North Attleboro	+171.25
New England Power Assn.	+105.86
Turners Falls Power Co.	+69.26
City of Lowell	+55.20
Locks and Canals Corp., Lowell	+5.20
City of Lawrence	+5.08
Town of Framingham	+4.06
City of New Bedford	+2.55
City of Attleboro	+2.26
City of Worcester	+0.77
Comm. of Mass. Dept. of Public Works	
Town of Natick	−0.04
City of Chicopee	−0.36
City of Springfield	−0.46
Town of Greenfield	−0.83
City of Haverhill	−1.43
City of Brockton	−1.57
Holyoke Water Power Co.	−2.53
City of Holyoke	−2.60
City of Salem	−4.36
Town of Manchester	−4.47
City of Peabody	−4.82
Boston Low Water Datum	−4.87
Logan Airport Datum (Waterways)	−5.28
City of Lynn	−5.29
Logan Airport Datum (Highways)	−5.35
City of Somerville	−5.39
Town of Wellesley	−5.50
City of Beverly	−5.53
Town of Dedham	−5.64
malden & Boston City Base	−5.65
City of Newton	−5.72
Town of Brookline	−5.78
City of Quincy	−5.82
City of Revere	−5.84
medford & City of Everett	−5.90
City of Chelsea	−6.00
Town of Norwood	−6.03
Met. Water Supply Commission	−6.049
Mean Low Water (Waterways)	−6.23
City of Cambridge	−10.84
Town of Walpole	−23.28
U.S. Army Engineers	−100.35
Boston Navy Yard (Basic Bench)	−105.08
Met. District Commission (Sewers)	−105.62
Boston Transit Commission	−105.62
Town of Needham	−105.62

Mean High Water Boston Harbor

4.58

U.S.C.&G.S. Mean Sea Level Datum of 1929

0.12

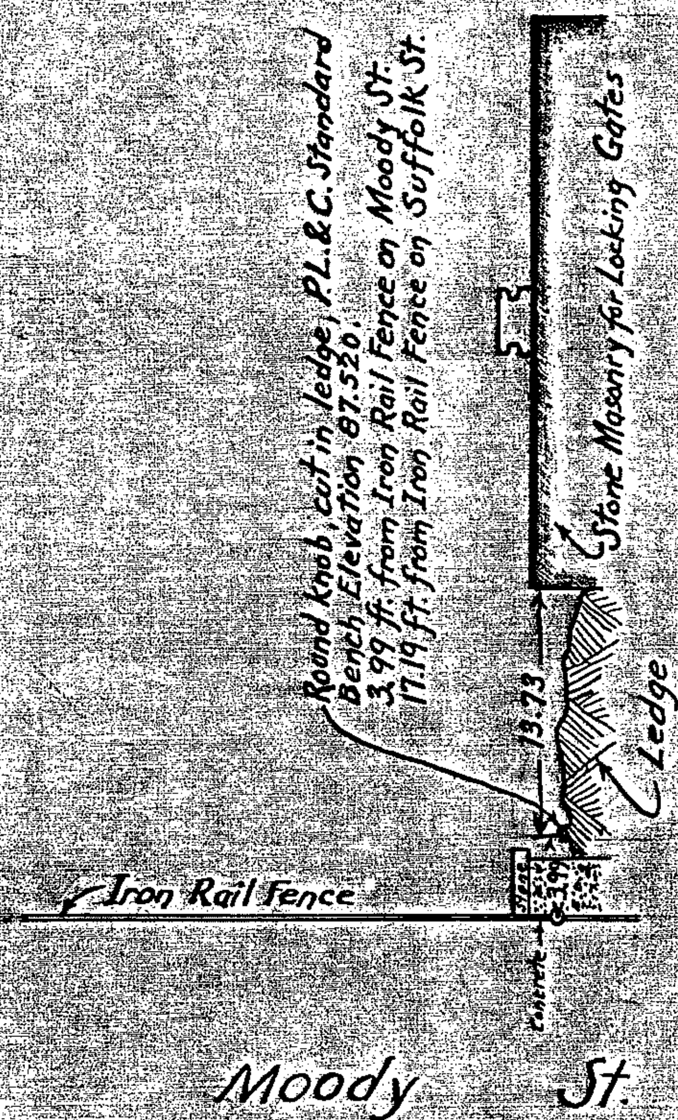
Mean Tide Level Boston Harbor

4.84

Mean Low Water Boston Harbor

Elevation of P. L. & C. Standard Bench

No Scale



Prominent Bench Marks.

Description	Height on General Scale.
Swamp Locks	
Brass-head bolt at head Merrimack Canal at L.M.S Upper Canal Gauge.	84.664
~~Brass-head bolt at #2 Pit Gauge~~	~~69.859~~
Brass-head bolt at Upper Canal Gauge R.H. end of Swamp Locks Dam.	84.150
Brass-head bolt at Swamp Locks Lower Canal Gauge.	68.649
Cut B.M. on stone at L.H. side of lock below middle gate of Swamp Locks.	78.728
Lower Locks	
Cut B.M. on capstone of Upper Lock of Concord River Locks.	68.800
Brasshead bolt at Concord River Lower Lock Gauge used as River Gauge for Middlesex Co.	48.641
B.M. cut in masonry at west end of Mid'sx. Co's Dam. Concord River.	62.936

Prominent Bench Marks

Description	Height on General Scale.
Hamilton Canal.	
Cut B.M. on corner of underpinning at N.E. corner of Hamilton #4 Mill near Hamilton Wasteway Gate House.	85.670
Lower Pawtucket Canal.	
Cut B.M. ☐ at R.H. side Lock just above Upper Gate of Lower Locks	68.800
Hunt's Falls. South Side.	
On Copper Tack at end Whittier Fence	
B.M. marked VI on boulder below Lower Dump	51.777
B.M. " VII " " near Lower Rapids.	52.605
Cut B.M. on Well Cover opp Alder St.	49.191
Hunt's Falls North Side	
Upper Monument.	48.280
B.M. stone bound cor Christian-First Sts	71.541
Lower Monument.	37.463
B.M. #10 on boulder at bend above Abbott Isl.	6.245

Prominent Bench Marks.

Description	Height on General Scale
Boott Mills - Amory St.	
Brass-head bolt at Counting Room Gauge.	
B.M. on square iron bolt in top of wall at River Gauge.	59.671
Boott Mills - Mass. Div.	
Brass-head bolt at Counting Room Gauge.	69838
Brass-head bolt at Merrimack River Gauge.	
"Prescott"	
Brass-head bolt at Eastern Canal Gauge L.H. side of canal near Bridge.	68524

Prominent Bench Marks.

Description	Height on General Scale.
Northern Canal.	
B.M. ▣ on capstone of pier at head of Lock, Pawtucket Dam.	96.113
Copper B.M. L.H. side about 35 feet above Moody Street Bridge.	86.445
Western Canal.	
Standard Bench ⊙ on ledge R.H. side canal at down-stream side of Moody Street.	87.520
B.M. cut in coping (down-stream side) of bridge over Western Canal at Broadway nearest to L.H. side.	94.312
Merrimack Canal.	
B.M. in Moody St. Feeder Gate House	84.513

Prominent Bench Marks.

Description	Height on General Scale.
"Suffolk Yard."	
Cut B.M on canal wall near up-stream corner Tremont Gate House.	87.488
Brass-head bolt near Suffolk Race Gauge in underpinning of stable.	78.234
"Tremont Yard."	
Cut B.M on canal wall near up-stream corner Tremont Gate House	87.488
"Lawrence Yard."	
Cut B.M on stone base on line of Columns in 4-5-6 Wheel-room	62.114
Brass-head bolt at River Gauge at up-stream side of Lawrence Wasteway.	60.048

Prominent Bench Marks.

Description	Height on General Scale.
Merrimack River L.H. side looking down-stream.	
On top 1852 Monument above Powtucket Dam	95.757
On covering stone above brook south side Varnum Ave. at Totman Street	92.351
On top of Lowell and Dracut line bound on bank of River	89.553
On East side of North abutment to Country Club Bridge	97.136

Prominent Bench Marks.

Description	Height on General Scale.
Merrimack Mfg. Co.	
Brass-head bolt at Tower Gauge	85.105
Brass-head bolt at River Gauge	52.875
"Hamilton Yard."	
Cut B.M. on underpinning N.E.	
corner #4 Mill.	85.670
Brass-head bolt at Lower Canal Gauge	
"Appleton Yard."	
Brass-head bolt at Upper Canal Gauge	83.310

Prominent Bench Marks.

Description	Height on General Scale.
Merrimack River RH side looking down-stream. On West end of N. abutment of Pawtucket St. crossing over B&M tracks	95.752
On top of 28th mile post from Boston.	100.782
On capstone arches over Stony Brook north side of track.	96.462
On big boulder just above old piling opp upper end of Tyng's Island	92.463

Prominent Bench Marks.

Description	Height on General Scale.
Lawrence Section.	
Brass-head bolt in underpinning of	
Law. Sec. Cloth-Room Building.	71.746
Brass-head bolt at Law. Sec. River Gauge.	53.858 44.706 ↳ Low down
Upper Pawtucket Canal.	
B.M. ◎ on abutment of Great Gate L.H.	
side of Lock & lower side of Gate House	100.953
B.M. ⊡ on R.H. abutment of Red	
Bridge upper end of abutment.	Abutment changed
B.M. ⊡ on top of Doherty wall 25 ft.	
below upper end of wall.	90.066

Canal Bridges

Name	Built and Rebuilt	Length of Span in feet	Width in feet	Maintained by	
Pawtucket Canal					
Pawtucket St.	1823-1927	93 to 84	32' widened to 44'	L & C	
Broadway (O.G.L.)	1852-1919	64 to 74	41' widened to 50'	L & C	
School St.	1876-1912			L & C 1872	City 1912
Fletcher St.	1826-1919	92	50 to 52'	L & C	
Central St.	1883-1922 and 1938	85 to 87	65	L & C	
Merrimack Canal					
Merrimack St.	1890	38	50' widened to 72'	50' L & C	2 Sidewalks City
• Market St.	1828-1910	41	63		City 1841
Western Canal					
• Dutton St.	1831-1949	35	60		City 1841
• Worthen St.	1874-1926	35	43	City 1874	Saco 1926 & Successors
• Broadway	1833	40	50		City 1883
• Jefferson St.	1891-1930	50	40		City 1891
• Market St.	1831-1916	35	63		City 1841
Merrimack St.	1831-1919 and 1938	26	50' widened to 70'	50' L & C	2 Sidewalks City
• Moody St.	1831-1913	32	50		City 1841
Eastern Canal					
E. Merrimack St.	1835-1909	61	60	50' L & C.	N. Sidewalk City
* Bridge St.	1835-1901 and 1938	45	50' widened to 65	L & C. 1835	State 1938
Northern Canal		Including Locks			
• School St.	1848-1916	125	58	L & C. 1848	City 1916
Pawtucket St. High Bridge	1849-1920	154 to 163	30	L & C.	
• Aiken St.	1898	102	50		City 1898
• Cabot St.	1847-1949	102	50		City 1885
Suffolk St.	1847-1926	102 to 106	45	L & C.	

• Figures from City Engineers.
* Rebuilt by State.

Areas of Different Canals Including Penstocks and Races.

Description	Areas Sq. Ft.	Totals Sq. Ft.	Remarks.
Tremont Wasteway	22000	22000	
Lower Level of Western Canal.			
Tremont Races	60727		
Suffolk Races	42836	plugged at Penstock	
"Lawrence Yard" Penstocks	11640		
Lawrence Section Penstocks	11747		
Lawrence Canal	24870		
Total - Lower Level of Western Canal.		151,819	

Areas of Different Canals Including Penstocks and Races

Description	Areas Used Sq. Ft.	Areas Not used Sq. Ft.	Remarks
Lower Level of Pawtucket Canal from Swamp Locks Dam to Boott Dam	275,900	*	* Lower Level includes Eastern Canal whose Area equals 96,800 sq ft
S-L-S Races		14,400	Penstocks plugged
Appleton Races	12,000		
Hamilton Races	14,000	19,100	
Bigelow Races	4500		
Middlesex Penstocks		4,400	Wheels taken out Penstock plugged
Prescott Penstocks	15,700		
Moss Penstocks	35,000		
Boott Penstocks	22600.		
Totals	379,700	37,900	

Areas of Different Canals Including Penstocks and Races.

Description	Areas Used Sq. Ft.	Areas Not Used Sq. Ft.	Remarks
Northern Canal and Upper end of Western Canal	447950		From head of Northern Canal to Locking Gates in Western Canal
Suffolk Penstocks		3022 Penstocks Plugged	
Tremont Penstock	7574		
Moody St. Feeder	41700		
Total	500246		
Merrimack Canal	133462		Including down to Merrk. Mfg. Co's Forebays
Bigelow Penstocks	16000		
			Wheels Out. Penstocks plugged.
S.L.S. Penstocks		11808	No 6 Penstock area not included.
Total	148462		
Total carried forward	645686	14830	

Areas of Different Canals Including Penstocks and Races

Description	Areas Used Sq. Ft.	Areas Not Used Sq. Ft.	Remarks.
Total brought forward	645686	14830	
Pawtucket Canal from Old Guard Locks to Merrimack River	162475		
Pawtucket Canal from Old Guard Locks to up-stream side of Fletcher Street	384651		
Swamp Locks Basin from up-stream side of Fletcher St. to Locking Gates	110086		To Merrimack Canal and to Ham Canal Locking Gates.
S.L.S. #6 Penstock		1184	Wheel Out. S.d
Total (Pawtucket Canal & Swamp Locks Basin)	657212	16014	
Western Canal	111650		Locking Gates
Total carried forward	1414548	16014	to Pawtucket Canal

Areas of Different Canals Including Penstocks and Races.

Description	Areas Used Sq. Ft.	Areas Not Used Sq. Ft.	Remarks.
Total brought forward	1,414,548	16014	
Hamilton Canal	66475		
Appleton Penstocks	11887		
Hamilton Penstocks	9150	5480	
Total (Upper Level)	1,502,060	15,450	

Length and Width of Canals.

Description	Length Feet	Width Feet
Merrimack Canal.		
from Locking Gates to		
Merrimack Bell Tower.	2579	
from Moody Street		
Feeder to Bell Tower.		50
from Locking Gates to		
Moody Street Feeder.		40
Boott Penstock	310	8
Northern Canal.		
from Head Gates to		
Suffolk Street.	4400	80 to 100
from Pawtucket Street		
Bridge to Suffolk St.		100
Western Canal.		
from end of Northern		
Canal to Pawtucket	3196	35 to 55
Canal.		

Length and Width of Canals.

Description	Length Feet	Width Feet
Upper Powtucket Canal.		
from Merrimock River		
to Old Guard Locks.	1691	80 to 106
from Old Guard Locks		
to Swamp Locks Dam.	5030	84 to 100
Lower Powtucket Canal		
from Swamp Locks Dam		
to Lower Locks Dam.	2152	100
Eastern Canal.		
from Lower Locks Dam		
to Boott Dam.	2037	40 to 65
Hamilton Canal.	1936	35 to 100

Length and Width of Canals.

Description	Length Feet	Width Feet
Moody Street Feeder.	1418	30
Tremont Wasteway from Tremont Gates to Hall Street Dam.	606	28
Lower Level of Western Canal from Hall Street Dam to Lawrence Dam.	330	78
Lawrence Canal	829	30
Total length of all Canals	26,714	

Pawtucket Dam.

Length of Pawtucket Dam	1092.5 feet
Top of Dam by general scale	82.00
Flashboards July to Feb	5 ft. high
Flashboards March to June	4 ft. high
Quantity passing with one foot depth.	3600 c.f.p.s.
Quantity passing with two feet depth.	10300 c.f.p.s.
Average height of Dam	12.00 feet

Headgates.

Names	Number	Area each Sq. Ft.	Heights of Sills.	
Northern Canal Gates	10	120	67.00	
Old Guard Locks Gates	5	90	72.90	*
Northern Canal Waste Gates	4	23.3	59.00	* C.F.P.S. 2250

Note

* Discharge figured with Canal at 85.00

Waste Dams

Name	Discharge figured at Grade	Height of Sill of Dam	No of Bays	Total Discharge of Bays C.F.P.S.	Size of Gate Sq. Ft.	Discharge of Gate C.F.P.S.	Height of Sill of Gate
					Deep Gate		
Swamp Locks	82.50	78.4	16	2096	34.4	669	66.1
Swamp Locks					Wide Gate 48	600	72.5
					2-Gates		
Lower Locks	68.00	64.5	6	590	24	479	55.5
Siphon Spillways-3						1400	
Merrimack	83.00	78.65	4	440	No	Gate	
Siphon Spillways-2						600	
Boott	67.00	64.32	2	123	48.2	477	61.58
Siphon Spillways-3						450	
Lawrence	69.00	65.00	8	1129	35.1	471	58.82
Siphon Spillways-3						900	
Mass. Wasteway	67.30	63.9	4	433	No	Gate	
	84.00		2		Each	Each	
Tremont Gates	78.00		Gates		49.5	975	72.8
			2		Each	Each	
Hamilton Gates	82.50		Gates		30.4	275	76.59
Merr'k Iceway	83.00	77.00	2	548			
	75.6		78 Ft.	260			
Hall St. Dam	76.6	74.6	long	735			
	77.6			1350			

Flumes.

Name	Length Feet	Width Feet	Area of Cross-Section of Grade	
			Area Sq. Ft.	Grade
Hamilton and	100	49.34	705.9	82.00
Appleton	Measuring Flume gone			
Merrimack	70	48.74	540.6	83.00
Boott	70	41.02	349.9	67.00
Massachusetts	100	65.46	772.7	68.00
Saco-Lowell Shop	50	Flume gone		69.00

Percent of Efficiency at wheel at full gate.

No.	Name												
1		85	80			80		83	84	82		82	80
1A									84				
2		78	78			82		83	82	82		82	80
2A													
2B													
2C													
3	78	81	80			78		82	82	82		82	80
3A													
4	78	81	80					83	80	80		82	86
4A								83					
5		81	80					83	83				86
5A	80								84				
6		80	80										86
7					82								
8					82								
9	72	75			82								
10	82				82								
11	82				82								

12 80±

Merrimack Mfg. Co. Main Yard

No of Wheel	Kind and Size	R.H. or L.H	Date when Wheel was put in	Avg. Fall Feet	Discharge in C.F.P.S.	Full Opening of Speed gate Inches	Estimated Horse Power	Revs. per Min.
3	45" Special McCormick	R.H.	1896	37	207.0	19.57	719.9	169
4	45" Special McCormick	L.H.	1896	37	207.0	19.57	719.9	169
5&6	Pair of 39" Hercules	R.H. & L.H.	1911	37	429.0	18.7	14380	200
9	50" Allis Chalmers #15	RH	1919	37	423.5	Swing Gate 5.772	13900	180
10	42" Hercules	L.H.	1894	37	184.0	18.44	6322	165
11	42" Hercules	L.H.	1894	37	184.0	18.44	6322	165
	Totals				1634.5		55322	

Water Wheels

Lawrence Section. Canal

1 - Merrimack Mfg. Co. 1121-

No of wheel	Kind & Size	R.H. or L.H	Date when wheel was put in	Avg. fall feet	Full opening of speed gate.	Discharge C.F.S.	*Estimated horse power
1	54" Hercules	L.H.	1896	23	23.60	2428	5189
2	54" Hercules	L.H	1896	23	23.60	2428	5189
3	54" Hercules	R.H.	1896	23	23.83	2552	5455
4	54" Hercules	R.H.	1896	23	23.83	2552	5455
	Totals					9960	21288

*On Wheel Shaft.

Net H.P. on Switchboard (full operation) 1690

Kilo-watts on Switchboard 1260

Tremont Side Cont.
Merrimack Mfg. Co.

No of Wheel	Kind and Size	R.H. or L.H.	Date when Wheel was put in	Avg. Fall Feet	Discharge in C.F.P.S.	Full Opening of Speed gate Inches	Estimated Horse Power	Revs. per Min.
1	46.5" Type "S" Morgan Smith	R.H.	1924	15	3345	Swing Gate 10.24"	467	120
2	46.5" Type "S" Morgan Smith	R.H.	1921	15	3345	Swing Gate 6.42"	467	120
3	40.8" Type "S" Morgan Smith	R.H.	1919	15	2875	Swing Gate 7.404"	400	128
4	46.5" Type "S" Morgan Smith	R.H.	1920	15	3345	Swing Gate 6.54"	467	120
	Totals				12910		1801	
Net H.P. on Switchboard (full operation)								1650
Kilo-watts on Switchboard								1230

Waterwheel Generators

Merrimack Mfg. Co.

Main Yard – Lawrence Section – Tremont Yard.

	No of Wheel	R.P.M.	Volts	Amperes	KVA.	KW. at .8 P.F.
Main Yard	3+4	164	2300	314	1250	1000
	5+6	200	2300	276	1100	900
	9	180	2300	235	940	750
	10	164	2300	94	375	300
	11	164	2300	94	375	300
					4040	3250
Lawrence Section	1,2,3,4*	360	600	433	450	360**
		360	600	530	550	440
					1000	800
Tremont Yard	1	120	600	361	375	300
	2	120	600	361	375	300
	3	128	600	280	290	235
	4	120	600	361	375	300
					1414	1135

* Law. Sect. No 4 disconnected.

** " " Unable to run generators in parallel.

Water Wheels A 11

*Textron American, Inc.

No. of Wheel	Kind and Size	R.H. or L.H.	Date when Wheel was put in	Avg. Fall Feet	Discharge in C.F.P.S.	Full Opening of Speed gate Inches	Estimated Horse Power	Revs. per Min.
OK 1	45" Type "Z" Leffel	R.H.	1922	13	374	Swing Gate 8.00"	459	120
OK 2	39" Type "Z" Leffel	L.H.	1919	13	278	Swing Gate 7.13"	341	133
OK 3	36" Type "Z" Leffel	R.H.	1918	13	237	Swing Gate 6.60"	287	150
1/0 4	45" Type "Z" Leffel	R.H.	1920	13	374	Swing Gate 7.99	459	120
500 5	45" Type "Z" Leffel	R.H.	1920	13	374	Swing Gate 7.81	459	120
	Totals				1637		2005	

* Formerly Hamilton Mfg. Co.

Waterwheel Generators

Textron American, Inc. - "Hamilton Yard"

No of Wheel	R.P.M.	Volts	Amperes	KVA.	KW. at .8 P.F.
OK 1	120	600	336.5	350	280
OK 2	133	600	217	225	180
OK 3	150	600	193	200	160
No 4	120	600	336.5	350	280
Soon 5	120	600	336.5	350	280
				1475	1180

"John St."
"Boott mills"

31

Water Wheels

300

Boott Mills - Amory St.

	No. of Wheel	Kind and Size	R.H. or L.H.	Date when Wheel was put in	Avg. Fall. Feet	Discharge in C.F.P.S.	Full Opening of Speed gate. inches	Estimated Horse Power	Revs per Min.
No	1	45" Allis Chalmers-12	R.H.	1919	21	3355	Swing Gate 6.625	680	150
No	2	72" Swain	L.H.	1874	21	201	13.08	358.8	79
OK	3	33" Leffel	R.H.	1949	21	250	Swing Gate 5.83	4823	200
OK	4	33" Leffel	R.H.	1949	21	250	Swing Gate 5.83	4823	200
Soon	5	33" Leffel	RH	1949	21	250	Swing Gate 5.83	4823	200
OK	6	72" Allis Chalmers	R H	1923	21	1025	Swing Gate 9.72	1925	100
No	9	80" Swain	R.H.	1875	21	242.5	12.15	4329	80
				Totals		C.F.P.S. 2553		HP 4843.6	

Waterwheel Generators

Boott Mills - Amory St.

No of Wheel	R.P.M.	Volts	Amperes	KVA.	K.W. at .8 P.F.
No 1	150	600	481	500	400
No 2	600	600	300	310	250
OK 3	200	600	361	375	300
OK 4	200	600	361	375	300
Soon 5	200	600	361	375	300
OK 6	100	600	1445	1500	1200
No 9	450	600	361	375	300
				3810	3050

Water Wheels

*Boott Mills.–"Massachusetts Yard"
Main Power, Section 8 and No. 12

	No of Wheel	Kind and Size	R.H. or L.H.	Date when Wheel was put in	Avg. Fall Feet	Discharge in C.F.P.S.	Full Opening of Speed gate inches	Estimated Horse Power	Revs. per Min.
Main Power	OK 1	48" Type "C" Hercules	R.H. & L.H.	1910	22	5050	24.00"	1010	133
	No 2	48" Type "C" Hercules	R.H. & L.H.	1910	22	5050	24.00"	1010	133
	No 3	48" Type "C" Hercules	R.H. & L.H.	1910	22	5050	24.00"	1010	133
Section 8	OK 4	42" Type "D" Hercules	R.H.	1918	22	332.8	Swing Gate 5.25"	655	138.5
	OK 5	42" Type "D" Hercules	R.H.	1918	22	332.8	Swing Gate 5.25"	655	138.5
	No 6	42" Type "D" Hercules	R.H.	1918	22	332.8	Swing Gate 5.25"	655	138.5
	No 12	46.5" Type "S" Morgan Smith	R.H.	1920 & 1921	17	357.0	Swing Gate 64.6"	588	128
		Totals				28704		5583	

Major Repairs

* Formerly Massachusetts Cotton Mills

Water Wheels

*Boott Mills–"Prescott Wheels"

No of Wheel	Kind and Size	R.H. or L.H	Date when Wheel was put in	Avg. Fall Feet	Discharge in C.F.P.S.	Full Opening of Speed gate inches	Estimated Horse Power	Revs. per Min.
7	33" Type "D" Hercules	R.H.	1919	21	161.0	18.00"	330	180
8	33" Type "D" Hercules	R.H.	1919	21	161.0	18.00"	330	180
9	33" Type "D" Hercules	R.H.	1919	21	161.0	18.00"	330	180
10	33" Type "D" Hercules	R.H.	1919	21	161.0	18.00"	330	180
11	33" Type "D" Hercules	R.H.	1919	21	161.0	18.00"	330	180
	Totals				805.0		1650	

* Formerly Massachusetts Cotton Mills

625
360
750
360
2.095

625
720

35

Waterwheel Generators

Boott Mills – "Massachusetts Yard"
Main Power, Section 8, Prescott Wheels and No 12

	No. of Wheel	R.P.M.	Volts	Amperes	KVA	KW. at .8 P.F.	
Main Power	1 + ~~2~~	133	600	1504	1565	1250	cut in half
	3 No	133	600	904	940	750	
					2505	2000	
Section 8	4 OK	138.5	600	433	450	360	
	5 OK	138.5	600	433	450	360	
	6 No	138.5	600	433	450	360	
					1350	1080	
Prescott	7	180	600	264	275	220	Gone
	8	180	600	264	275	220	
	9	180	600	264	275	220	
	10	180	600	264	275	220	
	11	180	600	264	275	220	
					1375	1100	
	12	128.5	600	433	450	360	

Water Wheels ~~Ex~~ Assets

*Boott Mills-"Bigelow Yard"

No. of Wheel	Kind and Size	Revs. per. Min.	R.H. or L.H.	Date when Wheel was put in	Full Opening of Speed gate inches	Discharge C.F.P.S.	Avg. Fall Feet	Estimated Horse Power
Unit 1	2-33" Style C 2-31" Style D Hercules	150	R.H. L.H.	1911 1913	16.5"	376	13	444.4
Unit 2	2-33" Style C 2-31" Style D Hercules	150	R.H. L.H.	1911 1913	16.5"	376	13	444.4
Unit 3	2-33" Style C 2-31" Style D Hercules	150	R.H. L.H.	1911 1913	16.5"	376	13	444.4
	Totals					1128		1333.2

* Formerly Bigelow Carpet Co.

Assets

37

Waterwheel Generators

Boott Mills – "Bigelow Yard"

No of Wheel	R.P.M.	Volts	Amperes	KVA	KW. at .8 P.F.	
1	150	600	320	330	265	No
2	150	600	320	330	265	OK
3	150	600	320	330	265	130
				990	795	

1 wheel Running ?
Apple wheel

Water Wheels

*Jackson Properties Inc.

No of wheel	Kind & Size	R.H or L.H.	Date when wheel was put in.	Avg. fall Feet	Full opening of speed-gate in.	Discharge C.F.P.S.	Estimated Horse Power
1	54" McCormick	L.H.	1901	13	24.25	210.6	260.6
1A	54" McCormick	R.H.	1901	13	24.40	211.0	261.1
2	(Pair) Special 39" Hercules	L.H & R.H	1926	13	17.40	2185	2650
3	(Pair) Special 39 Hercules	L.H & R.H	1926	13	17.40	2195	2650
4	(Pair) " Rodney 38 Hunt	L.H. & R.H.	1939	13	4.10" 4.02"	1820	2254
5	48" McCormick	R.H.	1906	13	21.58	1574	189.8
5A	48" McCormick	R.H.	1906	18	21.58	157.4	189.8
	Totals					13574	

* Formerly Appleton Company

Waterwheel Generators

* Jackson Properties, Inc.

No of Wheel	R.P.M.	Volts	Amperes	KVA.	KW. at .8 P.F.
141-A	450	600	482	500	400
243	450	600	482	500	400
4	600	600	145	150	120
5+5-A	600	600	144	150	120
				1300	1040

* Formerly Appleton Co.

Water Wheels Scagr 11 wheel 40

* Doherty Realty Co., Inc.

No. of Wheel	Kind and Size	R.H. or L.H	Date when wheel was put in	Avg. fall feet	Full opening of Speed gate inches	Discharge C.F.P.S.	Estimated Horse Power	Revs. per Min.
1	51" Type B Hercules	L.H.	1909	22	22.5	249	496	360
2	51" Type B Hercules	L.H.	1909	22	22.5	249	496	360
3	51" Type B Hercules	R.H.	1909	22	22.5	249	496	360
4	24" Type D Hercules	Pair R.H. L.H.	1916	21	13.3	Pair 159	Pair 325	300
5	24" Type D Hercules	Pair R.H. L.H.	1916	21	13.3	Pair 159	Pair 325	300
6	24" Type D Hercules	Pair R.H. L.H.	1916	21	13.3	Pair 159	Pair 325	300
	Totals					1224	2463	

* Formerly Lawrence Mfg. Co.

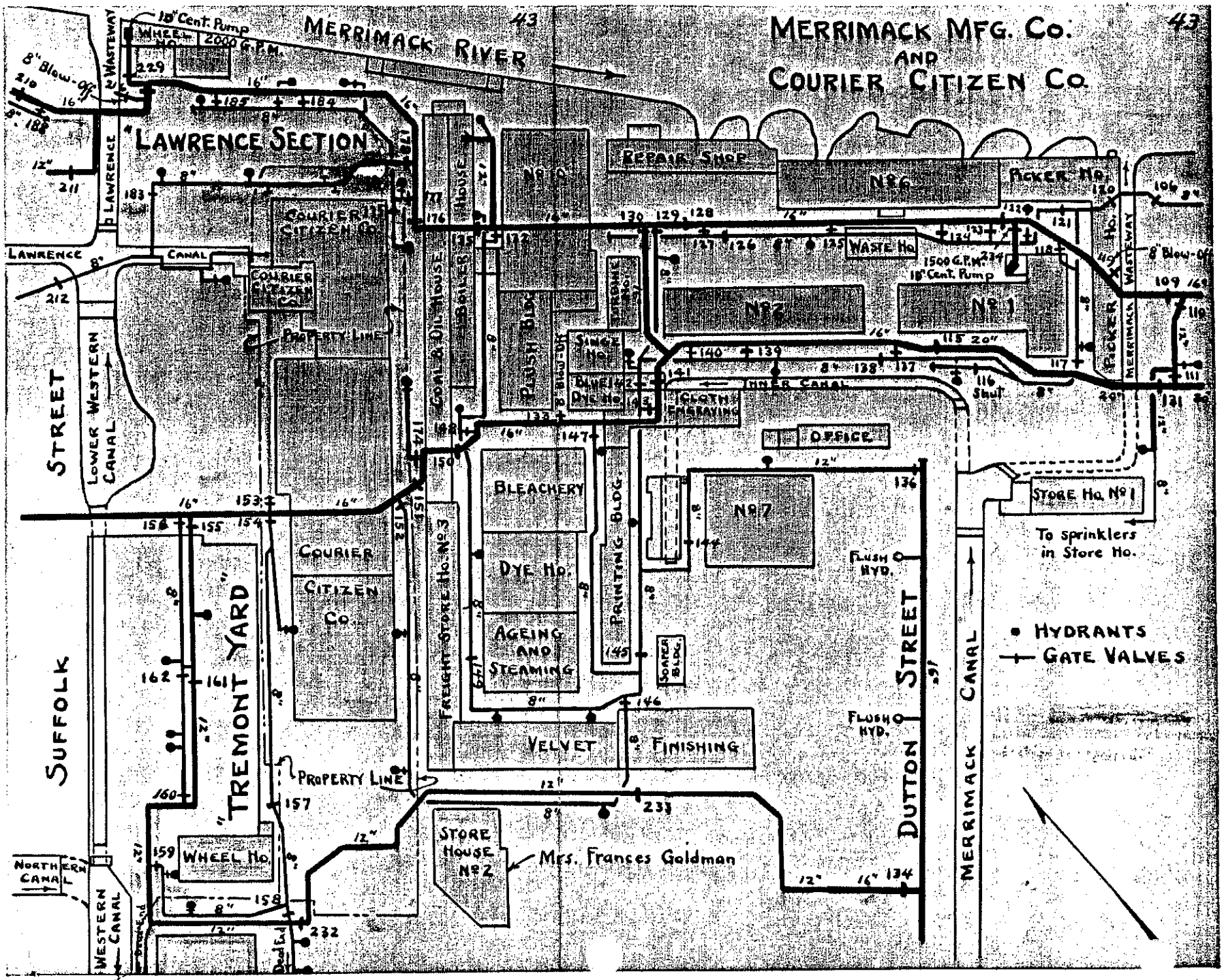
Waterwheel Generators

* Doherty Realty Co, Inc.

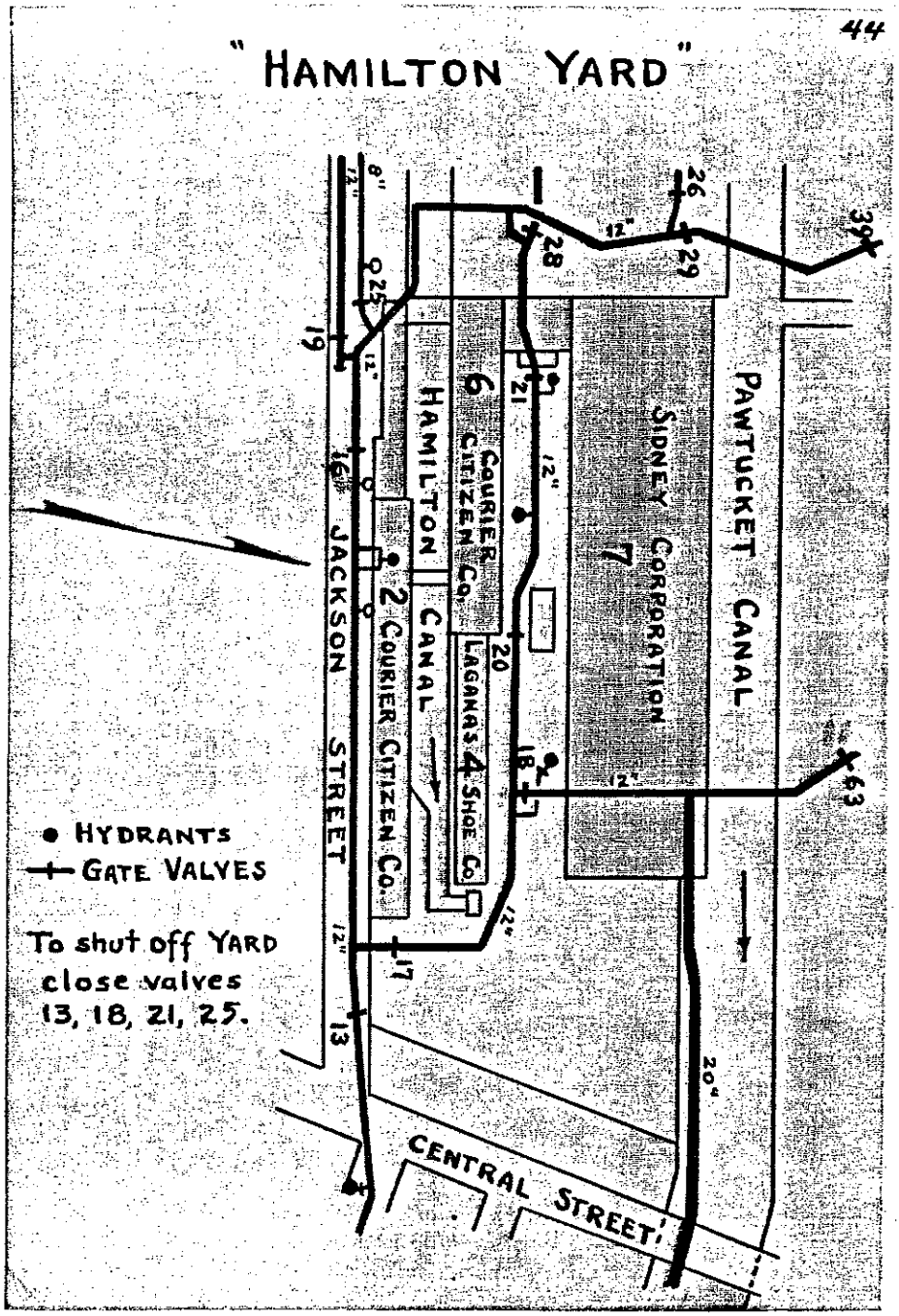
No. of Wheel	R.P.M.	Volts	Amperes	KVA.	KW. at .8 P.F.
1,2,3	360	600	963	1000	800
4,5,6	300	600	433	562	450
				1562	1250
* "Lawrence Yard					

Type of Wheel Horizontal or Vertical

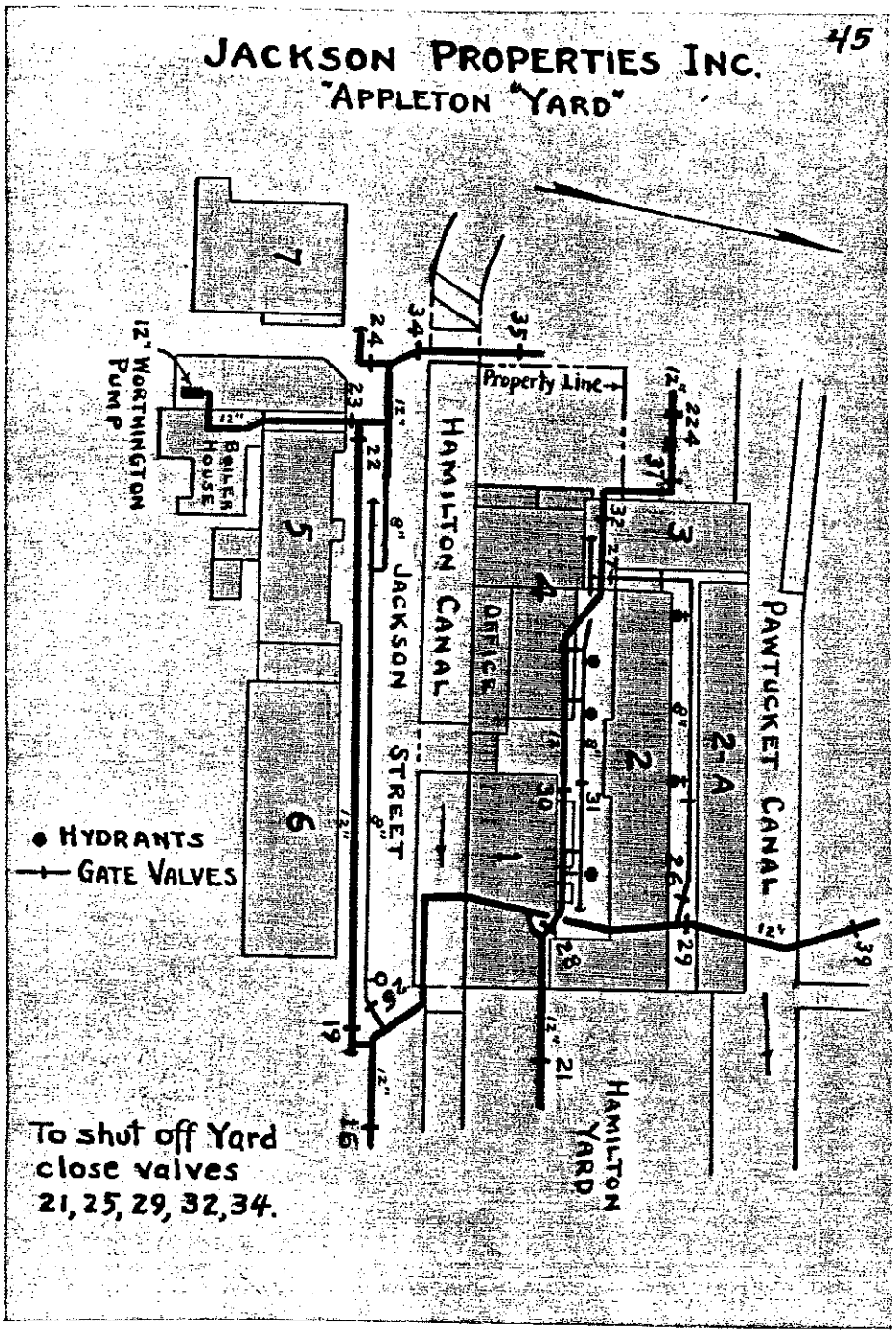
Number of Wheel	Merrimack Mfg. Co.	Merrimack Mfg. Co. Tremont Yard.	Merrimack Mfg. Co. Lawrence Section.	Hamilton Company Newmarket Mfg. Co.	Jackson Properties Inc.	Boott - Mass. Div.	Boott - Prescott	Boott - Assets Div.	Doherty Realty Co, Inc.	Boott Mills		
1		Vert.	Hor.	Vert.	Hor.	Hor.		Hor.	Hor.	Vert.		
1A					Hor.							
2		Vert.	Hor.	Vert.	Hor.	Hor.		Hor.	Hor.	Vert.		
3	Hor.	Vert.	Hor.	Vert.	Hor.	Hor.		Hor.	Hor.	Vert.		
3A												
4	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.			Hor.	Vert.		
4A												
5	Hor.			Vert.	Hor.	Vert.			Hor.	Vert.		
5A					Hor.							
6	Hor.					Vert.			Hor.	Vert.		
7							Vert.					
8							Vert.					
9	Vert.						Vert.			Vert.		
10	Hor.						Vert.					
11	Hor.						Vert.					
12						Vert.						


MERRIMACK MFG. CO.
AND
COURIER CITIZEN CO.
43
43
MERRIMACK RIVER
LAWRENCE SECTION
18" Cent. Pump
WHEEL No. 229
2000 G.P.M.
8" Blow-off
LAWRENCE WASTEWAY
LAWRENCE CANAL
COURIER CITIZEN Co.
PROPERTY LINE
LOWER WESTERN CANAL
STREET
SUFFOLK
TREMONT YARD
COAL & OIL HOUSE
BOILER HOUSE
No 10
REPAIR SHOP
No 6
PICKER No. 120
WASTE Ho.
1500 G.P.M. 18" Cent. Pump
No 2
No 1
PICKER No. 119
MERRIMACK WASTEWAY
8" Blow-off
FLUSH BLDG.
SANGE Ho.
BLEACHERY Dye Ho.
TURBINE HOUSE
INNER CANAL
CLOTH MEASURING
OFFICE
STORE Ho. No 1
To sprinklers in Store Ho.
BLEACHERY
No 7
DYE Ho.
AGEING AND STEAMING
PRINTING BLDG.
SOAPER BLDG.
FREIGHT STORE Ho. No 3
VELVET FINISHING
FLUSH HYD.
DUTTON STREET
MERRIMACK CANAL
HYDRANTS
GATE VALVES
WHEEL Ho.
STORE HOUSE No 2
Mrs. Frances Goldman
NORTHERN CANAL
WESTERN CANAL

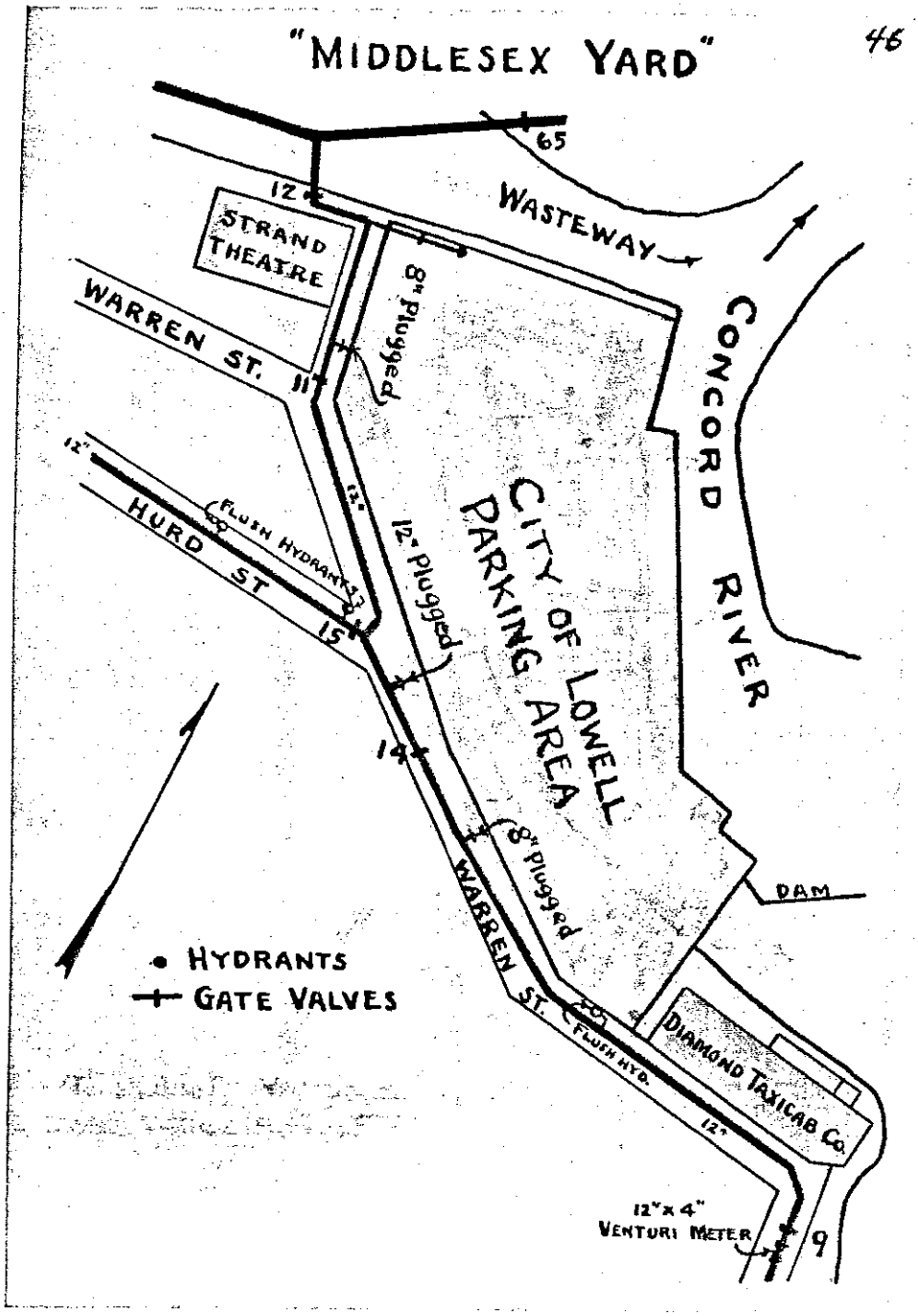
"HAMILTON YARD"

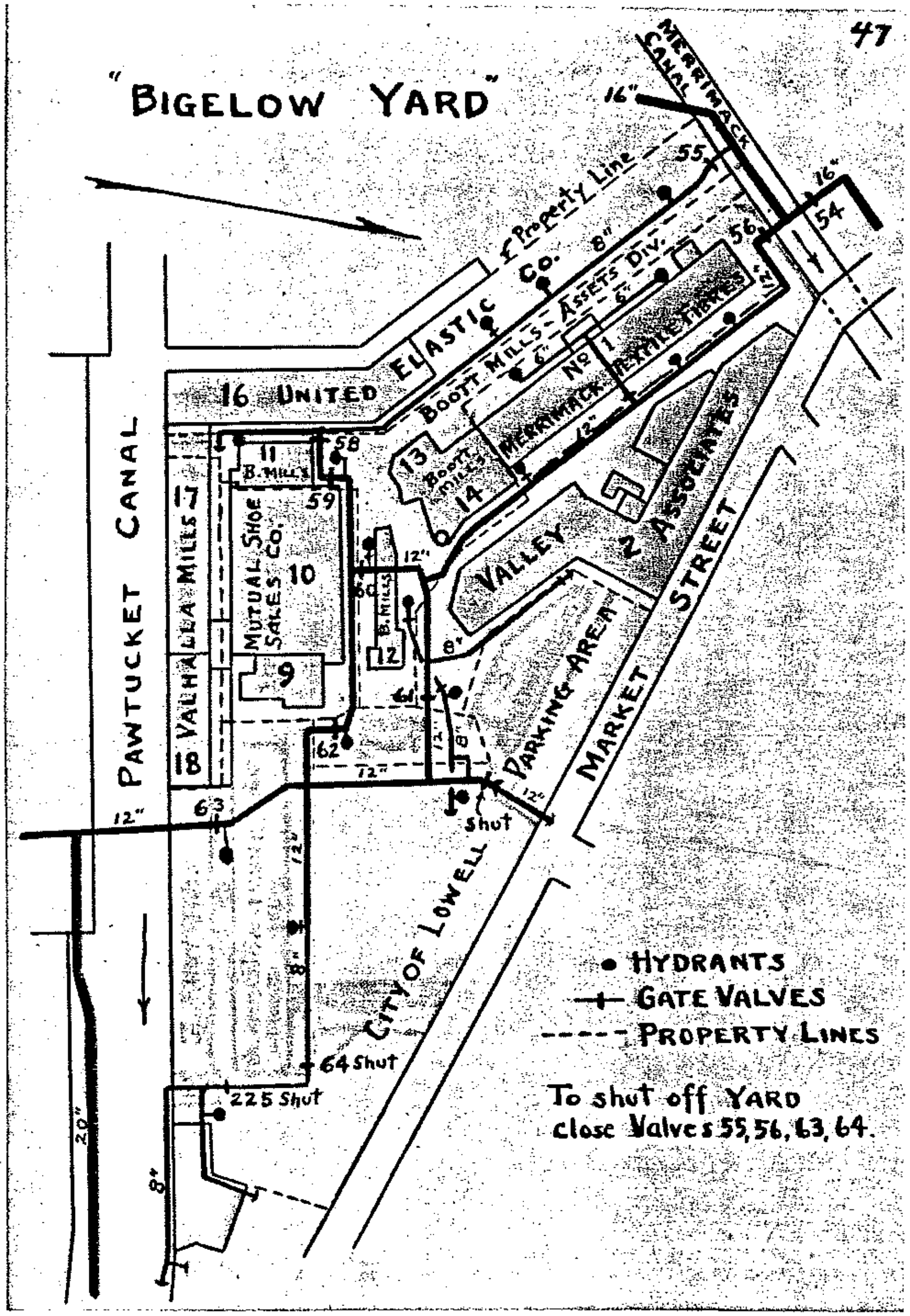


JACKSON PROPERTIES INC.
"APPLETON "YARD"

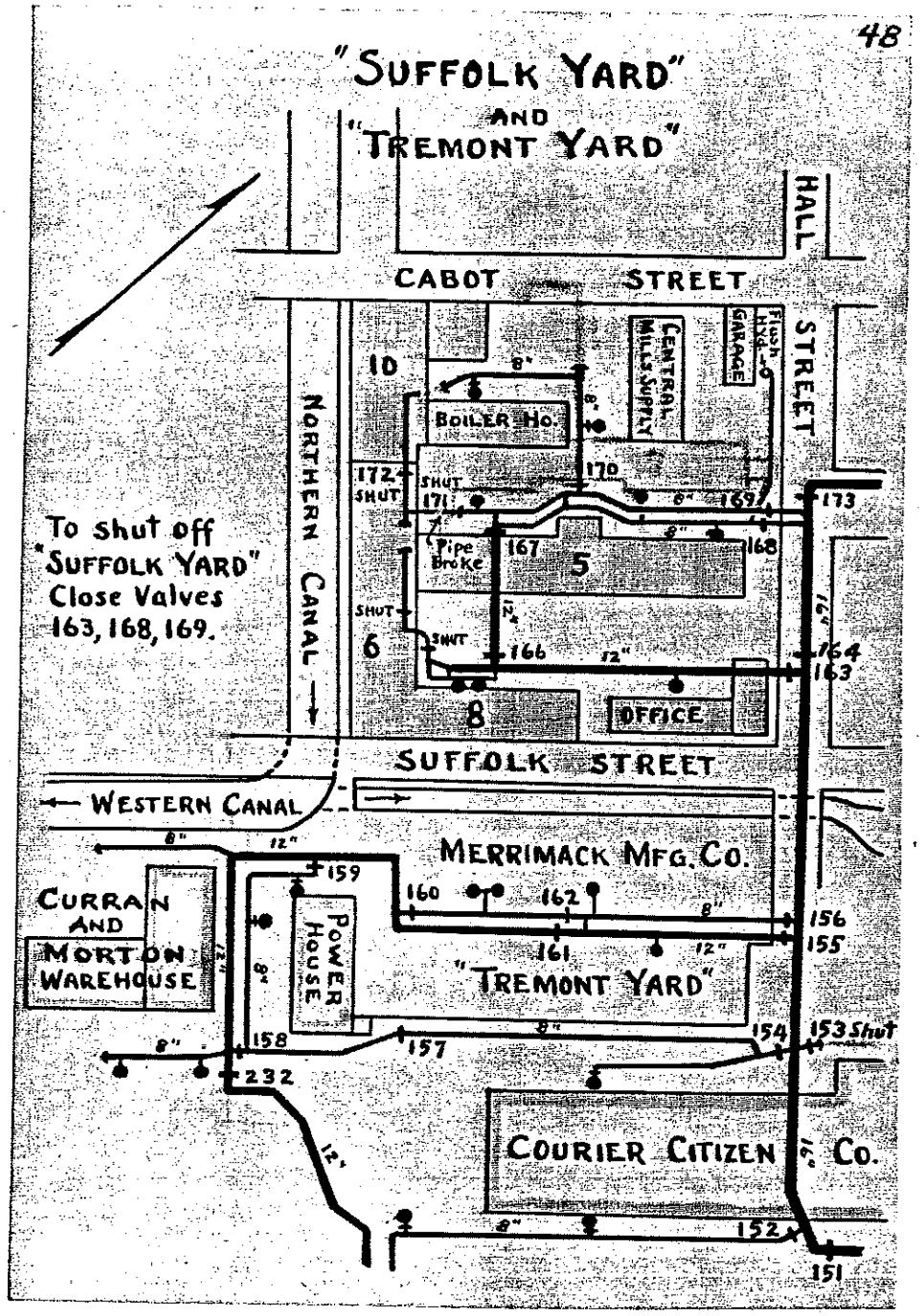


To shut off Yard close valves 21, 25, 29, 32, 34.

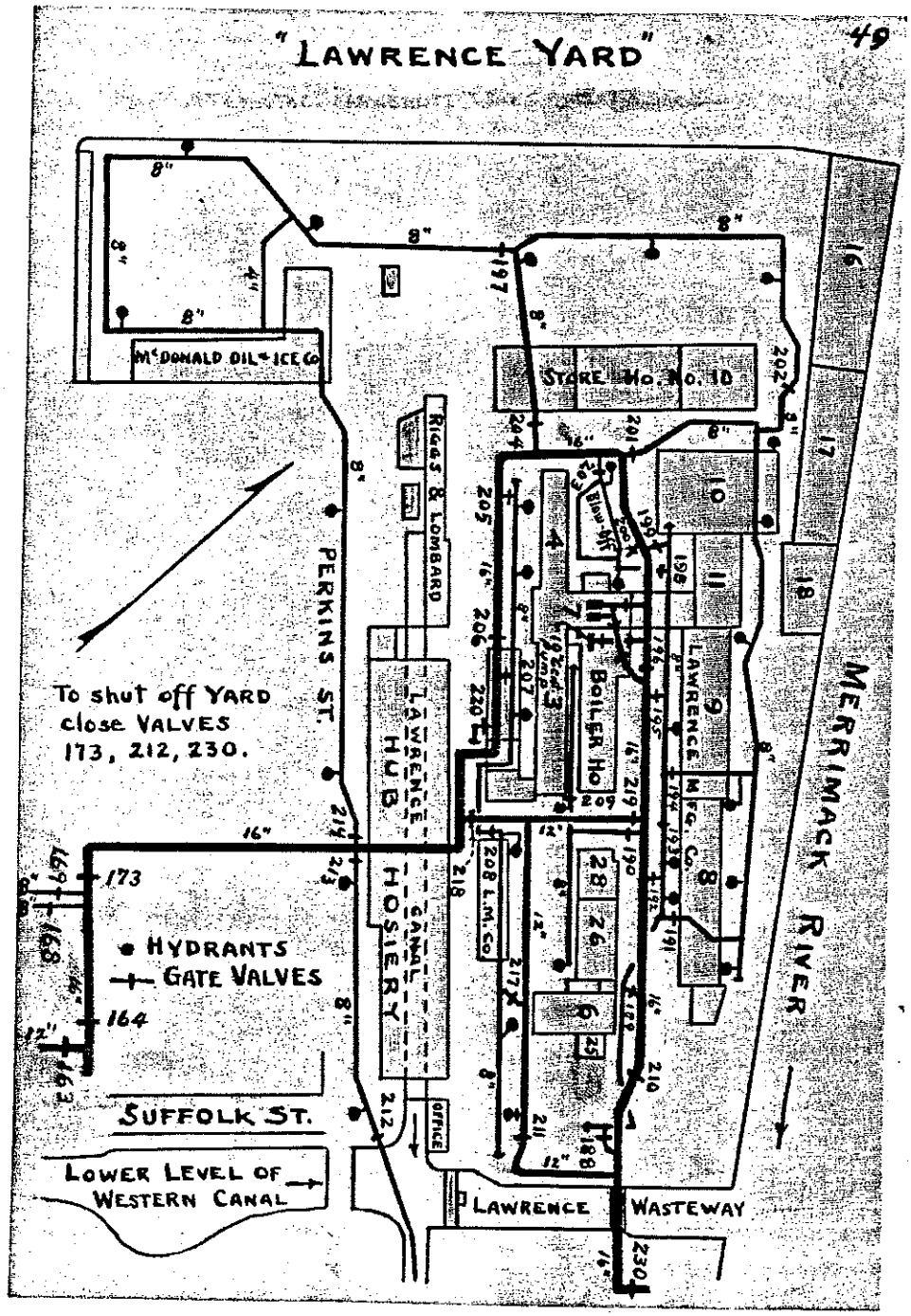

"MIDDLESEX YARD"
65
12"
WASTEWAY
STRAND THEATRE
WARREN ST.
11"
8" Plugged
CONCORD RIVER
12"
HURD ST
FLUSH HYDRANT
12" Plugged
CITY OF LOWELL PARKING AREA
15"
14"
8" Plugged
DAM
WARREN ST.
FLUSH HYD.
12"
DIAMOND TAXICAB Co.
12"x 4"
VENTURI METER
9
• HYDRANTS
GATE VALVES

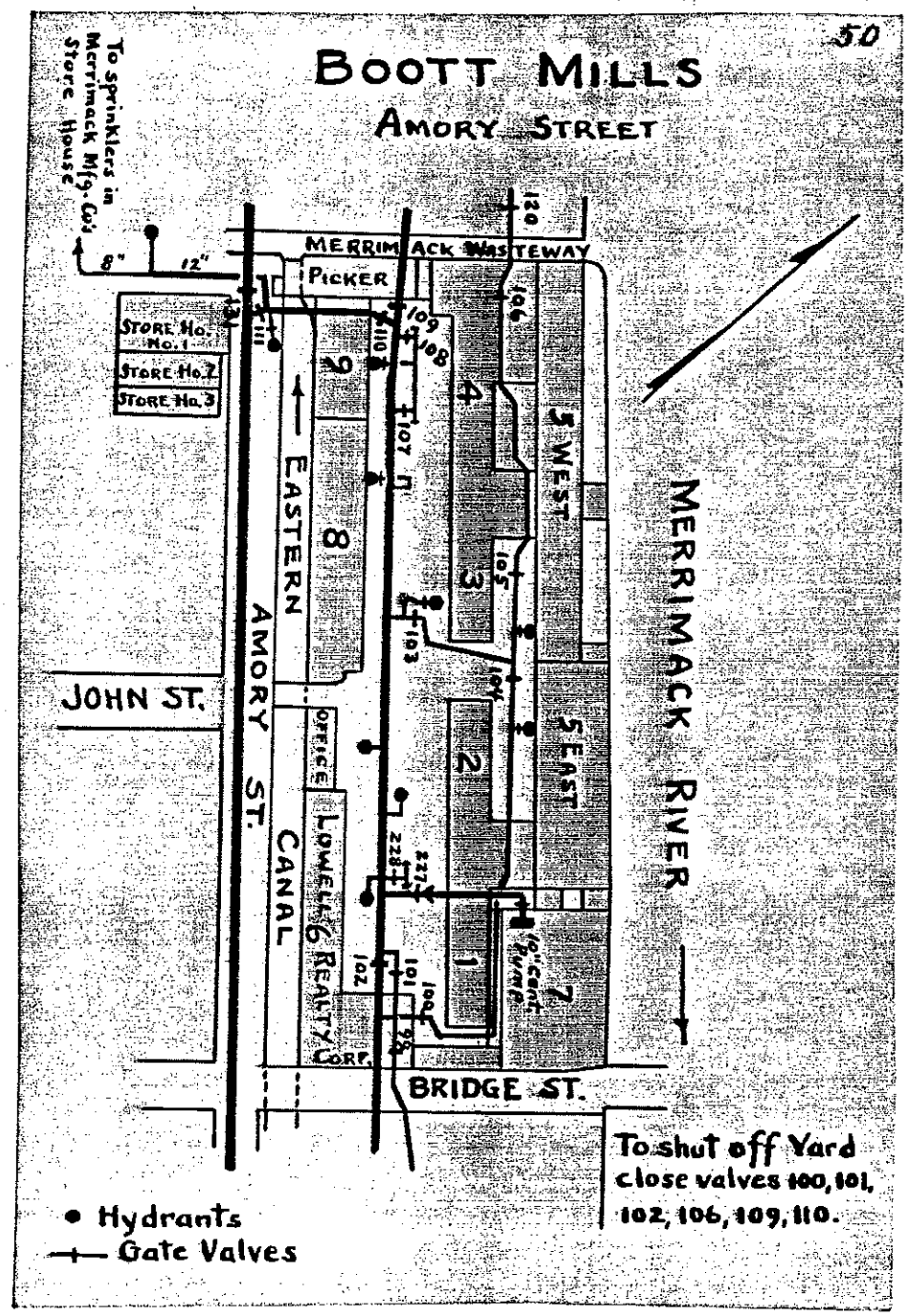


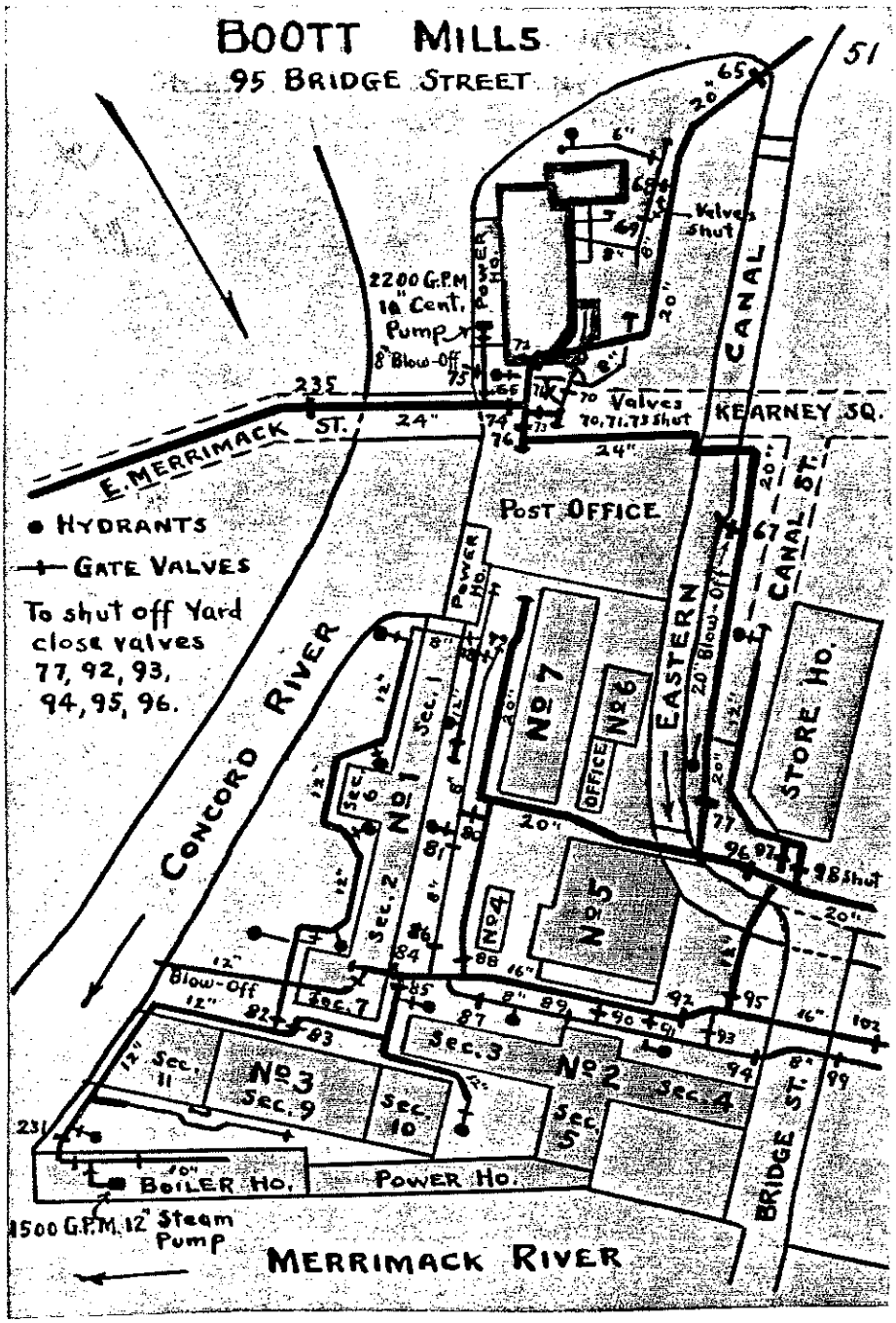
"BIGELOW YARD"
MERRIMACK CANAL
16"
55
54
56
℄ Property Line
ELASTIC CO.
8"
BOOTT MILLS - ASSETS DIV.
6"
TEXTILE FIBRES
No 1
MERRIMACK
12"
16 UNITED
13
BOOTT MILLS
14
11
B. MILLS
58
59
PAWTUCKET CANAL
17
VALHALLA MILLS
MUTUAL SHOE SALES CO.
10
9
18
60
B. MILLS
12
VALLEY
2
ASSOCIATES
PARKING AREA
MARKET STREET
61
62
63
12"
Shut
CITY OF LOWELL
64 Shut
225 Shut
20"
8"
• HYDRANTS
GATE VALVES
PROPERTY LINES
To shut off YARD
close Valves 55, 56, 63, 64.

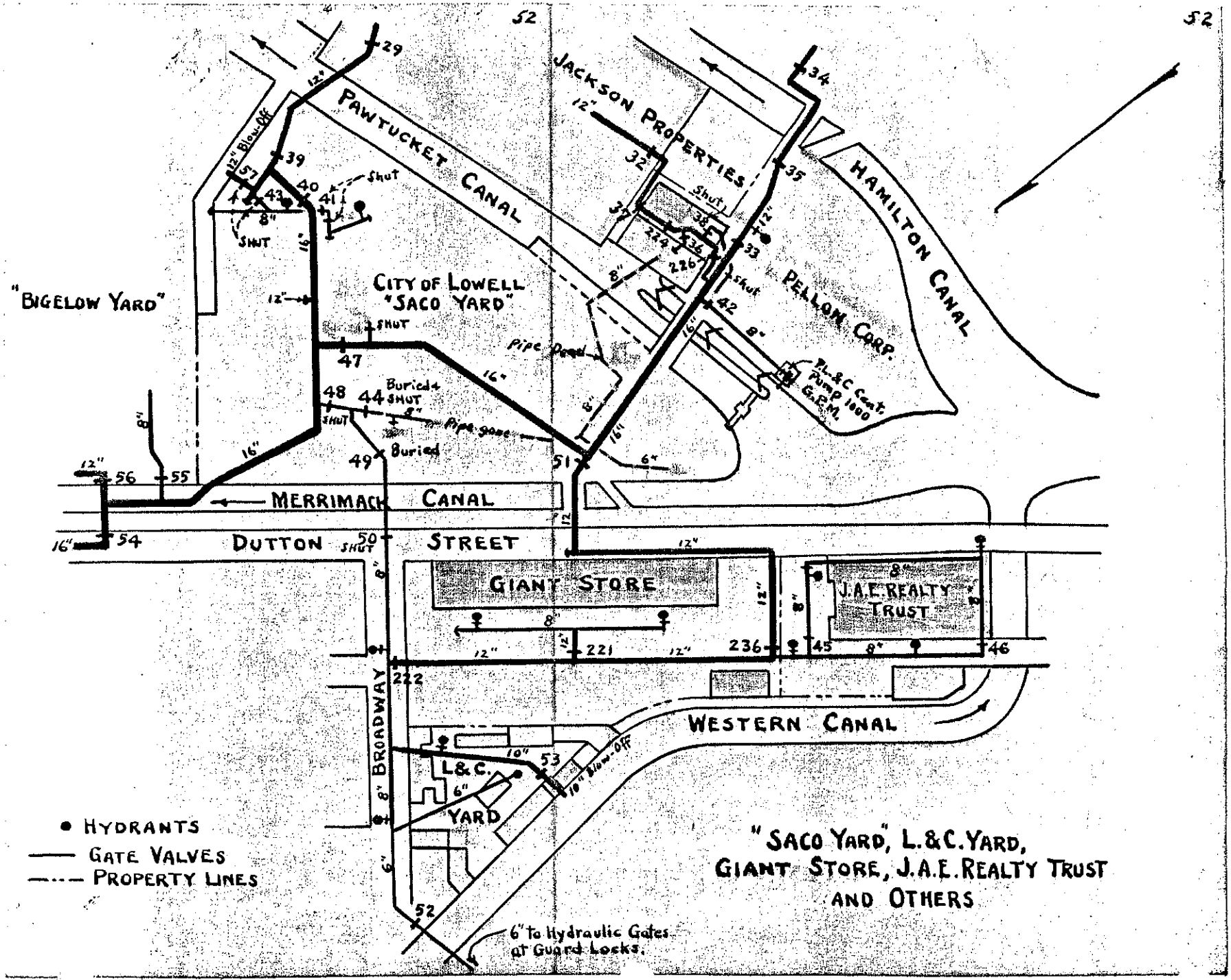

"SUFFOLK YARD"
AND
"TREMONT YARD"
HALL
CABOT STREET
STREET
CENTRAL MILLS SUPPLY
GARAGE
Flush House
10
8"
BOILER No.
NORTHERN CANAL
172
SHUT
SHUT
171
170
169
173
To shut off "SUFFOLK YARD" Close Valves 163, 168, 169.
Pipe Broke
167
5
168
SHUT
6
SHUT
166
12"
16"
164
163
8
OFFICE
SUFFOLK STREET
WESTERN CANAL
8"
12"
MERRIMACK MFG. CO.
159
160
162
8"
156
155
CURRAN AND MORTON WAREHOUSE
POWER HOUSE
161
12"
"TREMONT YARD"
8"
158
157
8"
154
153 Shut
8"
232
12"
COURIER CITIZEN
16" Co.
8"
152
151

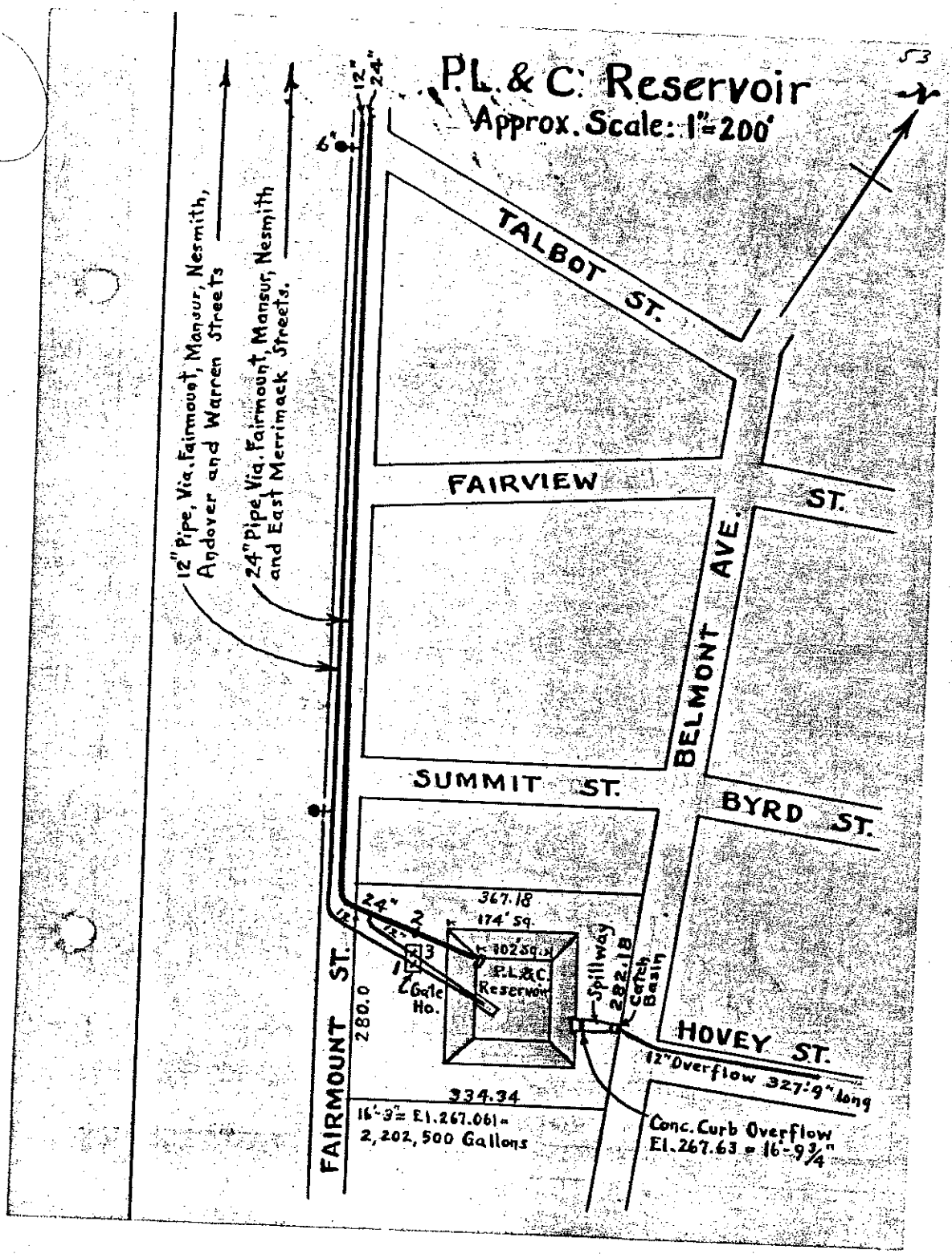
"LAWRENCE YARD"




BOOTT MILLS
AMORY STREET
To sprinklers in Merrimack Mfg. Co's Store House
8"
12"
MERRIMACK WASTEWAY
PICKER
STORE No. No. 1
STORE No. 2
STORE No. 3
EASTERN
AMORY ST.
CANAL
JOHN ST.
OFFICE
LOWELL 16 REALTY CORP.
WEST
EAST
MERRIMACK RIVER
BRIDGE ST.
9
8
4
3
2
1
7
5
120
109
108
107
105
104
103
102
101
100
99
98
111
110
227
228
To shut off Yard close valves 100, 101, 102, 106, 109, 110.
Hydrants
Gate Valves


BOOTT MILLS
95 BRIDGE STREET
E. MERRIMACK ST.
KEARNEY SQ.
CANAL ST.
CANAL
EASTERN
CONCORD RIVER
MERRIMACK RIVER
BRIDGE ST.
POST OFFICE
POWER HO.
STORE HO.
BOILER HO.
POWER HO.
No 1
No 2
No 3
No 4
No 5
No 6
No 7
OFFICE
Sec. 1
Sec. 2
Sec. 3
Sec. 4
Sec. 5
Sec. 6
Sec. 7
Sec. 9
Sec. 10
Sec. 11
2200 G.P.M. 16" Cent. Pump
8" Blow-Off
Valves shut
70 Valves 70, 71, 73 shut
20" Blow-Off
12" Blow-Off
96 Shut
1500 G.P.M. 12" Steam Pump
● HYDRANTS
GATE VALVES
To shut off Yard close valves 77, 92, 93, 94, 95, 96.


52
52
"BIGELOW YARD"
CITY OF LOWELL
"SACO YARD"
PAWTUCKET CANAL
JACKSON PROPERTIES
HAMILTON CANAL
PELLON CORP.
MERRIMACK CANAL
DUTTON STREET
GIANT STORE
J.A.E. REALTY TRUST
WESTERN CANAL
BROADWAY
L&C. YARD
Pipe Dead
Pipe Stone
Buried
SHUT
12" Blow-Off
10" Blow-Off
6" to Hydraulic Gates at Guard Locks.
HYDRANTS
GATE VALVES
PROPERTY LINES
"SACO YARD", L.&C. YARD,
GIANT STORE, J.A.E. REALTY TRUST
AND OTHERS


53
P.L. & C. Reservoir
Approx. Scale: 1"=200'
12"
24"
6"
12" Pipe, Via. Fairmount, Mansur, Nesmith, Andover and Warren Streets
24" Pipe, Via. Fairmount, Mansur, Nesmith and East Merrimack Streets.
TALBOT ST.
FAIRVIEW
ST.
BELMONT AVE.
SUMMIT ST.
BYRD ST.
HOVEY ST.
FAIRMOUNT ST.
280.0
24"
12"
367.18
174' Sq.
1025 Sq. Ft.
P.L.&C. Reservoir
Gate Ho.
Spillway
282.18
Catch Basin
12" Overflow 327'-9" long
334.34
16'-3" = El. 267.06 =
2,202,500 Gallons
Conc. Curb Overflow
El. 267.63 = 16'-9 3/4"

Document Accession #: 20180814-5118 Filed Date: 08/14/2018

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
15 State Street – 8th Floor
Boston, Massachusetts 02109-3572

August 14, 2018

9043.1
ER 18/0281

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

RE: COMMENTS ON PRE-APPLICATION DOCUMENT
COMMENTS ON SCOPING DOCUMENT 1
STUDY REQUESTS
Boott Hydropower, LLC
Lowell Hydroelectric Project, FERC No. 2790-072
Merrimack River, Middlesex County, MA, and Hillsborough County, NH

Dear Secretary Bose:

This responds to the Pre-Application Document (PAD) for the Lowell Hydroelectric Project, (Project) located on the Merrimack River in Middlesex County, Massachusetts and in Hillsborough County, New Hampshire. The PAD is being provided in preparation of an application for a new Federal license for the project. The U.S. Department of the Interior (Department) offers the following comments based on the PAD (submitted to us by Boott Hydropower, LLC, [Boott] on April 30, 2018) and additional information obtained at the Federal Energy Regulatory Commission (Commission, FERC) scoping meeting held on July 17, 2018, and the site visit held on July 18, 2018. The comments represent contributions from the Department's U.S. Fish and Wildlife Service (Service) and the Lowell National Historical Park, National Park Service (NPS).

U.S. FISH and WILDLIFE SERVICE

PRE-APPLICATION DOCUMENT

PROPOSAL

The Lowell Project consists of a 1,093-foot-long, 15-foot-high masonry gravity dam (Pawtucket dam) topped by a 5-foot-high, pneumatic crest gate system,[1] which creates a 720-acre

[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.

impoundment extending approximately 23 miles upstream. The dam has a gross storage capacity of approximately 3,600 feet between the maximum normal water surface elevation of 92.2 feet National Geodetic Vertical Datum of 1929 (NGVD) and the minimum water surface elevation of 87.2 feet NGVD when all five pneumatic gates are fully lowered. The spillway is 980.5 feet long. The project includes a two-tiered network of man-made canals, totaling approximately 5.5 miles in length, which provide flow to 21 Boott-owned hydroelectric units.[2] Nineteen of the units are located in four powerhouses (Assets, Bridge Street, Hamilton, and John Street) situated in the canal and have various runner speeds and diameters. The remaining two units are located in the main powerhouse (E.L. Field) on the Merrimack River, which uses water from the northern canal to generate power. Units in the E.L. Field powerhouse are identical, 8.6-MW horizontal Kaplan turbine-generator units, each with a maximum hydraulic capacity of 4,000 cfs.

Boott currently operates the project in a run-of-river mode. The current license requires an instantaneous minimum flow of 1,990 cfs or inflow, whichever is less, as measured immediately downstream of the project.

Boott operates both upstream and downstream fish passage facilities at the project. These include a lift at the E.L. Field powerhouse that conveys fish to the northern canal, an upstream anadromous vertical-slot fishway at the Pawtucket dam, and a downstream bypass facility at the E.L. Field powerhouse. The fish ladder has a total operating flow of 500 cfs and acts as the primary source of flow in the 0.7-mile-long bypass reach (other than spillage over the Pawtucket dam spillway when inflow exceeds the maximum hydraulic capacity of the project's stations). The current license contains no minimum bypass flow requirement.

In the PAD, Boott has proposed no additional protection, mitigation, or enhancement (PME) measures.

COMMENTS

4.0 Project Location, Facilities, and Operations

Boott provided a detailed description of the project facilities. However, several important pieces of information are missing:

- the minimum hydraulic capacities, runner diameters and runner speeds of turbines at the project (housed in the E.L. Field, Assets Station, Bridge Street, Hamilton Station, and John Street powerhouses);
- clear trashrack spacing at intakes to all of the turbines; and,
- the calculated approach velocity at the trashracks/intakes (based on the wetted trashrack area).

[2] Boott submitted an Application for Amendment of License to the Commission 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.

4.1 Civil Works

Tailrace Channel

Telemetry studies in 2002, 2011, and 2013, showed emigrating American shad that approach the Project via the tailrace have difficulty using the fishway entrance (Sprankle 2005; Alden 2011; Blue Leaf Environmental 2013). In 2016, Gomez and Sullivan engineers performed an analysis of upstream passage at the lift and recommended that Boott excavate the ledge outcropping in the tailrace channel to approximately 10 feet below normal tailwater level extending 50 to 100 feet downstream from the entrance (Gomez and Sullivan 2016). On July 18, 2017, Boott submitted design plans to the Merrimack River Technical Committee (MRTC; comprised of Federal and State agencies) for review prior to the start of construction. On July 26, 2017, the MRTC submitted their recommendations. On August, 18, 2017, at the request of Boott, the National Oceanic and Atmospheric Administration (NOAA) and the United States Fish and Wildlife Service (Service) provided additional information pertaining to the MRTC's recommendations (Attachment A). The PAD does not contain any information regarding the tailrace excavation project. We recommend Boott update the PAD to include the details we have provided here.

In the PAD, and the Commission's pre-filing milestone timetable included in the scoping document, the first study season is scheduled to begin during spring of 2019. However, Boott plans to complete the tailrace excavation project during late summer of 2019 (Attachment B). The tailrace excavation project will change flow dynamics in the tailrace channel and therefore the hydraulic conditions fish will likely encounter as they migrate upstream. As such, we ask that the studies requested herein related to upstream fish migration and flow in the tailrace area occur after the excavation is complete (second study season, or 2020) so natural resource agencies can properly assess the impacts project operations might have on migratory fish and develop adequate passage and protection measures if necessary.

4.5 Description of Project Operations

Fish Passage Operations

Boott states it has provided, and assessed the effectiveness of, American eel (*Anguilla rostrata*) passage at Lowell. The effort to pass eels at the project began in 2014 when temporary eel ramps were deployed near the ladder. However, the effectiveness of these structures has never been quantified. In 2018, Boott agreed to: (1) continue to operate the existing anadromous fish ladder for eels (releasing 30 cfs) until September 30; and, (2) perform six, dewatered, visual inspections of the ladder. To date, there have been no siting surveys performed at Lowell. Therefore, it is unknown if eels congregate at other areas within the project boundary (e.g., the outfall of the canal power stations) or if passing eels at the ladder is the most appropriate technique. The Department likely will include, in any fishway prescription issued for the project, a requirement that Boott conduct an upstream eel passage siting survey after a new bypass flow regime has been implemented to determine areas of eel concertation so permanent upstream passage facilities can be properly sited.

National Park Service Requirements

In this section of the PAD, Boott states that it maintains canal water levels "within appropriate limits during the May 15 to October 15 tour boat operating season," however no additional information is provided. We recommend Boott update the PAD to include further information regarding water levels maintained in the canal and any additional, relevant, information regarding the operations agreement they have with the National Park Service.

5.4 Fish and Aquatic Resources

Overview

The fish ladder at the Pawtucket dam has a total operating flow of 500 cfs and is the primary source of flow in the 0.7-mile-long bypass reach which extends from the Pawtucket dam downstream to the E.L. Field powerhouse. However, there is no information provided in the PAD to support this flow release is adequate to meet the life history requirements of fish and wildlife (including invertebrates such as freshwater mussels). Therefore, the Department recommends that Boott undertake a study that evaluates habitat in the bypass reach at a range of flows, including the existing 500 cfs release. The study design should include habitat mapping of the entire bypass reach in addition to collecting hydraulic and habitat measurements (i.e., depth, velocity, wetted perimeter, substrate) along a number of transects to assess the existing flow release and alternative flows.

Boott states, "fish are capable of bypassing the Project's entire canal system via the Merrimack River and can use the existing upstream and downstream fish passage facilities at the Pawtucket Dam and the E.L. Field Powerhouse." While downstream-migrating fish can potentially avoid entering the canal, despite there being no exclusionary measures in place, a study by Normandeau Associates, Inc., found only 7 percent of juvenile alewives utilized the bypass (Normandeau 1991). A follow up study (Normandeau 1995) performed after the bypass was enlarged found that of 1,779 marked fish, only 37 percent utilized the downstream fish passage facilities. While efficiency increased by approximately 30 percent from 1991 to 1995, the bypass remains less than 40 percent effective at passing fish downstream.

Although bypass effectiveness studies were performed at Lowell in the early 1990s, it is still unclear as to which route American shad (*Alosa sapidissima*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and eel select as they move downstream (spillway, fish ladder, canal, turbines, existing bypass), the survival estimates associated with each route, the effect the Pawtucket gatehouse has on downstream movement, the effect the pneumatic crest gates have on emigration, etc. To fill these data gaps and better understand downstream passage at Lowell, especially in relation to the canal, the Department recommends that Boott conduct studies which assess: (1) the behavior, approach routes, passage success, survival and delay of adult American shad and river herring as they emigrate to the ocean; (2) the impact project operations have on the downstream migration of juvenile alewife which can serve as a proxy for blueback herring and American shad in this instance; and (3) downstream route of passage and survival of adult silver-phase American eel.

Abundance

The Merrimack River supports a variety of migratory fish species, including American shad, river herring (alewife and blueback herring), American eel, and sea lamprey (*Petromyzon marinus*). Table 5.4-2 lists the number of river herring, shad, and eel that have passed the Lawrence Project (FERC No. 2800, the first hydroelectric dam on the Merrimack River), and Lowell since 1983. In 2017, Boott claims that 177,738 eels swam upstream past Lawrence. However, our records indicate an estimated 8,645 elvers were lifted in the hopper and 17,691 passed the eelway at the dam (26,336 eels total). The Department recommends that Boott update Table 5.4-2 to: (1) ensure listed, annual, fish passage counts are accurate; and (2) include sea lamprey passage counts.

Other Site-Specific Fisheries Information

In this section of the PAD, Boott states that American shad studies were conducted in 1999 and 2000, which led to significant modifications and upgrades to the E.L. Field powerhouse fish lift, thereby improving passage efficiency. However, it is unclear as to which modifications Boott is referring.

According to our records, a lack of modifications and upgrades to the project coupled with poor fish passage led to a radio-telemetry study of shad migration in 2002 (Sprankle 2005). This study found 55 percent of the shad that passed upstream of Lawrence made their way into the Project tailrace near the fishway entrance. However, only 6.2 percent of the tagged shad were actually passed upstream of the project via the fish lift. This was consistent with fish passage counts taken at Lowell in 2002; only 9.7 percent of the shad which passed Lawrence subsequently passed Lowell. These data led to a dye test, also conducted by Ken Sprankle, in June 2003. During this qualitative evaluation, concentrated dye was released into the fishway entrance channel and observed. Results demonstrated the flow field extends downstream from the fishway and stalls approximately 35 feet from the entrance, effectively cutting off the progression of shad moving up the tailrace and into the fishway. Based on fish counts at Lawrence and Lowell, passage efficiencies for American shad have not improved at the project over the past 20 years. From 1996 to 2017, passage efficiency at the project has not exceeded 30 percent. Additionally, the internal fish lift efficiency has remained low. In 1996, fish lift efficiency ranged from 0.5 to 2.4 percent. In 2000, studies conducted by Boott suggested efficiency increased to 42 percent (Boott 2000). While this latest assessment does suggest an improvement in operations compared to previous years, an internal fish lift efficiency of 42 percent is still low as overall passage efficiency is based on the combined near/far field attraction efficiency and internal lift and ladder efficiency. Based on the information above, and considering the ledge removal improvements which will take place in 2019, the Department recommends that Boott perform a study assessing American shad upstream route selection passage effectiveness and migratory delay after the ledge is removed.

Boott goes on to state, “A 1988 acoustic telemetry study performed by RMC Environmental Services (RMC) 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., found similar findings as the 1988 adult American shad telemetry study.” While it is true that 80 percent of the fish successfully exited the canal, it should be

noted: (1) the sample size was small, only 25 fish were used in the analysis; and (2) the delay caused by existing infrastructure was substantial, ranging from 1 to 5 days. Also, as a point of clarification, there were two studies conducted in 1991 by Normandeau Associates, Inc., which focused on downstream passage of river herring and shad. The scope and findings of these studies did not include upstream passage through the gatehouse, which was the focus of the RMC 1988 study. To date, the RMC study has been the only evaluation of upstream passage of shad in the northern canal and gatehouse. As a component of the studies provided herein, we recommend that Boott track and monitor clupeid behavior in the canal.

Major Findings of Fish Passage Studies Since 1988

In the PAD, Boott provides an overview of the fish passage facilities at both projects, when they began operating, and studies which have been conducted to determine their effectiveness at passing target species. We would like to offer some points of clarification, specifically on information listed in Table 5.4-3.

- 1988: Passage of Radio-Tagged American Shad through the Northern Canal Headgate Structure. Boott states that "24 of 25 radio-tagged shad (96%) released at fish lift exit passed the Northern Canal headgate structure with little delay." However, 19 of the 24 shad (80 percent) which successfully passed did not pass through the headgate structure but rather the adjacent boat lock facility. When the boat lock was closed, delay ranged from 1 to 5 days. Since a majority of the shad were observed reaching the headgate structure within an hour, the delay in migration associated with closing the boat lock was approximately 23-119 hours. The study notes that most fish approached the road bridge adjacent to the gatehouse but fell back downstream. The delay experienced by these shad is significant and, from the information provided by Boott, it is unclear how often the boat lock has been open during the upstream migratory season since the 1988 study was performed. We are concerned that the operation and management of the northern canal headgate may contribute to migratory delay and is an issue that will need to be resolved in order to successfully pass fish upstream and achieve a sustainable population of shad in the Merrimack River.

- 1991: An Assessment of the Effectiveness of a Fish Bypass for Passing Juvenile Alewives at the Lowell Hydroelectric Project. The findings listed in the table fail to include two critical results: (1) the bypass effectiveness for juvenile alewife was only 7 percent, even when bypass flows reached 2 percent of the turbine flow; and (2) when the bypass flow was increased by 50 percent, due to the units shutting down, the number of fish using the bypass increased by a significant amount (4,250 alewives in 10 minutes versus 0 in the previous 4.5 hours)

- 1996: Lowell Hydroelectric Project Internal Fish Lift Efficiency Monitoring Program. The internal fish lift efficiencies should be included in the findings, as they were extremely low, ranging from 0.5 percent to 2.4 percent.

- 1999: An Assessment of Internal Fish Lift Efficiency at the Lowell Hydroelectric Project. The study findings section states, "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." While this statistic may technically be correct, it actually represents a decrease from 1992 and 1995, when the ratios of total shad lifted at Lowell were 31 percent and 38 percent, respectively.

- Boott performed two fish lift internal efficiency studies and in the major findings column claims the crowder position has a beneficial impact on fish passage efficiency. However, this contradicts the study findings listed for the 1996 Normandeau Associates, Inc. study. As noted above, the Department suggests that Boott include information regarding modifications made to the fish lift which supports its contention of improved internal efficiency.

- A report by Gomez and Sullivan (2016) titled "Analysis of Upstream Fish Passage Facilities and Operations" was not included in the PAD. We recommend Boott update Table 5-4.3 to include this study, which identifies specific areas of improvement needed to increase the Lowell fishways reliability and upstream passage efficiency. Recommendations provided in the report include: (1) installing a pivot gate to update the existing vertical gate; (2) excavating the ledge outcrop downstream of the fishway entrance; (3) reopening the street side entrance; and (4) installing an entrance extension. The analysis also highlights the aging infrastructure at the project and the need to replace specific components, along with cost estimates.

6.0 Preliminary Issues, Project Effects, and Potential Studies

Fish and Aquatic Resources

Boott has not proposed any studies for relicensing at this time, but has identified potential resource issues which include: bypass flows, fish passage, historical resources, boating access, and inundation of upstream floodplains. Relevant to fish and aquatic resources, the Department believes new studies need to be conducted, with sufficient fish sample sizes, to better understand upstream and downstream passage at the project as well as instream flows in the bypass reach.

Downstream Passage

The Department recommends that Boott conduct new studies to fully understand how post-spawned adult shad and river herring, juvenile shad and river herring, and adult silver phase eels move past the Pawtucket dam, through the canal system, turbine intakes, and the downstream bypass facility. In addition, turbine injury and mortality studies are needed and should be used in conjunction with results of the passage routing studies, where applicable, to calculate total through-project survival rates. The Department herein provides study requests in order to address these information needs.

Upstream Passage

Yearly site inspections, performed by the Service, have identified a number of problems with respect to American shad at the lift and ladder fishway entrances. The Department believes that a comprehensive radiotelemetry study is needed to understand the relationship between project operations, including spill flows, and shad and river herring movement through the Merrimack River, including attraction to and passage through these facilities. Additionally, a study to define

the relationship of the complex hydraulic conditions at the spillway fish ladder entrance and the tailrace fish lift entrance is needed in order to evaluate data on fish behavior and passage at those locations. Therefore, the Department is providing herein study requests to address these information needs.

Instream Flows in the Lowell Bypass

The bypass reach is 0.7 mile long (from the Pawtucket dam to the E.L. Field powerhouse) and contains diverse habitat. There are approximately 11 miles of free-flowing river downstream of the Pawtucket dam which also contain a diversity of habitat, including important spawning and rearing habitat for migratory fish species such as American shad. To date, there have not been any empirical studies which assess the adequacy of the existing flow protocols. The Department herein submits study requests intended to address these information gaps.

ADDITIONAL INFORMATION

The following information is needed:

- the minimum hydraulic capacities, runner diameters and speeds of the turbines in each powerhouse associated with the project;
- a more thorough description of how project operations are monitored and recorded;
- hourly data (water surface elevations, dam discharge, generation) for the project in spreadsheet format for the past 5 years;
- a detailed description of modifications made to the existing fish passage facilities, including dates changes were made;
- a detailed description of canal operations; and
- a detailed description of modifications made to the bypass extending from the Pawtucket dam to the E.L. Field powerhouse (weir installation, excavation, etc.).

RECOMMENDED STUDIES

Boott is not proposing to undertake any studies as part of this relicense proceeding. Enclosed please find formal study requests (Attachment C) by the Service in the format required pursuant to 18 CFR §4.38(b)(5). Please note the Service also supports the study requests provided by the other agencies including, but not limited to, National Marine Fisheries Service, Massachusetts Division of Fish and Wildlife, and Massachusetts Department of Environmental Protection.

SCOPING DOCUMENT 1

3.6.3 Project Decommissioning

The Commission proposes to eliminate this alternative from detailed study in the environmental analysis, because no party has suggested project decommissioning would be appropriate in this case. The Commission asserts that there would be significant costs involved with decommissioning the project, including lost energy production.

We recommend that the Commission include project decommissioning in the environmental analysis. Although no party has suggested this alternative, up to this point in the Integrated

Licensing Process, there has been no formal opportunity to provide such a recommendation. Further, the Commission has supplied no supporting information to justify the contention of significant decommissioning costs (which could run the gamut from "locking the door" to full dam removal at the Lowell Project). Given the substantial increase in the numbers of proposed renewable energy projects, it is possible that there may be no net loss of energy production when viewed on a regional basis. Also, we are requesting a number of studies to understand the impacts of the project. Study results could identify impacts which either cannot be mitigated or would be prohibitively expensive to mitigate. In light of that possibility, decommissioning of the Lowell Project should be retained as a potential alternative that the Commission may need to address.

4.1.2 Geographic Scope

The Service recommends the geographic scope of the Commission's environmental analysis (pertaining to impacts to cumulatively affected fishery, water quantity, and water quality resources) extend from the Eastman Falls dam (FERC No. 2457) and Lake Winnipesaukee to the confluence of the Pemigewasset and Winnipesaukee Rivers, downstream to the Atlantic Ocean, as this represents the extent in which river herring and American eel are managed in the basin.

4.2.1 Aquatic Resources

Effects of project facilities and operations on fish migration should be analyzed cumulatively as well as for individual projects. Additionally, effects of entrainment should not be limited to fish populations, but should include impacts to food web interactions and overall ecosystem productivity.

LOWELL NATIONAL HISTORICAL PARK, NATIONAL PARK SERVICE

COMMENTS

PAD Section 1.0 Introduction and Background

The 5.6 miles of historic canals are wholly within the boundary of Lowell National Historical Park and are a principle resource that Congress directed the Park to protect. Additionally, the canal system and support buildings are designated as a National Historic Landmark, offering the highest provision of historic preservation protection under the National Historical Policy Act of 1966. The canal system is also located within the boundaries of:

- Lowell Locks and Canals National Historic Landmark District;
- Lowell Water Power System National Historic Civil Engineering Landmark; and
- Lowell Power Canal System and Pawtucket Gatehouse National Historic Mechanical Engineering Landmark.

The first mention of historic resources in the PAD is located on Page 28, section 4.9 following the description of all resources. These significant designations should be inserted into the Intro/Background Section.

PAD Section 4.0 Project Location, Facilities, and Operations

Nearly all of the Civil Works described in Section 4.1 are historically significant structures, listed as contributing features within the National Historic Landmark District. Please include date of construction for each of the Civil Works referenced on pages 10-15 or Sections 4.1.1 through 4.1.11. Please also include, where applicable, a reference to significant historical resources in this section. For example, "Constructed in 1847, the Pawtucket Gatehouse is located at the southern abutment of the Pawtucket Dam…The Pawtucket Gatehouse is the site of origin for the historically significant Francis Turbine which is still intact within the building."
The following table cross-references PAD names with the language produced by Proprietors of Locks and Canals on Merrimack River (PLC) as recorded in the "Lowell Canal Survey" by the 1976 Historic American Engineering Record (HAER). The current PAD names of certain Civil Works do not match the naming convention used in the National Register Nomination or by the National Historical Park and should be revised accordingly.

PAD ID	**PAD name**	**Historic Name (construction dates) [alternate names]**
4.1-1	Pawtucket Dam	Pawtucket Dam (1826, 1830, 1847,1875)
4.1.2	Northern Canal	Northern Canal (1848)
4.1.2a		Great River Wall (1848)
4.1.2b		Northern Canal Waste Gates (1848,1872)
4.1.3	Pawtucket Gatehouse	Pawtucket Gatehouse (1848) [a.k.a. Northern Canal Gatehouse]
4.1.4	Pawtucket and Downtown Canals	
4.4.4a		Pawtucket Canal (1796, 1823)
4.4.4b		Merrimack Canal (1823)
4.4.4c		Lowell Canal (1828)
4.4.4d		Hamilton Canal (1828)
4.4.4e		Western Canal (1831)
4.4.4f		Lawrence Canal (c. 1831)
4.4.4g		Eastern Canal (1836)
4.4.4h		Moody Street Feeder (1848) [see 4.1.5.2 below]
4.1.5	Miscellaneous Canal Structures	
4.1.5.1	Guard Lock and Gates Facility	
4.1.5.1a		Guard Locks (1824, 1850) [Gatehouse over upper lock gates constructed 1881]
4.1.5.1b		Francis Gate (1850)
4.1.5.1c		Pawtucket Canal Gatehouse (1870)
4.1.5.2	Moody Street Feeder Gatehouse	Moody Street Feeder Gatehouse (1848)
4.1.5.3	Lawrence Dam	Lawrence Dam (1831) [at junction of Western and Lawrence Canals]
4.1.5.4	Hall Street Dam	[on Western Canal]
4.1.5.5	Tremont Wasteway [Treemont on map – PAD fig 4.0.2]	[at confluence of Western and Northern canals]
4.1.5.6	Lower Locks and Dam	Lower Locks (1824, 1843) [includes two chamber navigation lock, dam, gatehouse, spillway, and associated structures]

4.1.5.7	Swamp Locks and Dam	Swamp Locks (1824, 1841) [Where the upper Pawtucket Canal splits into the Western, Merrimack, Lower Pawtucket, and Hamilton canals. Swamp Locks complex includes two chamber navigation lock, dam, spillway, control house, and associated structures]
4.1.5.8	Merrimack Dam and Merrimack Gate	[at foot of Merrimack Canal]
4.1.5.9	Rolling Dam	[controls flow from Merrimack Canal into Boott Mill arm of the Eastern Canal]
4.1.5.10	Boott Dam	
4.1.5x	[Historic canal water control structures not identified in PAD of concern to National Park Service]	
		Western Canal Guard Gates [between Merrimack and Moody streets]
		Hamilton Canal Guard Gates [at head of Hamilton Canal near Swamp Locks]
		Hamilton Wasteway and Gatehouse [at foot of Hamilton Canal near Central St]
		Massachusetts Wasteway Gatehouse [at Bridge St, where Eastern Canal bents to feed Boott Mills/John Street Powerhouse]
4.1.6	Mill Buildings	The PAD notes that only the turbines and associated equipment are included in the project boundary, not the buildings that surround them. Nonetheless, it would be useful to cross reference generating facilities and the mill complexes where they are housed
	John Street Power Station	Boott Mills
	Bridge Street Power Station	Massachusetts Mills (unit numbers?) and Prescott Mills (unit numbers?)
	Hamilton Power Station	Hamilton Mills (unit numbers?) and Appleton Mills (unit numbers)
	Assets Power Station	Market Mills Powerhouse
4.1.7	Tailrace Channel	
4.1.8	Bypass Reach	
4.1.9	Control Structures	[across Northern Canal at EL Field powerhouse. Colloquially called “Hydro Lock” by National Park Service staff. Need more precise name to avoid confusion with 4.1.3 Pawtucket Gatehouse, a.k.a. Northern Canal Gatehouse.]
4.1.10	Fish Passage Structures	
4.1.11	Eldred L. Field Powerhouse	

PAD Section 5.8 Recreation and Land Use

In Section 5.8.1 – Please include canal-adjacent walkways and NPS boat tours as recreational resources.

On Page 108, please revise "Portions of the Lowell National Historical Park are within the project boundary" to "The entire 5.6 mile power canal system and supporting historic structures and equipment along with paved recreational trails constructed immediately adjacent to the canals are recreational resources within the Project Area and boundary of the National Historical Park. Additionally, the 5.6 mile power canal system is located within the boundary of the Lowell Locks and Canals National Historic Landmark District, Lowell Water Power System National Historic Civil Engineering Landmark; and Lowell Power Canal System and Pawtucket Gatehouse National Historic Mechanical Engineering Landmark."

Please add in the system of interconnected walkways/multi-use trails located along the canal and river edge as existing recreational facilities. Lowell National Historical Park has worked for decades, together with our partners, to build a system of interconnected river and canal adjacent trails. Boott has helped facilitate the construction of some trails by providing necessary easements. As key links in the trail network are constructed, we've witnessed increases in both recreational and transportation use by park visitors and the local community. Trails are an essential component of the Park's alternative transportation system – which also includes trolleys and tour boats – designed to link the Park's scattered sites located throughout the densely developed city. The vision for the trail system is outlined in the Park's 1980 General Management Plan and sister documents, the Preservation Plan (1980) and the Preservation Plan Amendment (1990). Because Lowell was developed as a textile factory town, with industrial efficiency as the most important factor in determining historical land uses, very few parks exists. These linear trails connect residents to waterfronts and offer a reprieve from the industrial city. In addition, trail systems have been an economic engine for the City with $54 million in public investments toward trail development resulting in over $527M in private investment in the development of adjacent properties. With strong support from our partners and local community, developing the missing links and connecting to other regional trails, increasing public access, and maintaining trails in good condition continues to be a priority of the national park.

The National Park Service offers seasonal ranger-guided canal and river boat tours which provide unprecedented access to the historic canals. Each summer, thousands of visitors experience the canals and learn about their history in NPS-led boat tours, https://www.nps.gov/lowe/planyourvisit/guidedtours.htm.

PAD Section 5.9 Aesthetic Resources

Please include mention of trash accumulation and vegetation in the Aesthetic Resources as an existing condition. One of the top public complaints/concerns regarding aesthetics relates to the presence of trash and the overgrowth of vegetation which collects additional trash. (See photo, August 2018 near Hamilton Gatehouse).

PAD Section 5.10 Cultural Resources

The section on Historic Resources is only 3 pages long, does not reference the Congressional mandate for the National Park Service to protect and preserve the historic 5.6 mile canal system for this and future generations, and does not include any photos. Many of the resources listed as "Key Components" of the Locks and Canals Historic District on pages 135-136 are also described in Section 4.1 "Civil Works." The historical significance of these structures and date of construction should be described in further detail in this section of the report given their national significance, location within the boundary of multiple protected areas, and because the resources contribute to the significance of the Lowell National Historical Park; Lowell Locks and Canals National Historic Landmark District; Lowell Water Power System National Historic Civil Engineering Landmark; and Lowell Power Canal System and Pawtucket Gatehouse National Historic Mechanical Engineering Landmark.

Please find and replace reference to National Historic Park to the correct naming convention Lowell National Historical Park throughout the document.

"The Lowell National Historical Park" Section contains numerous inaccuracies. Please reference PL 95-290, Lowell Canal System Cultural Resources Inventory, and subsequent plans and studies referenced in this letter to correct, or to incorporate text below:

> Lowell National Historical Park was established by Congress June 5, 1978 (PL 95-290). Although the area within the park boundary is 142 acres and the larger Lowell Historic Preservation District encompasses 583 acres, only 19 acres are in federal ownership. The Park is by design a partnership park in which federal, state, and local governments as well as the private sector and local community carry out the legislative intent of the park unit. Physical resources protected by the park include the original 5.6-mile power canal system, a nationally recognized engineering marvel with its sophisticated dams, locks, and gatehouses; 7 of the original 10 textile mill complexes (5.3 million square feet); significant examples of early housing types, institutions, and transportation facilities; and diverse museum collections. In addition to the industrial artifacts, Lowell retains much of its rich cultural heritage, as reflected in the ethnic diversity and preserved traditions of its citizens.
>
> Lowell National Historical Park's museum collection includes the Proprietors of Locks and Canals (PLC) Records from 1747 through 2008 which document the original construction and on-going maintenance of the canal system and includes 9,304 architectural / engineering drawings, 6,770 original photographic prints, 79 film

negatives, 9 glass-plate negatives, and 39 glass lantern-slides produced by PLC between the years 1883 and 1956.

PLC Volume I https://www.nps.gov/lowe/learn/historyculture/upload/LOWE-ARCHIV-FindingAid-0908-PL-CI.pdf
PLC Volume II https://www.nps.gov/lowe/learn/historyculture/upload/LOWE-ARCHIV-FindingAid-0908-PL-CII.pdf

Lowell National Historical Park together with the University of Massachusetts Lowell College of Education facilitate education programs at the Tsongas Industrial History Center at the Boott Mills that reach approximately 40,000 students and teachers annually. These programs use the resources of the National Park including the historic canals, industrial mills powered by the canals, and the Merrimack River.

Lowell National Historical Park would not be a unit of the national park system if the historic canal system were not present. Continued preservation of and public access to the 5.6 mile historic canal system and supporting historic structures are essential to meet Lowell National Historical Park's Congressional intent.

There is no reference to the Lowell Heritage State Park in the Historic Resources section of the PAD. A summary description of the state park should be included in the Historic Resources Section. The Massachusetts Department of Conservation and Recreation (DCR) issued a comprehensive Resource Management Plan in 2014, that describes its complex rights on the canal system, including gatehouse structures and other elements.

Page 137 – The current condition of buildings in the historic district is not up to date and requires additional research and revision. As of August 2018, the collaboration between Lowell National Historical Park and its partners has resulted in the rehabilitation of over 98% of the 5.3 million square feet of historic mill space adjacent to the canals and hundreds of additional buildings in the downtown historic district.

PAD Section 6.2.1 – Preliminary List of Resource Issues Table

Please add "**Historic Resources**" as a "Resource Area" and "**Ownership and maintenance responsibilities / obligations of the 5.6 mile historic canal system and supporting historic buildings and mechanical equipment, Impacts of High/Low Water Levels, Vegetation"** as "Issues pertaining to Specific Resource Areas."
Please add "**Aesthetic Resources**" as a resource area and "**Vegetation and Trash**" as "Issues…"

Under **Recreation**, please also include "**Flow rates, water levels, and functional lock chambers**" under "Issues."

In April 2008, FERC initiated a request to Lowell National Historical Park for information regarding compliance and status of the license agreement. NPS enumerated several on-going license issues in a response letter. The NPS letter was forwarded to Enel/Boott Hydropower, Inc. and an additional response was provided by Enel/Boott Hydropower, Inc. These letters illuminate many on-going issues and areas of concern between the national park and licensee and are attached as Attachment D for reference.

Additionally, preliminary discussions with staff and partners following the July 17 Scoping Meeting revealed the following specific issues which are directly related to Boott Hydropower Inc.'s (Boott's) current license / project operations.

IMPACT OF PROJECT OPERATIONS ON CULTURAL RESOURCES

Cultural Resource Issues Requiring Repair

1. **Great River Wall Maintenance:** The structural integrity of the Great River Wall and public safety are issues of highest concern to the NPS, given a past collapse of a portion of the wall. Vegetation management, water levels, and other factors related to Boott's operation may affect the structural integrity of this National Historic Landmark District feature as well as the life and safety of trail and canal users.
2. **Repair Hydro Locks:** This set of locks was installed by Boott as part of the mitigation for their 1983 FERC license and remains under the applicant's ownership. The Park has been unable to use the lock chamber because the gates need repair and are mired in mud. This needed repair is also a high priority for the NPS.
3. **Repair Northern Canal Waste Gatehouse:** The water level in the Northern Canal runs high and damages some of the wood structure under this gatehouse at the Great River Wall. The National Park hired EYP Architects to assess the repair needs which are now substantial (See Attachment E, 2017 Northern Canal Waste Gatehouse Project Scoping Report). Plans and specifications can be provided. The damage is directly attributable to Boott operations and should be repaired.
4. **Replace/Repair of Moody St Feeder Gatehouse Gate:** Boott cut a hole in a portion of one of the gates some years ago to install a high voltage power line and never replaced the gate materials. If the hole in the gate was filled, the Park could continue using its historic water turbine for student and visitor programs at Suffolk Mill when the system is drained. This will also be an essential issue if partner organizations would like to move forward with plans to activate ice skating or other recreational activities in the Merrimack Canal.
5. **Lower Locks Fill Valve:** The Lower Locks Fill Valve is owned by Boott while DCR owns the adjacent lock chambers and gatehouse superstructure. Boott does not use the valve in its canal system control operations and no longer maintains it. The valve, which is no longer operable, is needed for the operation of the locks, which are most often used for recreational purposes by the Lowell Parks and Conservation Trust for its whitewater rafting program. In addition, the above-water part of the valve mechanism, the granite platform, and its railing are a focal point of the Lower Locks site, forming a part of the historic scene. The valve is in failure mode because of the deterioration of the section of canal wall on which the mechanism and its operating platform are set. The National Park had 50% construction documents prepared by a consultant in 2012 for the rehabilitation of the valve, which would consist of reconstruction of the section of failing wall beneath and the resetting of the valve operating mechanism and its granite platform slab atop the wall. Those documents can be shared with Boott, but would have to be finalized to be used as contract documents. The NPS consultant's contract has since expired. The full repairs were not completed because that contract was modified due to funding limitations

to instead provide documents for a temporary stabilization of the valve mechanization, which was exhibiting signs of potential catastrophic failure. In 2012, the National Park contracted the stabilization of the valve platform as a temporary stopgap measure. However, that stabilization was presumed to be a temporary fix to last 2 or 3 years because it could not address the root problem of the deterioration of the wall supporting the valve. Permanent repairs are needed.

6. **Hall Street Dam & Lawrence Dam:** This is a scenic area beside the arena and Lawrence Mills. There is a lot of vegetation that has grown on and around the dam so that the point may be lost on a visitor that it is a dam. The vegetation is further damaging the existing stone work. Rebuilding the dam would allow the water to cascade over the stepped dam as it did in the past and refill the pond that existed behind the dam. The nearby Lawrence Dam needs rehabilitation work so that the gates will allow the basin between Hall Street Dam and the Lawrence Dam to be maintained at a higher water level more regularly. The reconstruction of the missing gatehouse structure on the dam is a long term goal.
7. **Western Canal Sectional Gates:** Repairs are needed to many gates which isolate water levels within the system. If the Western Canal Sectionalized Gates are repaired, areas of the canals could be de-watered without interrupting power production while keeping the optimal water levels in other areas throughout construction duration.

IMPACT OF PROJECT OPERATIONS ON RECREATIONAL, LAND USE, AND AESTHETIC RESOURCES

Recreational, Land Use, and Aesthetic Resource Issues Requiring Repair

1. **Repair Hydro Locks:** This set of locks was installed by Boott as part of the mitigation for its FERC license. They have not been transferred to NPS and remain owned by Boott. The Park has been unable to use the lock chamber because the gates need repair and are mired in mud. NPS cannot operate boat tours along the Northern Canal without repair to the locks.
2. **Replace/Repair of Moody St Feeder Gatehouse Gate:** Boott cut a hole in a portion of one of the gates some years ago to install a high voltage power lines and never replaced the gate materials. Water leaks through the whole cut in the gate for the cable and as a result water levels cannot be controlled. This could prohibit future on-water recreation proposed by partners due to lack of water control.
3. **Trash removal:** One of the top public complaints Lowell NHP hears is regarding trash floating in the canal. Trash accumulation can result in negative impacts to recreational users as well as aesthetic resources. A plan for optimal trash removal should be documented in a formal agreement among parties.

PAD Section 7.1 Qualifying Comprehensive Plans Deemed Applicable

The NPS intends to file a number of the plans listed below with FERC for certification as Comprehensive Plans pursuant to Section 10(a)(2)(A) of the Federal Power Act.

Legislative History of the Lowell National Historical Park (LOWE) and Associated Planning and Management Documents.

In 1976, the Lowell Locks and Canals National Historic District (the District) was listed on the National Register of Historic Places (NR). It was included as part of Lowell National Historical Park's designation as a National Historic Landmark (NHL) in 1977. The NHL District encompasses approximately 125 acres of land including canals, gates, locks, dams and associated structures. The first canal dates to 1796 and was initially used for transportation of goods around Pawtucket Falls. The canal system was adapted in 1822 to provide waterpower for the developing textile industry. The District also included several mill yards and worker housing associated with the textile industry that were constructed in the early 19th century.
On June 5, 1978, Congress established Lowell National Historical Park. The enabling legislation states that the purpose of the park is 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 generation by implementing to the extent practicable the recommendations in the Report of the Lowell Historic Canal District Commission." The "five-and-sixth-tenths-mile power canal system" is named specifically as a historical resource to be protected and preserved by the NPS and is located wholly within the 142 acre boundary of the National Historical Park and the 583 acre Preservation District established under the 1978 Act.

The Lowell Canal Survey by the Historic American Engineering Record (1976) documented the history of the development of the canal system in Lowell and includes detailed narrative, photographs, drawings, and maps of the historic canal system.

The Brown Book (1977) entitled *Report of the Lowell Historic Canal District Commission to the Ninety Fifth Congress of the United States of America*
https://www.nps.gov/lowe/learn/management/upload/1977_-Brown-Book-_reduced.pdf provided the justification for the **establishment of the Lowell National Historical Park (LOWE) in 1978. PL 95-290 June 5, 1978** https://www.gpo.gov/fdsys/pkg/STATUTE-92/pdf/STATUTE-92-Pg290.pdf established LOWE and tasked the Commission with develop what became the ***Preservation Plan* in 1980**
https://www.nps.gov/lowe/learn/management/upload/LOWE_475_D5_A_0001-18-0613.pdf.
That plan set out the primary themes and responsibilities for LOWE which are listed at page 5 as 1. "Preserving the 19th Century Setting," 2. Encouraging the Varieties of Cultural Expression," and 3. Projects Mandated by the enabling legislation. ***Details of the Preservation Plan*** was issued shortly afterward.
https://www.nps.gov/lowe/learn/management/upload/LOWE_475_D5_18-0612.pdf.

The 1981 General Management Plan for Lowell National Historical Park (LOWE)
https://www.nps.gov/lowe/learn/management/upload/1981-LOWE-GMP.pdf was the initial long term planning document for LOWE. Included in the GMP at page 37 is a discussion on Canal System Management which identifies the initial parties to the cooperative agreement that formed the basis for future MOU's, the most recent of which was signed 1991 in association with the original licensing of the hydro project in 1983. Those parties included the NPS, the City of Lowell and the Commonwealth of Massachusetts. The NPS, along with the City of Lowell and the Commonwealth of Massachusetts (DCR) intend to work with the applicant to develop a new MOU to address canal operations and management.

LOWE and its associated canal system was designated a National Historic Landmark in 1977. The Commonwealth of Massachusetts effected a Taking (see Middlesex North Registry of Deeds Book 3830 Page 70) in 1986 whereby the Commonwealth took ownership of various canal resources in order to consolidate ownership. This gave the Commonwealth the right to provide public access to the canal system and adjacent walkways, and provided authority to spend money to improve and maintain various historic structures.

In 1987, Congress (PL 100-143) reauthorized the Lowell Historic Preservation Commission http://uscode.house.gov/statutes/pl/100/134.pdf and directed them to prepare a **Preservation Plan Amendment which was submitted to the Secretary of the Interior on May 19, 1990.** https://www.nps.gov/lowe/learn/management/upload/LOWE_475_D5_A_0001-18-0613.pdf. The Amendment focuses on development, management and use of the canal system and adjacent properties, many of which were developed into public walkways which remain an integral part of the park and the visitor experience.

In 1995, the Commonwealth granted an easement, assigning the Commonwealth's non-fee interests to the NPS for the purpose of developing canal resources, preservation of historic resources associated with the canal and providing continued and additional public access. The 1978 enabling legislation provided for the NPS to manage resources associated with the District without fee ownership, in what is now referred to as a Partnership Park.

In 2003, the NPS completed the **Addendum to the 1981 General Management Plan for LOWE** https://www.nps.gov/lowe/learn/management/upload/2003-LOWE-2003-GMP-Addendum.pdf, focused primarily on re-establishing roles and responsibilities following the sunset of the Commission. Most of the Commission's responsibilities were transferred to NPS staff at LOWE.

The most recent NPS prepared document is the **September 2017 *Foundation Document*** https://www.nps.gov/lowe/learn/management/upload/2017_LOWE-Foundation-Doc_Email-Size.pdf for LOWE, outlines why LOWE was established, which resources are nationally significant, and updates our management priorities. The Foundation Document (FD) reaffirms our Legislative Purpose, National Significance and Fundamental Resources and Values. As part of the FD, NPS prepares Significance Statements (P.6) that express why a park's resources and values are important enough to merit designation as a unit of the National Park System. Among those are The Lowell Canal System[3] and Integrity of Historical Urban Landscape.[4] The plan identified LOWE's Fundamental Resources and Values, those resources or values essential to meeting the legislated purpose of the park and warrant primary consideration for future planning and management decisions including maintenance and operations.

[3] The Lowell canal system is nationally recognized as one of the most impressive civil and mechanical engineering achievements of the 19th century because of its grand scale and technological complexity, and is the site of origin for the famed "Francis" turbine. The canal system, used as both a transportation corridor and power source, facilitated the growth of the industrial city. Lowell NHP Foundation Document (Lowell, MA: NPS, 2017) p6.

[4] A very large proportion of original buildings, structures, and urban landscapes have survived in Lowell's park and preservation district and now are recognized as important historical artifacts. These include the entire 5.6-mile power canal system with its sophisticated dams, locks, and gatehouses, 7 of the original 10 mill complexes, and significant examples of early housing types, institutions, and transportation facilities. Lowell NHP Foundation Document (Lowell, MA: NPS, 2017) p7.

Fundamental Resources and Values (P.7) include the **Water Power System/Canal System**[5] and the **Immersive Experience**[6] provided to visitors, including water-based tours of the canal system and hands on interpretive and educational opportunities that provide insights into Lowell's industrial past and that of the nation as a whole. Significance Statements outlined current conditions and trends, and identified key threats to NPS resources as well as opportunities to protect and enhance those resources. NPS developed a fundamental resources and values table in the 2017 Foundation Document that provides details on data and planning needs associated with the **Water Power System/Canal System** (P.12-14) and for the **Immersive Experience** (P.18-20). Key Issues and Associated Data Needs were identified at pages 33-35 and the associated tables at pages 36-41. Among them are the Renewal of the Enel Green Power License, Jurisdictional Challenges (land rights and ownership), and Private Ownership in the Park and Preservation District. See Attachment F for further detail.

RECOMMENDED STUDIES

Please see Attachment G for study requests recommended by NPS.

[5] **Water Power System / Canal System.** The Lowell National Historical Park boundary includes 9.6 miles of major riverbanks and all 5.6 miles of historic canals in Lowell, all of which comprise the waterpower system that harnessed waters of the Merrimack River to power the city's mills. In fact, the Merrimack River and its natural attributes dictated the location of the city itself. The water power and canal system includes the Pawtucket, Merrimack, Hamilton, Western, Eastern, Lowell, and Northern Canals and canal banks, as well as several associated locks, gatehouses and dams, and Pawtucket Falls. This system, which still operates as a source of hydroelectric power, provides an opportunity to interpret both the historic significance of water in industry, as well as the engineering of a waterpower system. Public access has been expanded over the years to support these interpretive opportunities, including creation of a pedestrian canalway and riverwalk and the development of related exhibits and programs such as the Suffolk Mill Turbine Exhibit.

[6] **Immersive Experience.** Lowell National Historical Park provides a variety of hands-on interpretive and educational opportunities that allow visitors to immerse themselves in Lowell's industrial past. Key park experiences include exhibits that feature a working turbine and weave room, as well as boat tours of the canal system and rides through the park on historic replica trolleys, which are among the most popular and unique experiences in the park. The Tsongas Industrial History Center, a partnership between Lowell National Historical Park and the University of Massachusetts Lowell College of Education, is a hands-on center where students can learn about the American Industrial Revolution through interactive activities such as weaving, working on an assembly line, creating canal systems and testing water wheels, and measuring water quality.

Thank you for the opportunity to review and comment on this project. If you have questions regarding these comments, please contact Julianne Rosset, U.S. Fish and Wildlife Service at julianne_rosset@fws.gov, (603) 227-6436 or Kevin Mendik, National Park Service at kevin_mendik@nps.gov, (617) 223-5299. Please contact me at (617) 223-8565 if I can be of further assistance.

Sincerely,

Andrew L. Raddant
Regional Environmental Officer

ATTACHMENTS

CC: Enel (kevin.webb@enel.com

LITERATURE CITED

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Blue Leaf Environmental. 2013. Additional Analysis of American Shad Three- Dimensional Behavior in the Tailrace of the Lowell Project. Submitted to Boott Hydro, LLC. Final Report. Blue Leaf Environmental, Inc. Ellensburg, Washington. 4 pp.

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ATTACHMENT A

United States Department of the Interior

FISH AND WILDLIFE SERVICE

New England Field Office
70 Commercial Street, Suite 300
Concord, NH 03301-5087
http://www.fws.gov/newengland

September 26, 2017

Mr. Randald Bartlett, P.E.
ENEL Green Power North America, Inc.
100 Brickstone Square, Suite 300
Andover, Massachusetts 01810

Dear Mr. Bartlett:

Ref: Lowell Hydro Project – FERC No. 2790
Ledge Excavation Design Comments and Recommendations

This responds to the Lowell Ledge Excavation Designs that you submitted to us via email on July 18, 2017. We have been working with ENEL Green Power North America, Inc. (ENEL) for many years to enhance upstream fish passage, and the proposed ledge removal is part of a larger effort to address upstream fish passage performance at the Lowell Hydroelectric Project (FERC No. 2790). Thus far, progress has been made to improve internal fish lift operations protocols, fish lift entrance evaluations, and fish ladder repairs and maintenance. However, the U.S. Fish and Wildlife Service (Service), along with other agencies, have indicated in prior meetings and correspondence that additional measures are necessary at both the tailrace fish lift and spillway fish ladder in order to achieve adequate American shad and river herring passage effectiveness.

At a meeting on August 15, 2017, ENEL's proposed ledge removal designs were discussed and the Service and other agency representatives outlined our recommendations on the proposed designs. As agreed to at the meeting, the Service's Bryan Sojkowski and Bjorn Lake (of the National Marine Fisheries Service) prepared the attached memo which provides more explanation and details regarding our recommendations.

Thank you for meeting with us and providing us the opportunity to comment on the designs. If you have any questions, please contact John Warner at 603-227-6420 or Julianne Rosset at 603-227-6436.

Sincerely yours,

Thomas R. Chapman
Supervisor
New England Field Office

Enclosure

cc: CNEFRO - Joe McKeon, Mike Bailey (via email)
RO/Fisheries - Bryan Sojkowski (via email)
NHFGD - Matt Carpenter (via email)
MDFW- Caleb Slater (via email)
MDMF- Gloucester - Ben Gahagan (via email)
NMFS - Sue Tuxbury (via email)
NMFS - Bjorn Lake (via email)
FERC - Division of Hydropower Administration and Compliance
Reading File
ES: JRosset: 9-26-17:603-227-6436

Technical Memorandum

To: Randald Bartlett, P.E., Senior Operations Manager – Northeast, ENEL Green Power North America, Inc.

From: Bjorn Lake, P.E., PhD, NOAA Fisheries; Bryan Sojkowski, P.E., USFWS

Re: P-2790 Lowell Ledge Removal Project

Date: August 18, 2017

OBJECTIVE

The purpose of this project is to remove a ledge outcropping that is a potential deterrent to immigrating diadromous fish readily detecting and entering the fish lift entrance at the Lowell Hydroelectric Project (P-2790). Telemetry studies in 2002, 2011, and 2013 have shown that immigrating American shad that approach the project via the tailrace have difficulty utilizing the entrances of the fishway (Sprankle 2005; Alden 2011; 2013). In 2016, Gomez and Sullivan Engineers completed an analysis of the upstream passage system and recommended excavation of the ledge outcropping to approximately 10 feet below normal tailwater level extending 50 to 100 feet downstream from the entrance. During the March 30, 2017, Merrimack River Technical Committee meeting, we all agreed that the ledge removal project should move forward.

On July 18, 2017, the Merrimack River Technical Committee received the design plans for review before the commencement of construction. We sent a technical memorandum to ENEL Green Power North America, Inc., on July 26, 2017, providing our recommendations. Upon the request of ENEL, Julianne Rosset, Bryan Sojkowski, and Bjorn Lake met with ENEL representatives on August 15, 2017, at their Andover, Massachusetts office to discuss our recommendation. At that meeting, it was determined that the agencies should provide updated information on the low design flow for the upstream fishway and the corresponding tailwater elevation. This technical memorandum provides those updates.

RECOMMENDATION

The provided design drawings show a vertical excavation limit at an elevation of 48 feet (NAVD 88), extending approximately 80 feet downstream from the centerline of the fishway entrance. This excavation limit elevation roughly corresponds with the existing floor elevation of the fishway entrance chamber of 48.2 feet (NAVD 88), not including the 1-foot-high concrete lip at the entrance gate. Our criteria (both NOAA Fisheries and USFWS) for fishways is to be operational between the 5-95 percent flow exceedance values. Therefore, we recommend that the fishway be operational at tailwater elevations down to approximately 50 feet (NAVD 88), which corresponds to the tailwater elevation at the 95 percent exceedance flow.

Additionally, we recommend that the minimum water depth above the entrance channel floor sit at 4 feet. Typically, gate structures are utilized to constrict the flow at the entrance in order to achieve an attraction jet with a 4-6-foot-per-second velocity. Lowell currently operates a vertical gate that varies from 0.3-3 feet above the lip of concrete at the downstream end of the entrance floor. An ancillary criterion to the minimum of 4 feet of depth is that the water surface elevation of the tailwater is recommended to be, at a minimum, two times the body depth of the largest target species. An American shad with a body depth of 10" would require a minimum of 1.5 feet of depth. The current entrance at Lowell does not meet this criterion for the full range of fish passage flows and tailwater fluctuations. Therefore, only excavating the ledge to an elevation of 48 feet (NAVD88) will necessitate additional future ledge excavation, when modifications to the gate and entrance channel are made to meet our design criteria. We understand that those entrance modifications are outside the scope of work for the ledge removal project, however, we recommend altering the ledge removal design such that additional excavation is not necessary in the future.

In support of our flow and tailwater elevation recommendation, we conducted a hydrologic analysis of the project flows. We downloaded daily average flow data from the U.S. Geological Survey gauges on the Merrimack River below the confluence with the Concord River (USGS #01100000) and the Concord River immediately upstream from the Lowell canal system (USGS #01099500). The difference between these average daily flow values is the flow in the Merrimack River that passes through the Lowell Project. We downloaded the last 30 years of record (1987 to 2016) and calculated a flow duration curve for the upstream migration season (April 15-July 15). In addition, to predict corresponding tailwater elevations at the upstream fishway operational flow range, we used the updated tailwater rating curve provided in the recent upstream fish passage assessment (Gomez and Sullivan 2016). We fit a logarithmic function to the provided tailwater data ($R^2 = 0.9991$) such that we could use the resulting equation ($y = 2.786\ln[x] + 29.824$) to predict the corresponding tailwater elevation for the flow exceedance values. Table 1 shows the results of this analysis providing the justification for a design tailwater elevation of approximately 50 feet (NAVD 88).

Table 1. Flow duration exceedance values and predicted tailwater elevations for the Lowell Project.

Flow Exceedance Value	Project Flow (cfs)	Tailwater Elevation (ft)
5%	26,210	58.17
10%	19,870	57.40
25%	12,470	56.10
35%	9,752	55.41
50%	6,912	54.46
65%	4,938	53.52
75%	3,830	52.81
85%	2,851	51.99
95%	1,735	50.60

The three-dimensional telemetry studies conducted by Alden Labs in 2011 generated fish density plots that showed where immigrating American shad congregated in the tailrace (Figure 1 and Figure 2). The 80-foot length of the proposed ledge excavation appropriately reaches the zone of highest density at the turn in the tailrace (Figure 1). However, the proposed elevation of ledge excavation does not match the highest density of fish depth-wise (Figure 2). Over 80 percent of the fish detections occurred between the tailwater elevations of 40-50 feet with the highest density in the 45- to 50-foot bin (Figure 2). During the 2011 study period, the flow in the River was at or above the median for the period of record with the exception of one week in June when flow was lower than normal, suggesting that the density plots represent conditions during normal flow conditions, not low flow conditions (Figure 3). This provides further evidence that the entrance elevation needs to be lower than the existing 49.2 feet (NAVD 88), and only excavating the ledge to an elevation of 48 feet (NAVD 88) would not provide appropriate conditions for optimal entrance efficiency for the Lowell fish lift.

There are likely many ways to modify the entrance conditions at Lowell to improve fish passage performance. As the Technical Committee continues working with ENEL to improve passage at the Lowell Project, we can discuss various options that satisfy our fisheries management goals. At this time, we believe it is appropriate to excavate ledge down to an elevation of 44 feet (NAVD 88), as this provides more flexibility for future fishway entrance modifications.

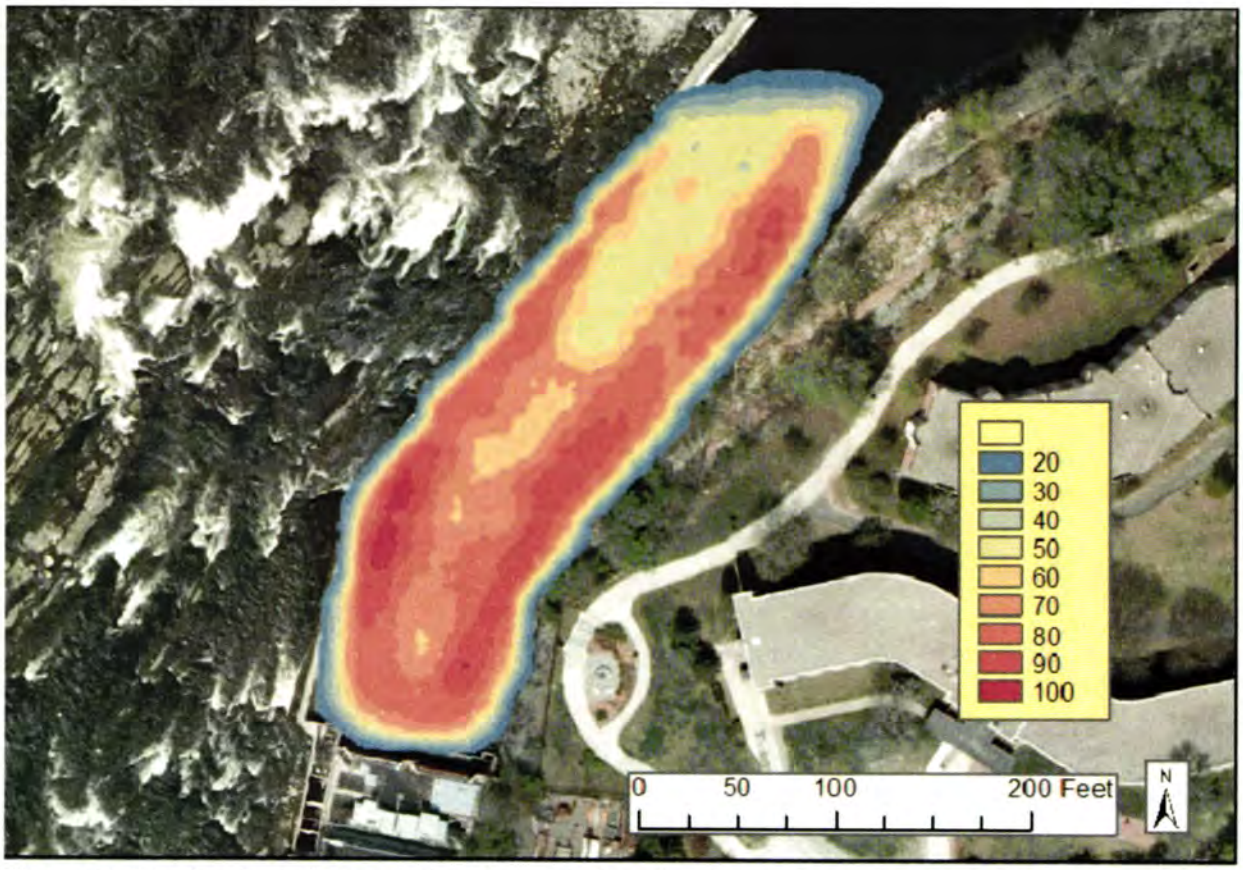

Figure 1. Bin density of tagged American shad during the study period (May 27-June 21) in the Lowell tailrace (Alden 2011).

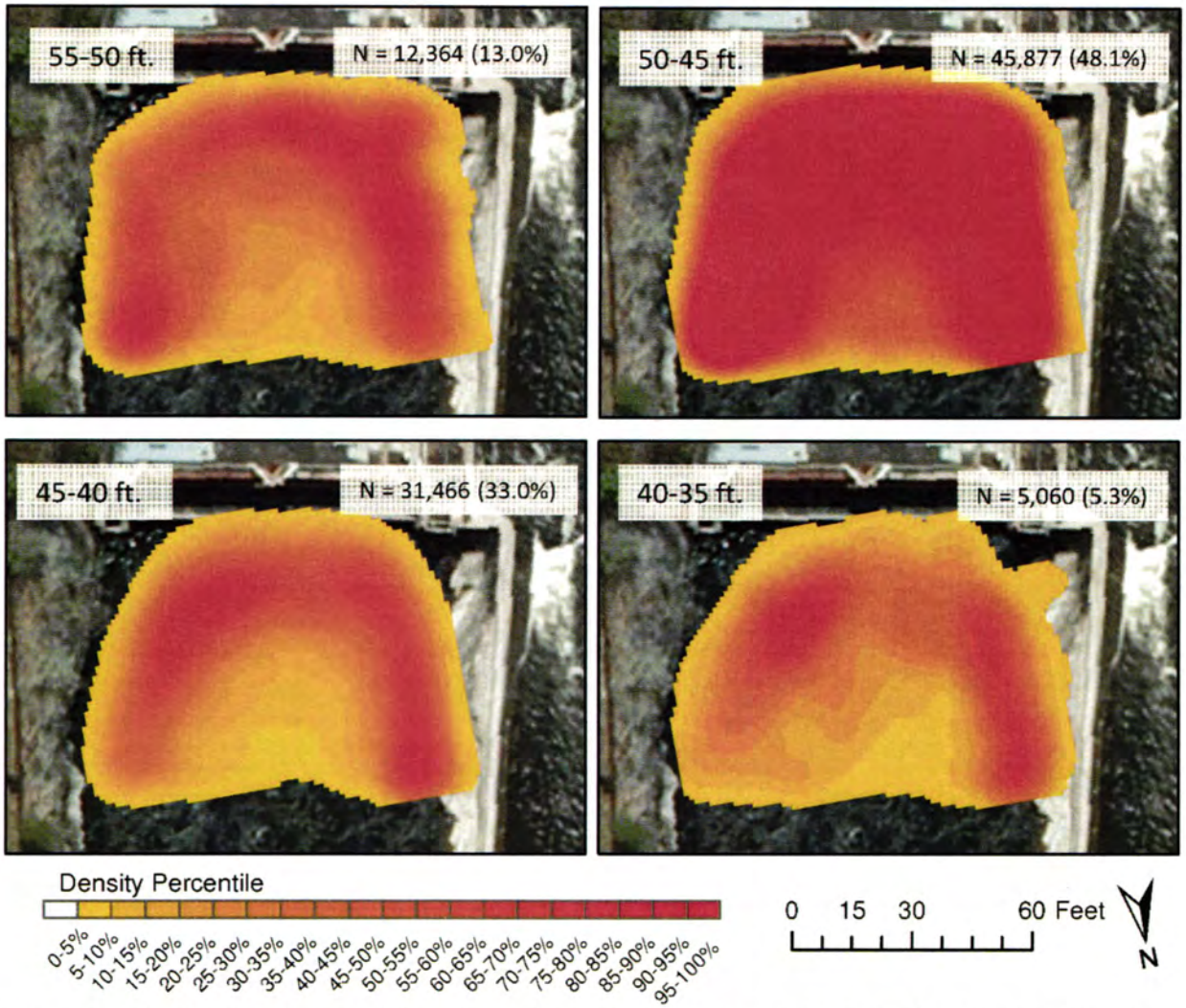

Figure 2. Bin density of tagged American shad within 65 feet of the Lowell powerhouse during the study period (May 27-June 21). Data are presented in 5-foot elevation bins (Alden 2013).

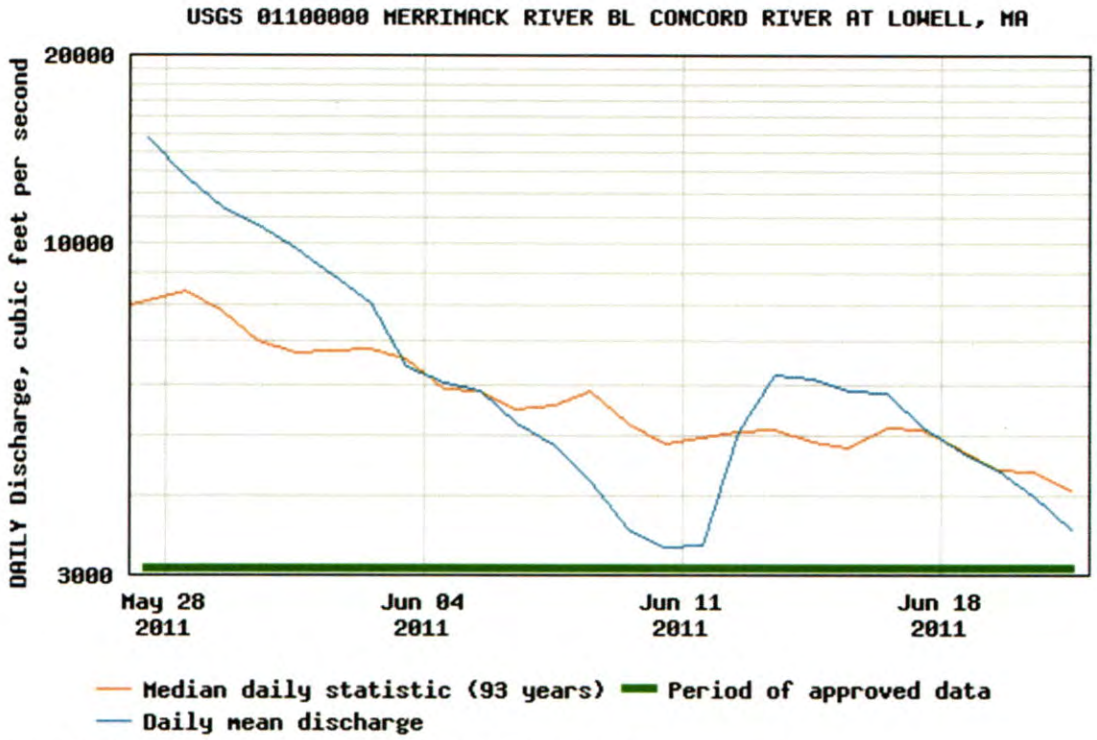

Figure 3. Hydrograph during the 2011 study period.

Document Accession #: 20180814-5118 Filed Date: 08/14/2018

Document Content(s)

ltr to enel re lowell hydro ledge excavation.PDF.....1-3

lowell ledge removal attachment-tech memo.PDF.....4-8

ATTACHMENT B

Rosset, Julianne <julianne_rosset@fws.gov>

[EXTERNAL] Lawrence and Lowell 2018 Action Items List

1 message

St Pierre, Conrad (EGP North America) <Conrad.StPierre@enel.com> Tue, Jun 19, 2018 at 2:37 PM
To: "Rosset, Julianne" <julianne_rosset@fws.gov>
Cc: "Smithwood, Doug" <doug_smithwood@fws.gov>, Bryan Sojkowski <Bryan_Sojkowski@fws.gov>, Michael_bailey <Michael_bailey@fws.gov>, Matthew A Carpenter <Matthew.Carpenter@wildlife.nh.gov>, "Donahue, Pat (EGP North America)" <Pat.Donahue@enel.com>, "Medford, Skip (EGP North America)" <Skip.Medford@enel.com>, "Fournier, Scott (EGP North America)" <Scott.Fournier@enel.com>, "ben.gahagan" <ben.gahagan@state.ma.us>, Bjorn Lake - NOAA Federal <bjorn.lake@noaa.gov>, "claudia_hernandez@fws.gov" <claudia_hernandez@fws.gov>, Caleb Slater <caleb.slater@state.ma.us>, "Tuxbury, Sue" <Susan.Tuxbury@noaa.gov>

To All—Per our meeting in March, we now have an update on the Lowell tailrace excavation project. Early in 2018, Enel permitting staff submitted applications for the project to local, state and federal agencies for approval. Unfortunately, some of these approval processes now appear to approach or exceed 9 months in duration. Also, after receiving only a single initial bid for the 2018 work, we received several competitive proposals in a second RFP, when the schedule was extended to summer, 2019. Because of these factors, Boott plans to complete the tailrace excavation project during late summer of 2019.

We appreciate your understanding and patience on this important but long-awaited improvement. Please feel free to contact me or anyone on the team with questions.

Thank you,

Conrad St. Pierre, PE.
Sr. Director of Hydro North America
Operations and Maintenance

enel Green Power

Enel Green Power North America, Inc.

100 Brickstone Square, Ste 300

Andover, MA 01810

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ATTACHMENT C

U.S. Fish and Wildlife
Study Requests

Boott Study Request # 1

Instream Flow Habitat Assessment of the Lowell Bypassed Reach
(Lowell, P-2790)

Goals and Objectives

The goal of this study is to determine an appropriate flow regime that will protect and enhance the aquatic resources in the bypass reach (Northern Canal) between the Pawtucket dam and the E.L. Field powerhouse. Specifically, the objective of this study is to conduct an instream flow habitat study to assess the impacts of a range of project discharges on the wetted area and optimal habitat for key species, including the quantity and location of suitable habitat.

The specific objectives of this field study, at a minimum, include:

1. Characterize and map wetted perimeter of the bypass reach over a range of bypass flows;
2. Survey and evaluate the water depth and mean channel velocity at transects within the bypass reach over a range of flows; and
3. Map and assess the value of aquatic habitat in the bypass reach over a range of flows, focusing on potential habitat for resident species, and spawning and migration habitat or rest/regrouping areas for migratory species.

Target fish species should include American shad, river herring (alewife and blueback herring), fallfish, white sucker, freshwater mussels and benthic macroinvertebrates. The final target species list should be developed in consultation with the fisheries agencies and based on the results of the mesohabitat mapping.

Resource Management Goals

The U.S. Fish and Wildlife Service (Service) seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation, and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to aquatic resources within the Lowell bypassed reach, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Provide a flow regime in the bypassed reach that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) and diadromous fishes.

3. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

These study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661, *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requester is a natural resource agency.

Existing Information

The Lowell Project bypasses a 0.7-mile-long section of the Merrimack River, from the Pawtucket dam to the E.L. Field powerhouse. There is presently no required minimum bypass flow. However, during the upstream fish passage season, the bypass reach receives 500 cfs through operation of the spillway fish ladder. In addition, the bypass reach receives flow whenever inflow exceeds the hydraulic capacity of all the project's stations. Pursuant to Article 37, Boott Hydropower, LLC, (Boott) maintains a minimum flow of 1,990 cfs or inflow, whichever is less, as measured immediately downstream of the project.

Available information in the PAD does not indicate how project operations have altered downstream hydrology, habitat quantity and quality, and water quality, which may affect resident and migratory fish, macroinvertebrates, aquatic plants and other biota and natural processes in the Merrimack River. The PAD provides no detailed description of the physical or biological characteristics of the bypassed reach.

An empirical study is needed to provide information on the relationship between flow and habitat in the bypassed reach for the Service to use in determining a flow recommendation.

Nexus to Project Operations and Effects

Although the project license requires Boott to maintain a minimum flow of 1,990 cfs or inflow (if less), downstream of the project, Boott states that in practice the project operates in a true run-of-river mode. The Department of the Interior is not recommending a below-project flow study, based on the assumption that any new license issued for the project will require instantaneous run-of-river operation (essentially codifying current operations).

The project includes a 0.7-mile-long bypassed reach. The current license contains no minimum bypass flow requirement. During the upstream fish passage season, the bypass reach receives 500 cfs via operation of the spillway fish ladder; otherwise, the reach only receives flow when inflow exceeds the hydraulic capacity of the project's generating capacity. To our knowledge, the lack of a required bypass flow was not based on any quantitative, rigorous scientific studies.

This section of the Merrimack River contains habitat which supports native riverine species, including important spawning and rearing habitat for migratory species like American shad and river herring (MRTC 2010). While the existing license does not require a minimum bypass flow, the Service believes one is needed to sufficiently protect the aquatic resources inhabiting the bypassed reach.

Results of the flow study will be used by the Service to determine an appropriate flow recommendation which will protect and/or enhance the aquatic resources in the bypassed reach for the duration of any new license issued by the Federal Energy Regulatory Commission (Commission).

Methodology Consistent with Accepted Practice

Bypass flow habitat assessments are commonly employed in developing flow release protocols that will reduce impacts or enhance habitat conditions in reaches of river bypassed by hydroelectric projects.

Given the size of the bypassed reach (0.7 mile long) and the important resources known to inhabit the reach (i.e., diadromous fishes); we believe a study methodology which utilizes an instream flow incremental methodology (IFIM) approach is appropriate for this site. This same protocol was used during the relicensing of the Housatonic River Project (FERC No. 2576),[1] and has been accepted by the Commission in other licensing proceedings.[2]

The study should have two components. The first component entails mapping habitat within the bypass reach. The number, location, and size (area and linear distance) of each mesohabitat type in the reach should be documented, including qualitative characterizations (e.g., dominant substrate, average depth, overhead and instream cover, etc.). The second component consists of conducting an instream flow study.

At a minimum, the study design should involve collecting wetted perimeter, depth, velocity, and substrate data within a range of discharge levels along transects located in the reach of river between the dam and the E.L. Field powerhouse. The measurements should be taken over a range of test flows, to be agreed upon by the natural resource agencies. This information should then be synthesized to quantify habitat suitability (using mutually agreed upon Habitat Suitability Index curves) of each test flow for target species/life stages identified by the fisheries agencies. We recommend Boott perform habitat modeling using one dimensional modeling techniques to better characterize flows and velocities in this complex channel area.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

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[1] Housatonic River Project License Application, Volume 4, Appendix F. Connecticut Light and Power Company, August 1999.

[2] Glendale Project (FERC No. 2801) Final Bypass Reach Aquatic Habitat and Instream Flow Study in Glendale Hydroelectric Project Application for Subsequent License (FERC No. 2801), Volume 2, Appendix B, pp. 7-8, October 2007.

Field work for flow studies can be reasonably extensive but will depend on consultation with Boott on study methodology and on-site decisions on locations for data collection and the number of collection locations. Post-field work data analysis would result in a moderate cost and effort. We anticipate that the level of effort and costs will be comparable to those experienced on similar Commission relicensing projects (e.g., the Glendale Project, FERC No. 2801).

REFERENCES

MRTC, 2010. A Plan for the restoration of American shad, Merrimack River Watershed. Prepared by the Technical Committee for Anadromous Fish Management of the Merrimack River Basin. 12 pp.

Boott Study Request # 2

Adult Alosine Downstream Passage Assessment and Protection Evaluation
(Lowell, P-2790)

Goals and Objectives

The goal of this study is to assess the adequacy of the turbines at the E.L. Field, Assets, Bridge Street, Hamilton, and John Street powerhouses, to minimize injury, entrainment, and mortality of fishes residing in the Merrimack River, and to recommend appropriate mitigative measures as necessary.

The specific objectives of the field study, at a minimum, are: (1) assess the risk of adult American shad and alewife becoming injured, impinged, or entrained in the E.L. Field, Assets, Bridge Street, Hamilton, and John Street powerhouse units; (2) estimate turbine survival; (3) assess the risk of injury or mortality at the spillway and downstream bypass; and (4) evaluate potential passage and protection measures.

Resource Management Goals

The Atlantic States Marine Fisheries Commission has developed several documents related to the management of American shad and river herring:

1. Atlantic States Marine Fisheries Commission. 1999. Amendment 1 to the Interstate Fishery Management Plan for shad and river herring. (Report No. 35). April 1999.
2. 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.
3. Atlantic States Marine Fisheries Commission. 2009. Amendment 2 to the Interstate Fishery Management Plan for shad and river herring, Arlington, Virginia. May 2009.
4. Atlantic States Marine Fisheries Commission. 2010. Amendment 3 to the Interstate Fishery Management Plan for shad and river herring, Arlington, Virginia. February 2010.

Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring includes an objective of maximizing the number of juvenile recruits emigrating from freshwater stock complexes and recommends enhancing survival at dams during emigration by evaluating survival of post-spawned adults and juvenile fish passed via each route (e.g., turbines, spillage, bypass facilities, or a combination of the three) at any given facility, and implementing measures to pass fish via the route with the best survival rate.

Specific to resident riverine and migratory fish entrainment, the Service's goals are:

1. Minimize current and potential negative project operation effects such as turbine entrainment that could hinder management goals and objectives.

2. Minimize project-related sources of mortality to resident and migratory fishes in order to restore natural food web interactions and ecosystem functions and values.

These study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661, *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requestor is a natural resource agency.

Existing Information and the Need for Additional Information

No project-specific information exists regarding risk of impingement and/or entrainment of adult alosines. In the PAD, Boott provided little information that would inform the relative risk of impingement or entrainment in any of the 21 units associated with the project. Moreover, information regarding fish mortality at the spillway and the downstream bypass was not discussed. While Normandeau Associates, Inc., performed a study in 2003 pertaining to the survival of Atlantic salmon smolts through the turbines, (1) the sample size was small (20 fish); (2) the study was not performed at a full range of gate settings; and (3) salmon are a robust fish species and cannot be used as a proxy for alosines. The 2003 study did shed light on a predation issue, however, in the project's tailrace. Of the salmon that passed downstream, 69 percent were suspected to be preyed upon after using the downstream bypass facility. As Normandeau Associates, Inc., noted in their study results, predators residing in the tailrace can have a large impact on emigrating migratory fish species that use the current bypass facility at the project.

To date, no directed studies of alosine injury, entrainment, or mortality have been conducted at the project's modified spillway, the downstream fish bypass facility, or through the turbines. These information gaps need to be filled so the natural resource agencies can assess the relative and cumulative impacts of project operations on outmigrating adult alosines and develop adequate passage and protection measures to meet management goals and objectives.

Nexus to Project Operations and Effects

Hydropower projects generate electricity by moving water through a turbine-generator system. Typically, there are trashracks in front of the intakes leading to the turbines. If the rack spacing is narrow and velocities at the racks too high (relative to the swim speeds of fish species inhabiting or moving through the headpond), fish may become impinged against the racks and die. If rack spacing is wide and the velocities too high (relative to the swim speeds of fish species inhabiting or moving through the headpond), fish may become entrained (i.e., pass through the racks) and get injured or die while passing through the turbines.

Lowell's configuration likely presents problems with respect to providing safe, timely, and effective passage for outmigrating alosines. Pre-spawned adult American shad and river herring pass upstream through the Lowell fishways and/or are stocked into upstream habitats. These fish

need to be able to migrate back downstream because they are iteroparous in this region (McBride et al. 2016). Therefore, it is necessary to understand how alosines move through the project area and the level of injury or mortality caused by entrainment through the project's turbines and/or passage via the dam spillway and downstream bypass facility.

Methodology Consistent with Accepted Practice

The Service proposes a phased approach to this study.

Phase 1:

Spill, bypass, and turbine mortality should be assessed using a balloon-tag method.

For spill mortality sites (dam spillway and downstream bypass), tagged alosines will be injected or released into spill flow at points where water velocity exceeds 10 ft/sec to minimize the possibility of the fish swimming upstream into the headpond or canal. Passed balloon-tagged alosines will be recovered below areas of spill and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged alosines will be censored from the data.

For turbine mortality sites, tagged alosines will be injected into the intakes of units operating at or near full generation at points where intake water velocity exceeds 10 ft/sec to minimize the possibility of fish swimming back upstream through the intakes. Passed balloon-tagged alosines will be recovered in the tailrace and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged alosines will be censored from the data.

Phase 2:

Boott should investigate existing or potential future operational and/or physical measures that would minimize injury or mortality to outmigrating adult alosines moving past the project. Based on the results of this investigation, we recommend Boott provide a range of potential alternatives (e.g., increasing attraction to the existing downstream bypass, installing exclusionary screening, etc.).

Project operations (flows, levels, gate openings, number of units operating, and operation level) and environmental conditions (river flow, temperature, turbidity, air temperature, precipitation) should be monitored and recorded regularly (hourly measurements if possible) throughout the duration of the study to establish a more comprehensive understanding of how migration patterns are influenced by these parameters.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The cost and effort of each individual phase of this study are expected to be moderate. Based on the scale and scope of the subject study, we estimate the cost to be $25,000 to $50,000. In the

PAD, Boott proposes no studies to address this issue. The Service is not aware of any previously conducted or ongoing studies related to impingement, entrainment or survival of adult alosines at the project.

REFERENCES

McBride, R. S., Ferreri, R., Towle, E. K., Boucher, J. M., & Basilone, G. 2016. Yolked oocyte dynamics support agreement between determinate-and indeterminate-method estimates of annual fecundity for a northeastern United States Population of American Shad. PloS one, 11:e0164203.

Normandeau. 2003. Passage Route Selection and Survival of Atlantic Salmon Smolts Passed through the Lowell Hydroelectric Project. Submitted to Boot Hydro, LLC. Final report. Normandeau Associates, Inc. Westmoreland, New Hampshire. 130 pp.

Boott Study Request # 3

Telemetry Study of Upstream and Downstream Migrating Adult American Shad and River Herring to Assess Passage Routes, Effectiveness, and Delay

(Lowell, P-2790)

Goals and Objectives

The goal of this study is to assess the behavior, approach routes, passage success, survival, and delay of adult American shad and river herring as they encounter the Lowell Project during their upstream and downstream migrations to determine if project operations negatively impact their survival and production.

The following objectives will address this request:

1. Assess project operations effects on the timing, orientation, routes, and migration rates of shad and river herring;
2. Determine route selection and behavior of upstream migrating shad and river herring at the project under varied operational conditions, including a range of spill conditions (e.g., movement to the dam, attraction to the E.L. Field station discharge, movement between locations, delay, timing, etc.);
3. Determine delay/fallback associated with the northern canal;
4. Assess near field attraction to, and entrance efficiency of, the fish lift under a range of spill conditions and with the river-side entrance and street-side entrances open;
5. Assess near field attraction to, and entrance efficiency of, the spillway ladder under a range of spill conditions;
6. Evaluate the internal efficiency of the Pawtucket dam ladder;
7. Collect ladder and lift efficiency data, to include rates of approach to fishway entrances, entry into fishways, and passage under varied operational conditions, including a range of spill conditions;
8. Determine the proportion of post-spawned adults that select the power canal as a downstream passage route under varied operation conditions, including a range of spill conditions up to full spill; determine post-spawned adult downstream migration route selection, passage efficiency, and delay associated with the power canal under various operational conditions, including a range of spill conditions; and
9. Compare rates and measures of delay and movement among project areas and routes utilized (e.g., spill at dam vs. power canal) under the range of permitted and proposed spill and operational conditions.

If project operations are adversely affecting shad or river herring migration timing or are resulting in other deleterious population effects, we recommend Boott identify operational solutions or other passage measures that will reduce and minimize these impacts within the project area.

This study will require 3 years of field data due to the tailrace ledge excavation project which will be completed in 2019 and to capture inter-annual variability of river discharge, water temperatures, and variability in outmigration timing. We recommend that Boott perform the downstream routing portion of the study in 2019 (pre-ledge excavation) and 2020 (post-ledge excavation). In 2020 and 2021, after the ledge has been excavated, we recommend Boott perform the upstream portion of this study.

Resource Management Goals

The Atlantic States Marine Fisheries Commission, Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring, approved in 2010, includes the following objectives:

Upstream Passage

1. Fish must be able to locate, enter, and pass the passage facility with little effort and without stress.
2. Where appropriate, upstream fish passage effectiveness should be improved through operational or structural modifications.
3. Fish which have ascended the passage facility should be guided to an appropriate area so they can continue their upstream migration and avoid being swept back downstream.

Downstream Passage

1. Enhance survival at dams during emigration.
2. Evaluate survival of post-spawned adults and juvenile fish passed via each project route (e.g., turbines, spillage, bypass facilities, or a combination of the three).
3. Implement measures to pass fish via the route with the least delay and best survival rate.

The Service seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to American shad and river herring movement and migration, the Service's goal is to minimize current and potential negative project operation effects on the safe, timely and effective upstream and downstream passage of adult American shad and river herring.

These study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661, *et seq*.), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest

The requestor is a natural resource agency.

Existing Information and the Need for Additional Information

Several studies pertaining to the fish lift and downstream passage facilities at Lowell have been conducted for American shad. Studies of alewife passage are limited to a single downstream test performed in 1991. Previous studies pertaining to upstream shad migration (listed in Table 5.4-3 of the PAD) demonstrate passage through the existing lift at Lowell is relatively poor. Also, when analyzing annual passage counts for river herring and shad, the number of fish that utilize the Lowell lift versus those that pass at Lawrence is low (from 1996 to 2017 passage efficiency at Lowell has not exceeded 30 percent).

In 2016, for the first time since the issuance of the original license for the project, Boott agreed to operate the fish ladder at the Pawtucket dam for the duration of the anadromous fish upstream passage season, consistent with the operating timeframes defined for the powerhouse fish lift in the project's Commission-approved Comprehensive Fish Passage Plan. Therefore, to date, studies performed at Lowell have not tested the nearfield attraction, entrance efficiency, or internal efficiency of the ladder. Moreover, past studies have had statistically low sample sizes (less than 60 fish) and were all performed prior to the ledge excavation project which will occur in August 2019. Future studies should have a robust sample size (at a minimum, 150 fish per species) and array system. Additionally, to obtain a comprehensive understanding of fish behavior at Lowell, for both upstream and downstream migration, studies are needed to: (1) determine if project operations affect pre-spawned and post-spawned river herring and shad migration timing; (2) assess fish movement to, and through, the ladder at the Pawtucket dam; and (3) assess passage success at the tailrace fish lift post-ledge removal.

Nexus to Project Operations and Effects

Lowell tailrace turbulence, potentially exacerbated by the existing ledge outcropping, creates attraction issues at the entrance of the fish lift. Moreover, a lack of effective protection at the 21 turbines associated with the project increases the risk of entrainment and mortality alosines may experience as they migrate downstream to the ocean. During the upstream fish passage season, the Lowell bypass reach receives 500 cfs during the day and 300 cfs at night via operation of the spillway fish ladder; otherwise, the reach only receives flow when inflow exceeds the hydraulic capacity of the project's generating capacity. The spillway ladder is, therefore, only partially effective due to lack of flow.

Existing project operations and limited bypass flows can have a direct impact on diadromous fish migration. Migration delays, increased predation, mortality during passage over the dam or through turbines, and changes in route selection under different flow conditions are potential influences of the project on shad and river herring populations in the Merrimack River. Effective upstream and downstream passage and successful spawning and juvenile production are necessary to help achieve shad and river herring management restoration goals for the Merrimack River, particularly in the upstream reaches.

Methodology Consistent with Accepted Practice

The movement of migratory shad and river herring would be best studied by using radio telemetry, including passive integrated transponder (PIT) tags. Radio telemetry is an accepted technology that has been used for a number of studies associated with hydropower projects, including at the Bellows Falls (FERC No. 1855), Wilder (FERC No. 1892), and Vernon (P-1904) projects.

The study design must specify sample sizes, as well as tag and receiver configurations, to ensure rates of entry and exit to the tailrace, fish lift and fish ladder, downstream bypass, the bypassed reach, and canal, can be calculated with sufficient precision. We recommend that Boott capture shad and river herring below Lawrence and tag at least 150 individuals per species. Double-tagged (radio and PIT) shad and river herring should be released upstream of the Lawrence dam and upstream of the Lowell dam. Fish should also be released directly into the Pawtucket canal to adequately assess project conditions likely to be encountered during downstream migration. Additional, tagged, individuals may need to be released farther upstream to ensure enough fish encounter the dam during a sufficient range of turbine and operational conditions to test for project effects (especially in 2020 and 2021). A large array of stationary monitoring stations (radio and PIT) will be needed to provide an appropriate level of resolution for data analyses and to answer the natural resource agencies' questions regarding project operation effects. Additionally, since fish can drift a considerable distance downstream after they have died (Havn et al. 2017); a minimum of 25 dead river herring and 25 dead shad should also be released as a control group in this study. A plan and schedule for spill releases should be developed which provides sufficient periods of spill and various generating levels (treatments will require multiple days of consistent discharge).

Each component of this study will require 2 years of field data collection to attempt to account for inter-annual variability in river discharge, water temperatures, and the ledge excavation project which will be completed in 2019. We recommend Boott perform the downstream routing portion of the study in 2019 (pre-ledge excavation) and 2020 (post-ledge excavation). In 2020 and 2021, after the ledge has been excavated, the upstream portion of this study should be performed.

A related study request on computational fluid dynamics (CFD) modeling in the Lowell tailrace, in and around the fish lift and fish ladder entrances and powerhouse forebay, will complement this study and address related project operational effects.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Estimated cost for this study is expected to range from $400,000 to $500,000, with the majority of costs associated with equipment (radio and PIT tags, radio receivers, and PIT readers) and related field work labor. Since tagged shad and river herring will move throughout the area, to varying degrees, there will be expected cost savings (e.g., radio tags) to Boott, provided cooperation in study planning and implementation occurs.

Boott did not propose any studies to meet this need in the PAD.

REFERENCES

Havn, T. B., F. Økland, M.A. Teichert, L. Heermann, J. Borcherding, S.A. Sæther, O.H. Tambets and E.B. Thorstad. 2017. Movements of dead fish in rivers. Animal Biotelemetry, 5: 7.

Boott Study Request # 4

Impact of Project Operations on Downstream Migration of Juvenile Alosines

(Lowell, P-2790)

Goals and Objectives

The goals of this study are: (1) conduct a field study of juvenile alewife outmigration in the Lowell impoundment, the power canal, and at the Pawtucket dam, to determine if project operations negatively impact juvenile alosine survival and production; and (2) determine if project operations affect juvenile alosine outmigration survival, recruitment, and production.

The following objectives will address this request:

1. Assess project operations effects of the Pawtucket dam on the timing, orientation, passage routes, migration rates, and survival of juvenile alewife;
2. Determine the proportion of juvenile alewife that select the Lowell canal versus the Pawtucket powerhouse, downstream bypass facility, or dam spill as a downstream passage route, under varied operational conditions;
3. Determine if there are any delays associated with downstream movement related to either dam spill or the Pawtucket powerhouse due to operations;
4. Determine the juvenile downstream passage timing and route selection in the Lowell canal, assess delays associated with the canal, and with project operations (e.g., stockpiling in the canal).

If it is determined the project operations are adversely affecting juvenile alosine survival, migration timing, or causing other deleterious population effects, identify operational solutions or other passage measures which will reduce and minimize these impacts within the project area. This study will require 2 years of field data to capture inter-annual variability of river discharge and water temperatures.

Resource Management Goals

The Atlantic States Marine Fisheries Commission Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management), approved in 2010, includes the following objective:

> Maximize the number of juvenile recruits emigrating from freshwater stock complexes. To enhance survival at dams during emigration, evaluate survival of post spawning and juvenile fish passed via each route (e.g., turbines, spillage, bypass facilities, or a combination of the three) at any given facility, and implement measures to pass fish via the route with the best survival rate.

The Service seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the projects. General goals include the following:

1. Ensure that protection, mitigation, and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to juvenile American shad and river herring movement and migration, the Service's goal is to minimize current and potential negative project operation effects on the safe, timely and effective downstream passage.

These study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661, *et seq*.), the Silvio O. Conte National Fish and Wildlife Refuge Act (P.L. 102-212; H.R. 794), the Federal Power Act (16 U.S.C. §791a, *et seq*.), the Atlantic States Marine Fisheries Compact (P.L. 539, 77th Congress, as amended by P.L. 721, 81st Congress), and the Atlantic Coastal Fisheries Cooperative Management Act (16 U.S.C. 5107).

Public Interest

The requestor is a natural resource agency.

Existing Information and the Need for Additional Information

The seaward migration of juvenile alosines is of great importance to the restoration of alewife, blueback herring, and American shad in the Merrimack River. However, data on the downstream migratory movements and rates of alosines past Lowell is sparse and relatively incomplete. In 1994 and 1995, Normandeau Associates, Inc., documented use of the bypass facility by downstream migrating alosines via the installation of a removable box trap. Passage efficiencies were 7 percent and 37 percent, respectively. However, to date, no directed studies of downstream alosine passage route selection has been conducted at the Lowell Project. These information gaps need to be filled so the natural resource agencies can assess the relative and cumulative impacts of project operations on outmigrating juvenile alosines and develop adequate passage and protection measures to meet management goals and objectives.

Studies conducted farther upstream on the Merrimack River, at Garvins Falls (FERC No. 1893), have shown it is possible to radio-tag juvenile alewife to evaluate alosine outmigration (Normandeau 2016). Alewife can be used as a proxy, in this instance, for the natural resource agencies to assess blueback herring and shad downstream migration patterns.

Nexus to Project Operations and Effects

Adult alosines, passed at Lowell via the fishways and/or stocking efforts, utilize upstream habitat to spawn on an annual basis. Similarly, juvenile alosines require safe and timely downstream passage measures at the project in order to successfully emigrate back to the ocean to contribute to the population. Presently, downstream migrants can easily enter the Lowell canal system, via

the Pawtucket canal, as there are no exclusionary measures in place. There are 19 turbines located in the canal, housed at four powerhouses (Assets, Bridge Street, Hamilton, and John Street), none of which have passage or protection measures. There are a variety of unit-types housed in each of the powerhouses, ranging in speed from 100 to 150 rpm. A study is needed to assess the impacts project operations have on outmigrating juvenile alosines.

The Service is not aware of any studies conducted specifically designed to answer the following questions:

1. What is the rate of alewife survival under a range of spill and gate configurations?
2. Are there delays in migration/movement at the dam, gatehouse, or in the canal?
3. For juveniles that enter the Pawtucket canal, what proportion subsequently enter the Western, Merrimack, Pawtucket, or Hamilton canals?
4. What is the rate of movement through the canal, what is the delay to juvenile alosine outmigration, and the potential accumulation of juveniles in the canal?
5. What proportion of juvenile alosines use the downstream bypass sluice versus the E.L. Field powerhouse turbines under varied operational conditions?

The Service is concerned project operations are: (1) impacting juvenile alosine outmigration survival; and (2) contributing to the failure of the Merrimack River alosine population to meet management targets.

Methodology Consistent with Accepted Practice

The impact of project operations to juvenile alewife outmigration, passage route selection, and migratory delay would be best studied via radio telemetry. This methodology has successfully been tested and employed by Normandeau Associates, Inc., at the Garvins Falls hydroelectric project (FERC No. 1893; Normandeau 2013; Normandeau 2016). Project discharge over a full range of existing and, to the extent possible, potential future operational conditions at the dam (likely increased bypass reach flows in new license), should be examined relative to migration rate and passage route selection of juvenile alosines to, and through, various areas of the project.

In addition, study fish should be collected and balloon-tagged to empirically determine rates of survival for fish passed over or through the dam's bypass sluice, main powerhouse, and 19 canal units under varied operations. For spill mortality sites (dam spillway and downstream bypass), tagged alosines should be injected or released into spill flow at points where water velocity exceeds 10 ft/sec to minimize the possibility of the fish swimming upstream into the headpond or canal. Passed balloon-tagged alosines will be recovered below areas of spill and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged alosines will be censored from the data.

For turbine mortality sites, tagged alosines will be injected into intakes of units operating at or near full generation at points where intake water velocity exceeds 10 ft/sec to minimize the possibility of fish swimming back upstream through the intakes. Passed balloon-tagged alosines will be recovered in the tailrace and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged alosines will be censored from the data.

Radio-tagged juvenile alewife will be released in areas upstream of the project at multiple release locations, to determine operation effects on migration rates, route, orientation, and entrainment, over a full range of permitted and operational conditions. The release of radio-tagged fish upstream of the project, and induction into the power canal, will provide data on concerns of delay and route selection to the canal, downstream bypass, crest gates, and turbines. Additionally, since fish can drift a considerable distance downstream after they have died (Havn et al. 2017); a minimum of 50 dead alewife should also be released as a control group in this study.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

Boott does not propose any studies to meet this need. Estimated costs for the study are expected to be moderate to high, between $100,000 and $300,000, with the majority of costs associated with equipment (radio tags, radio receivers) and related field work labor.

REFERENCES

Havn, T. B., F. Økland, M.A. Teichert, L. Heermann, J. Borcherding, S.A. Sæther, O.H. Tambets and E.B. Thorstad. 2017. Movements of dead fish in rivers. Animal Biotelemetry, 5: 7.

Normandeau 2013. Juvenile Alosine Radio Tag Attachment Test. Submitted to Boot Hydro, LLC. Final report. Normandeau Associates, Inc., Westmoreland, New Hampshire. 2 pp.

Normandeau 2016. Garvins Falls Juvenile Alosine Downstream Passage Telemetry Assessment. Submitted to Boot Hydro, LLC. Final report. Normandeau Associates, Inc., Westmoreland, New Hampshire. 13 pp.

Boott Study Request # 5

Downstream American Eel Passage Assessment
(Lowell, P-2790)

Goals and Objectives

The goal of this study is to determine the impact of the Lowell hydroelectric project on the outmigration of silver eels in the Merrimack River. Entrainment in the canal and at the conventional turbines at the project powerhouses (E.L. Field, Assets Station, Bridge Street, Hamilton Station, and John Street) can result in mortality or injury. It is important to understand the passage routes at the project and the potential for delay, injury, and mortality to assess alternative management options to increase survival.

The objectives of this study are:

1. Quantify the movement rates (including delays) and relative proportion of eels passing via various routes at the project (i.e., through the turbines, through the downstream bypass, spilled at the dams, etc.).
2. Evaluate instantaneous and latent mortality and injury of eels passed via each potential route.

Resource Management Goals

The Atlantic States Marine Fisheries Commission has developed two documents related to the management of American eel:

1. Interstate Fishery Management Plan for American Eel. April 2000. Atlantic States Marine Fisheries Commission.
2. Addendum II to the Fishery Management Plan for American Eel. Atlantic States Marine Fisheries Commission. Approved October 23, 2008. 8 pp.

Objectives of the management plan include: (1) protect and enhance American eel abundance in all watersheds where eel now occur; and (2) where practical, restore American eel to those waters where they had historical abundance, but may now be absent, by providing access to inland waters for glass eel, elvers, and yellow eel, and adequate escapement to the ocean for pre-spawning adult eel.

Addendum II contains specific recommendations for improving upstream and downstream passage of American eel, including requesting that member states and jurisdictions seek special consideration for American eel in the Commission relicensing process.

The Service seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to downstream passage of American eel, the Service's goals are:

1. Minimize current and potential negative project operation effects that could hinder management goals and objectives.
2. Minimize project-related sources of downstream passage delay, injury, stress, and mortality in order to maximize the number of silver eels migrating to the spawning grounds.

These study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661, *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requester is a natural resource agency.

Existing Information and the Need for Additional Information

Data on downstream migratory movements and rates of American eels past the project are sparse and relatively incomplete. A single study was performed by Normandeau Associates, Inc., in 2017 (Normandeau 2017). Seventeen silver-phase eels were tagged and released into the Merrimack River upstream of the Garvins Falls project. Of the 17 released individuals, 14 approached the Pawtucket dam. Eight were determined to have passed through the gatehouse and enter the forebay canal upstream of the E.L. Field powerhouse. Five eels passed the project via spill flow. One eel's passage route was classified as unknown. Zero individuals used the downstream bypass. This study had a small sample size, was of a relatively short duration (October 20-November 28, 2017), did not include monitoring stations or antenna arrangements in the canal, and was performed prior to the installation of the pneumatic crest gate system.

To date, no other directed studies of eel entrainment or mortality have been conducted at the Lowell Project. These information gaps need to be filled so the natural resource agencies can assess the relative and cumulative impacts of project operations on outmigrating eels and develop adequate passage and protection measures to meet management goals and objectives.

Nexus to Project Operations and Effects

The project configuration presents problems with respect to providing safe, timely, and effective passage for outmigrating eels. The intakes are likely deep and, while no specification for the trashracks were provided in the PAD, it is unlikely they would prevent entrainment of eels. The anadromous downstream passage facility at the project is also not expected to be effective for eels; the target anadromous species are surface-oriented, while eels tend to move much deeper in the water column. Additionally, there are no data pertaining to eel movements in the Lowell canal. Eels that move into the canal potentially have no alternative but to pass through hydropower turbines at the Assets, Bridge Street, Hamilton, and John Street powerhouses. Eels are known to occur upstream of the dam; therefore, it is necessary to understand how eels move through the project and the level of injury and/or mortality resulting from each potential passage route (i.e., the spillway, the downstream bypass facility, or the 21 turbines associated with the project).

Methodology Consistent with Accepted Practice

In order to understand the movements of outmigrating silver eels as they relate to operations at Lowell, radio telemetry technology should be utilized. Radio telemetry is an accepted technology which has been used for a number of studies associated with hydropower projects, including at the Bellows Falls (FERC No. 1855), Wilder (FERC No. 1892), and Vernon (P-1904) projects.

Studies should be designed to investigate route selection (i.e., entrainment vs. spill) independently from estimation of mortality/injury, because these metrics require different methodologies. Studies will also likely benefit from data collected over 2 study years (especially route selection studies, which may be more significantly affected by environmental conditions during a given season than mortality/injury studies). It is also envisioned that results from route selection studies can guide design of turbine mortality studies. Therefore, it is proposed, at a minimum, route selection studies be conducted in multiple years, but mortality/injury studies may be conducted after the first year of route selection studies have been completed.

Objective 1: Route Selection

This study will involve systematic releases of radio-tagged silver phase eels at strategic points above areas of interest, to assess general routes of passage (i.e., via spill, bypass, or turbines). Active downstream migrants should be collected within-basin if possible (i.e., Cabot or Holyoke bypass samplers), but fish sourced from out-of-basin may be acceptable to meet sample size demands. Experimental fish must meet morphometric (e.g., eye diameter relative to body size) criteria to ensure they are migrant silver phase. Collections should be made within the migratory season (late August to mid-October), and eels should be tagged and released within 21 days after capture, but preferably within 7 days (particularly if the test eels are from out-of-basin).

All telemetered eels will be radio- and PIT-tagged. PIT antennas will be installed and monitored continuously to verify passage of eels via bypass channels.

A minimum number of 150 telemetered eels (e.g., five separate groups of approximately 30 eels each) will be required to maximize the data return. Tagged eels should be released at least 5 km upstream of the Lowell Project. Groups of eels should be released during spill (if any) and non-spill and during periods of low, moderate, and high generation conditions. Up to 50 additional eels should also be released in the upper canal and allowed to volitionally descend through the canal to assure that a sufficient number of eels are exposed to canal conditions. Groups of eels should be released when the canal units are running and when the canal units are off. Additionally, since fish can drift a considerable distance downstream after they have died (Havn et al. 2017), a minimum of 25 dead eels should also be released as a control group in this study.

Telemetry receivers and antennas should be located upstream and downstream of the spillway, at the canal entrance, within the canal, in the downstream fish bypass entrance, at turbine intakes, the station tailrace, and downstream of the confluence of the Merrimack and Concord rivers. These locations will permit assessment of passage via the following potential routes: the power canal, spillway, downstream fish bypass, station turbines,and upstream fishway attraction water intake. The final placement of receivers and antennas should be developed in consultation with the fisheries agencies.

Mobile tracking (i.e., via boat) in the River and canal between release sites and several km downstream will be performed at regular intervals during and after releases to confirm routes and fates of passed fish or lost fish.

Movement rates (time between release and detection at radio antenna locations, and between radio antenna locations) of eels passing the projects by various routes will also be quantified.

The route selection portion of this study should occur in both study years.

Objective 2: Spill, Bypass, and Turbine Mortality/Injury Studies

Spill, bypass, and turbine mortality will be assessed using a balloon-tag method.

For spill mortality sites (dam spillways and downstream bypasses), tagged eels will be injected or released into spill flow at points where water velocity exceeds 10 ft/sec to minimize the possibility of eels swimming upstream into the headpond or canal. Passed balloon-tagged eels will be recovered below areas of spill and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

For turbine mortality sites, tagged eels will be injected into intakes of all 21 units associated with the project, operating at a full range of settings where intake water velocity exceeds 10 ft/sec to minimize the possibility of eels swimming back upstream through the intakes. Passed balloon-tagged eels will be recovered in the tailrace(s) and held for 48 hours in isolated tanks for observation of injury and latent mortality; unrecovered balloon-tagged eels will be censored from the data.

If the balloon-tag mortality component of the study occurs in study year one, all possible route selection sites would need to be evaluated. If the balloon-tag mortality component of the study occurs in study year two, results from the route selection study could be used to inform which sites need to be evaluated for mortality. Eels recovered from balloon-tag studies should not be used for route selection studies.

Data analyses of route selection and mortality (instantaneous and latent) will follow standard methodology.

Project operation (flows, levels, gate openings, number of units operating and operation level) and environmental conditions (river flow, temperature, turbidity, air temperature, precipitation) will be monitored regularly (hourly measurements if possible) throughout the duration of the studies and assessed for potential relationships to passage route selection, migratory delay, and/or passage survival.

These methodologies are consistent with accepted practice.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The level of cost and effort for the downstream eel passage study will be moderate to high; silver eels would need to be collected, tagged, and released in several locations over the course of the migration season. Antennas and receivers would need to be installed throughout the canal, at the intakes of the E.L. Field powerhouse, at the dam spillways and station bypass and monitored regularly. Data would need to be retrieved periodically, then analyzed. A multi-site route selection study conducted by the USGS Conte Lab on the Shetucket River in Connecticut cost approximately $75,000 for the first year of study. Costs are estimated at $100,000 per year for the route selection study and $50,000 to $75,000 for the spill, bypass, canal, and turbine mortality/injury study.

Boott did not propose any studies to meet this need in the PAD.

REFERENCES

Havn, T. B., F. Økland, M.A. Teichert, L. Heermann, J. Borcherding, S.A. Sæther, O.H. Tambets and E.B. Thorstad. 2017. Movements of dead fish in rivers. Animal Biotelemetry, 5: 7.

Normandeau Associates, Inc. 2017. Downstream Passage Evaluation for Silve-Phase American Eels at the Lowell Hydroelectric Project. 2017. Submitted to the City of Holyoke Gas and Electric Department. Final report. Normandeau Associates, Inc., Westmoreland, New Hampshire. 17 pp.

Boott Study Request # 6

Operations Analysis of the Lowell Canal
(Lowell, P-2790)

Goals and Objectives

The goal of this study is to understand the operations of the Lowell canal system. The specific objective of this study is to describe the operations of the Lowell canal which include, but are not limited to: how all of the canal units interact with the main units, how the canal units are sequenced, how often each of the units operate, the prioritization sequence of canal unit operations, the amount of time the units are operated during the downstream passage season, etc.

Resource Management Goals

The Service seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation, and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to aquatic resources, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Minimize current and potential negative project operation effects on fish in the project area.

Public Interest

The requestor is a natural resource agency.

Existing Information and the Need for Additional Information

The Merrimack River supports a variety of migratory fish species. However, there is no information pertaining to fish mortality and population effects resulting from entrainment in the canal and/or the canal units. Since there are no exclusionary measures at the entrance of the project's canal system, fish can easily enter the two-tiered network of man-made canals, which are approximately 5.5 miles in length. These man made canals provide flow to 19 Boott-owned hydroelectric units. Since the issuance of the original license for the project, there have been no directed studies of the Pawtucket, Western, Merrimack, or Hamilton canal units. Additionally, the PAD provides little operational information regarding the canal: flows of up to 2,000 cfs are routed into the canal, typically once the E.L. Field station's hydraulic capacity of 8,000 cfs has

been reached. These information gaps need to be filled so the natural resource agencies can assess the relative and cumulative impacts of project operations on riverine fishes and migratory alosines which may be moving through, or inhabiting, the canal and develop adequate passage and protection measures to meet management goals and objectives.

Nexus to Project Operations and Effects

The Lowell Project consists of a two-tiered, 5.5-mile-long, network of man-made canals which include several small dams and 19 turbine units. Flows enter the canal system upstream of the Pawtucket dam via the Pawtucket canal. There are no exclusionary measures for fish in place. Therefore, the Lowell canal presents problems with respect to providing safe, timely, and effective passage for fish trying to move past the project through the canal system.

Methodology Consistent with Accepted Practice

In order to determine the relative risk the canal units present to riverine and migratory fishes, it is necessary to understand how the canal operates. Therefore, we request Boott provide a detailed description of the operational protocol it uses to determine when and how much water flows into the canal at a time scale relevant to the migratory fish species expected to potentially utilize the canal as a passage route (e.g., May, June, and July for spent alosines; August through November for adult eels and juvenile alosines). Historical operations data should be examined relative to the hydrological data set to determine the percent of time the canal units would be expected to operate during each passage month. This analysis should be used in conjunction with the results of the passage route and turbine mortality studies to estimate total through project mortality for each target fish species/life stage.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The expected level of effort and anticipated cost will be low. Operations and hydrologic data are readily available and only need to be compiled and analyzed. We estimate the cost to be less than $10,000.

Boott Study Request # 7

Three-Dimensional Computational Fluid Dynamics (CFD) Modeling in the Vicinity of Fishway Entrances and Powerhouse Forebays

(Lowell, P-2790)

Goals and Objectives

The goal of this study is to determine the flow field conditions that exist in and around fishway entrances and the powerhouse forebay. The information from this request is meant to be coupled with data from the telemetry studies, such that a comprehensive understanding of fish behavior is developed.

The objective of this study is to create a series of color contour maps of velocity magnitude at select discharges agreed upon by the resource agencies and the licensee. With respect to upstream passage, the results will show approach velocities and flow fields that may create a response in fish. This information can be coupled with telemetry data (from the requested shad and river herring telemetry study) and passage counts to understand which conditions are optimal for guiding migrating fish to the fishway entrances and stimulating fishway entry.

With respect to downstream migration, the results will show velocities and flow fields in front of the E.L. Field powerhouse. Additionally, the results will indicate to what degree, if any, flow directs downstream migrating fish towards the downstream bypass facility.

Resource Management Goals

The management goals of this study request are to obtain information that will assist in enhancing the effectiveness of the current upstream fish passage facilities for upstream migrating trust species and reduce impingement, entrainment, and delay for downstream migrating fish. CFD models are a relatively cost effective way to analyze existing and future conditions. As such, changes in the amount of attraction water, changes in which turbines are operating, and which spillway gates are releasing water can all be examined. As stated, the results from this study are meant to be used along with the data generated from the requested telemetry study. The combined analysis from these two data sources can help assess which flow conditions are most advantageous for migrating trust species to enter the fishway under current and proposed conditions.

As for downstream migration of adult and juvenile shad, river herring, and adult eel, the results from the models will reveal flow magnitude and direction in front of the powerhouse. Given the limited information that currently exists on survival through the project, our management goal is to direct as many downstream migrating fish as possible towards the downstream bypass facility. With respect to upstream passage, we want to maximize the number of fish that find and enter the fishway entrances.These study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and

Wildlife Coordination Act, as amended (16 U.S.C. §661, *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requestor is a natural resource agency.

Existing Information and the Need for Additional Information

To date, no CFD modeled data exists in front of either the fish ladder or lift, nor do they exist in front of the E.L. Field powerhouse. A comprehensive understanding of fish behavior at the ladder and lift entrance, and the powerhouse forebay, is needed in order to create safe, timely, and effective upstream and downstream passage for American shad, river herring, and eels. Additionally, a better understanding of flow and how it affects fish passage is needed after Boott performs the ledge removal excavation project.

Nexus to Project Operations and Effects

The Lowell Project has direct impacts to upstream and downstream migrating shad, river herring, and eel. The development of these models will give resource agencies valuable information into the hydraulic cues which may elicit a response from upstream migrants. For downstream passage, the Service has approach velocity guidelines; the output from these models would inform the resource agencies under what conditions appropriate approach velocities are being met and when they are being exceeded.

With respect to upstream migration, the auxiliary water system (AWS) plays a critical role in determining whether or not fish are attracted to the entrance. The results from this study would allow an assessment of how well the AWS is performing and under what conditions it attracts the most fish.

With respect to downstream migration, the development of a CFD model under existing conditions also informs the design of future modifications and improves the survivability of downstream migrating shad, river herring, and eel.

The CFD models for the Pawtucket fishway and fish lift should be developed as part of year two studies, after the ledge excavation project is complete. It would be useful to have the gatehouse area CFD modeling completed in year one. This analysis may provide information on adjustments to canal operations or structures that can subsequently be analyzed.

Understanding the entrance conditions of the Pawtucket fishway under a range of spill conditions would be informative. If developed prior to the year one upstream shad telemetry studies, it would provide information on spill gate settings which would likely best achieve entrance and ultimately passage. Further work with the model can help in evaluating changes in ladder entrance or spill conditions that could improve passage and be tested with telemetry, video, and/or count data.

CFD modeling of the flows leading to the canal would aide in our interpretation of year one downstream passage telemetry results, but would not need to be completed prior to the year one telemetry (downstream juvenile alewife and downstream eel) studies. Those studies will provide the context for how and where shad, river herring, and eels are passing the project and how successful passage is. The CFD modeling could focus on the locations identified as important in the study results and Boott could assess changes to structures or operations and evaluate them in the model. Promising alternatives would then be tested in year three studies.

Methodology Consistent with Accepted Practice

A three-dimensional CFD model has become an increasingly common standard of analysis at hydroelectric projects around the nation. Within the northeast region, we have seen these types of models developed at the Holyoke (P-2004), Brunswick (P-2284), Shawmut (P-2322), Milford (P-2534) and Orono (P-2710) projects. We would expect to engage with the licensee in terms of determining the appropriate area and flows to be modeled. We expect the spatial extent of the model at each study site will vary. Given the large number of ways in which output from these models can be presented and the near infinite number of flows which could potentially be modeled, we would expect to consult with the licensee to reach agreed upon modeling efforts and scenarios to be examined.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The cost of developing, running and testing a CFD model can vary tremendously; one large variable in determining the cost is based on the amount of existing bathymetric data to which Boott currently has access. We roughly estimate that the cost of each CFD model could run as high as $50,000, assuming no bathymetric data currently exists. Proactive communication with resource agencies will reduce the cost and iterative effort. Given the level of effort that has occurred at other projects that have proposed to amend their license, we see the level of effort requested here as reasonable and in line with frequent modern industry practice.

Boott Study Request # 8

Bypass Zone of Passage
(Lowell, P-2790)

Goals and Objectives

The goal of this study is to determine zone-of-passage flows in the bypass reach that facilitate safe, timely, and effective fish passage through the project.

Specifically, the objectives of this study are:

1. Complete a detailed survey of the bypass reach;
2. Develop a high-resolution, two-dimensional hydraulic model of the bypass reach;
3. Release multiple flows from the dam to collect calibration data for the model;
4. Simulate additional flows through the bypass reach with the calibrated model; and
5. Determine minimum and optimal zone-of-passage flows for the project.

Resource Management Goals

The Service seeks the accomplishment of a number of resource goals and objectives through the relicensing process for the project. General goals include the following:

1. Ensure that protection, mitigation and enhancement measures are commensurate with project effects and help meet regional fish and wildlife objectives for the basin.
2. Conserve, protect, and enhance the habitats for fish, wildlife, and plants that continue to be affected by the project.

Specific to aquatic resources within the Lowell bypassed reach, the Service's goals are:

1. Protect, enhance, or restore diverse high quality aquatic and riparian habitats for plants, animals, food webs, and communities in the watershed and mitigate for loss or degradation of these habitats.
2. Provide a flow regime in the bypassed reach that meets the life history requirements of resident fish and wildlife (including invertebrates such as freshwater mussels) and diadromous fishes.
3. Minimize current and potential negative project operation effects on water quality and aquatic habitat.

These study requests are intended to facilitate the collection of information necessary to conduct effects analyses and to develop reasonable and prudent conservation measures, and protection, mitigation, and enhancement measures pursuant to the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §661, *et seq*.), and the Federal Power Act (16 U.S.C. §791a, *et seq*.).

Public Interest

The requester is a natural resource agency.

Existing Information and the Need for Additional Information

Article 36 of the original license required the licensee, in consultation with resource agencies, to develop an in-stream flow study plan to determine: (1) 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 (i.e., zone of passage). After completion of the approved studies, the licensee was to file a report on the results of the studies, and, for Commissions approval, recommendations for the flow releases from the project. The study plan was filed on August 13, 1983, with proof of agency consultation (Accession No. 19830818-0191). However, there are no study reports included in the record. Therefore, we have no quantitative data supporting the agreement that 300 cfs at night and 500 cfs during the day are adequate flows for zone of passage in the bypass reach.

In the Comprehensive Fish Passage Plan filed on March 9, 2000 (Accession No. 20000313-0322), the licensee states "The adequacy of flows for upstream fish passage at the Project was addressed by BHI's construction of six (6) concrete flow control weirs (with adjustable stoplog sections) in the bypass reach, at the request of U.S. Fish and Wildlife Service and in response to Article 36, section (2) of the Project's FERC license." Similar to the study plan, this is an agreement with no supporting information to substantiate the conclusion flows in the bypass reach are adequate for the full suite of diadromous species.

As part of compliance for Article 34 of the original license, the licensee filed as-built drawings of the existing fish passage facilities (Accession No. 19860902-0215). Within this abbreviated drawing set, drawing number 344D-PC001, 3844D-FC001, and 3844D-FC004 show topographic surveys for portions of the bypass reach. However, the drawings do not document the accuracy and precision of the survey, do not show the majority of the bypass reach, and are otherwise illegible.

Since agreeing upon the current zone-of-passage flows during the original license, there have been developments in topographic survey capabilities, a better understanding of the hydraulic requirements of diadromous species, multi-dimensional hydraulic modeling capabilities, and an increased need to pass fish at the spillway ladder.

Nexus to Project Operations and Effects

Diadromous fish orient their migration based on the environmental conditions of the river: flow, depth, velocity, and temperature (Goodwin 2014). Project operations affect the environmental conditions in the River, specific to this study request, the bypass reach. Two key hydraulic model outputs from the requested study are depth and depth-averaged velocity, which can be used to determine the likelihood of predation, delay, and the cessation of migration. Evaluating the flow fields in the bypass reach under different spill conditions will assist in the consultation process for determining an appropriate zone-of-passage flow in the bypass reach to optimize fish passage

at the project. These data will also contribute to the development of an administrative record in support of a potential settlement agreement, Section 18 fishway prescriptions, or 10(j) recommendations.

Methodology Consistent with Accepted Practice

We proposed the following methodology to accomplish the five objectives and ultimately the goal of the study, to determine zone-of-passage flows for the bypass reach.

Topographic survey

The bypass reach area is large, making traditional topographic survey methods laborious and costly. We recommend using Light Detection and Ranging (LiDAR) methods with limited traditional surveying. Outside of the fish passage season and during a river flow when the project is in control of the River, the bypass reach will be mostly dewatered. At this time, a licensed surveyor can fly the area to collect LiDAR data. Once this data is processed, traditional methods will fill in the gaps (e.g., pooled water areas, under bridges). The topographic survey shall be of sufficient resolution and quality to complete the remaining objectives.

Two-dimensional hydraulic model

There are many two-dimensional hydraulic models that are acceptable for accomplishing the goal of this requested study, many of which are open source. We are not requiring one model over the other, but Boott should understand and document the limitations of the modeling software used. At a minimum, the modeling output should produce depth-average velocity and depth for each cell in the mesh. The modeling domain shall be of sufficient size and mesh to delineate a zone of passage through the entire length and width of the bypass reach.

Calibration flows

The licensee should collect calibration data by spilling a minimum of two flows from the Pawtucket dam. The calibration flows should bracket the range of simulated flows in the study. We recommend 300 cfs for the low flow as it represents the current lowest operation flow for the fish ladder. For the high calibration flow, we recommend collecting data near the high fish passage design flow (i.e., the 5 percent exceedance value for the migratory period of record) which is approximately 26,000 cfs in the Merrimack River (bypass flow would be approximately 17,000 cfs with full project operation). Boott should collect calibration data (depth-averaged velocity and depth) with an Acoustic Doppler Current Profiler (ADCP) at a minimum of four cross sections, including the downstream boundary condition and use the ADCP in locations spread evenly throughout the bypass which are less turbulent.

Additional flow simulations

After calibrating the model, additional bypass flows should be simulated (and agreed upon with the natural resource agencies), including 500 cfs, 1,000 cfs, and up to the high calibration flow. The additional simulations should represent the full range of hydraulic conditions in the bypass reach from the low to high fish passage design flow.

Zone-of-passage determination

The model output should be used to delineate a zone-of-passage pathway for each of the modeled flows. To determine the zone of passage, we recommend Boott use the SprintSwim model developed by U.S. Geological Survey researchers (Haro et al. 2004).

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

The licensee should be able to finish the bypass zone-of-passage study in one year depending on seasonal flow conditions. The level of effort and cost is commensurate with a project the size of the Lowell facility and the likely license term. No alternatives are proposed.

REFERENCES

Goodwin, R. A., M. Politano, J.W. Garvin, J.M. Nestler, D. Hay, J.J. Anderson and M. Timko. 2014. Fish navigation of large dams emerges from their modulation of flow field experience. Proceedings of the National Academy of Sciences. p. 201311874.

Haro, A., T. Castro-Santos, J. Noreika and M. Odeh. 2004. Swimming performance of 716 upstream migrant fishes in open-channel flow: a new approach to predicting passage through velocity barriers. Canadian Journal of Fish and Aquatic Science. 61: 1590-1601.

ATTACHMENT D

Document Accession #: 20180814-5118 Filed Date: 08/14/2018

FEDERAL ENERGY REGULATORY COMMISSION
Office of Energy Projects
Division of Dam Safety and Inspections – New York Regional Office
19 West 34th Street, Suite 400
New York, NY 10001
Telephone No. (212) 273-5900 **Fax No. (212) 631-8124**

April 30, 2008

Re: Hydropower Projects Inspection and Compliance

To the Party Addressed:

Staff from this office conduct periodic inspections to ensure that hydropower projects licensed or exempted by the Federal Energy Regulatory Commission (FERC) are properly operated and maintained in compliance with license and exemption terms and conditions.

During FERC staff dam safety inspections, the project's structural features are inspected and all matters of dam safety, operations, maintenance and compliance are reviewed and discussed with the licensee or exemptee. During FERC Environmental and Public Use Inspections (EPUI), recreation, fish, and wildlife requirements are specifically addressed. Any concerns or questions resulting from the inspections are discussed at the projects, with follow-up letters as necessary.

Since an important part of these inspections includes an assessment as to whether the projects are being operated and maintained in compliance with their license or exemption terms and conditions, it is requested that you provide this office with information relative to any project-specific concerns within 45 days from the date of this letter. Following receipt of this information, we will contact your staff as appropriate.

To help ensure that projects are operating in compliance with the licenses and exemptions, and to improve liaison among the licensees, exemptees, FERC staff, and

resource agencies, we will continue to notify you of each EPUI and dam safety inspection, as appropriate, by forwarding a copy of our inspection confirmation letter to your agency. Because of our workload and the necessity to maintain tight scheduling during the inspection season, the scheduled time and dates for the inspections cannot be changed. If your representatives plan to accompany our staff on the inspection, they should contact our inspector sufficiently in advance of the scheduled inspection so that arrangements can be made to accommodate all participants, and they should arrive at the site at the scheduled time. We also wish to emphasize that, should your representative have any questions about matters of compliance or project operations during the inspections, these questions or concerns should be directed to the FERC representative who has the responsibility to ensure compliance with the license or exemption. We will then take whatever action is appropriate to resolve any problems or answer your questions.We appreciate your continued cooperation in our inspection program and look forward to working with you. If you have any questions, please call me at (212) 273-5930.

Sincerely,

Peter R. Valeri

Peter R. Valeri
Acting Regional Engineer

FERC
Boott Hydro

United States Department of the Interior

NATIONAL PARK SERVICE
Lowell National Historical Park
67 Kirk Street
Lowell, Massachusetts 01852-1029

IN REPLY REFER TO:

June 12, 2008

Peter R. Valeri
Acting Regional Engineer
Office of Energy Projects
Division of Dam Safety and Inspections
Federal Energy Regulatory Commission
19 West 34th Street, Suite 400
New York, NY 10001

Re: FERC Project no. 2790-000, Lowell, MA

Dear Mr. Valeri:

Thank you for the opportunity to comment on the above referenced hydropower project located on the Lowell Canal System in Lowell, MA by Enel/Boott Hydropower, Inc.

We do work with this licensee on a regular basis to accommodate the canal tours offered by the Lowell National Historical Park and on protection of the historic resources that make up the Lowell Canal System, which is a National Engineering Landmark and on the National Register of Historic Places, as well as being located fully within the Lowell National Historical Park, a unit of the National Park Service, as designated by P. L. 95-290, Title I § 103.

First and foremost, we wish to reinforce the requirements enacted in the law establishing the National Park in Lowell, which are applicable to FERC actions:

§ 410cc-12. **Consultations, cooperation, and conduct of activities by Federal entities; issuance of licenses or permits by Federal entities**

(a) "Any federal entity conducting of 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 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.

The Commission referenced in the law is the Lowell Historic Preservation Commission which is defunct, but whose legal obligations have been assumed by the Lowell National Historical Park. The Secretary reference is the Secretary of the Interior, under which the Lowell National Historical Park operates.

The National Park's primary concerns fall within two categories:

1. Operation of National Park canal-related programs in a safe manner and allow for consistent public programming based on the Park's annual operating program.
2. Preservation of the Canal and related structures that make up the Lowell Canal system.

1. Operation of National Park canal related programs in a safe and responsive manner.

Article 33, Section 7 of the License calls for "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."

a. Maintaining appropriate water levels for tour operations: The National Park Service has made considerable public investment in the development of the Canalway that includes public walkways and boat tour operations. The main attraction for visitors to come to Lowell National Historical Park is to experience Lowell by boat via the canals. The park collects a fee for the general public boat tours as well as a school group fee that is charged for school's participating in our daylong programs. The school programs in particular, are programmed well in advance. The inability to use the canals because of unexpected water levels drops causes great concern due to the loss of revenue and credibility to a nationally recognized education experience.

At the current level of the river (June 2008) National Park tour boats cannot enter the river pond for two reasons: 1) because of the removal of the flashboards, the water level is too low to operate above the guard lock chambers of both the Northern and Pawtucket Canals a and in the Merrimack River above the Pawtucket Dam, and 2) the trash boom is still across the mouth of the Pawtucket Canal. Because the water is so low, National Park Maintenance crews cannot get a work boat into the river to open up the boom. If the water levels are not raised soon this will have a major impact in the park tour operation for the beginning of our full summer season.

b. Timely Communication of Changing Water Levels for Safe Tour Operations: The park is respectful of the operational requirements for Boott Hydro but there needs to be a more formalized agreement/plan in place to ensure that changes in operation that effect water levels are communicated to the park to ensure that there will not be damage to property,

injury to park visitors that use the canals, and a loss of revenue and integrity to the visitor's experience. As boat tours expand in the canal system, as they have by the restoration of the Swamp Locks this year, certain bridge clearances have become tighter which requires slower more deliberate changes in the canal surface elevations to help assure the safety of the boat passengers. Unsafe operational procedures which quickly change canal levels without proper notice need to be reduced to a minimum with continual effort made to eliminate them.

c. Impairing Navigability: Many of the Boott Hydro owned bridges that the Park visitors pass under are in poor condition. This year the Pawtucket Street Bridge over the Northern Canal by the Hydro Plant is in particularly rough shape with the reinforced concrete walkways on each side sending concrete chunks falling to the lock chamber below. This condition makes it unsafe for the Park to exercise its right to run boat tours and open the walkway under the bridge without some protective scaffolding type structure or heavy duty netting to protect Park visitors from the falling concrete. Similarly, the Pawtucket Street Bridge over the Upper Pawtucket Canal has some exposed reinforcing and deteriorating concrete although not to the extent of the bridge over the Northern Canal. Lastly, the Broadway Street Bridge over the Pawtucket Canal requires constant vigilance in order to prevent an unsafe condition for Park visitors.

d. Accommodating Public Use; Operation of Surge Gate: The Commonwealth of Massachusetts acquired Recreation and Transportation Rights to sections of the Lowell Canal System, which have been made available to the National Park by easements provided by acts of the State Legislature. The National Park and other city and state agencies concurred with installation of a surge gate in the Northern Canal by the Licensee based on a stated, if not written, understanding that adding this structure would increase recreation access. However, Licensee's policy of locking down the surge gate "for safety reasons" whenever there are tours scheduled or walkway access is occurring along that canal negates what we were given to believe was the purpose of the surge gate. In other words, "Why did the surge gate get built if it's not operational when the public has access?" We understood that boating and pedestrian safety would be enhanced by having the surge gate operational at the times of public use and that the time of pedestrian access could potentially be extended as well.

2. Preservation of the Canal and related structures that make up the Lowell Canal system.

In the Cultural Resources section of the FERC License, mitigation is defined in order to address potential adverse effects of the original plant development to the Locks and Canal Historic District. However, this mitigation does not allow inconsistent actions after the date of the license that could result in adverse effects to the historic resources of the Lowell Canal System. Several past and proposed actions should be subjected to appropriate reviews:

a. Overtopping The Great River Wall: As a result of running the water at high levels within the Northern Canal, overtopping, extended surcharge loading, and lack of maintenance of the Great River Wall resulted in a failure of a section of that wall March 15, 1994.While repairs were accomplished with historical sensitivity, the National Park Service continues to be concerned that practice could result in further wall failures that would constitute an adverse effect to the historic district. There is a need to adjust the

operating levels in this canal to assure that overtopping does not occur and historic resources are protected.

b. **Pawtucket Dam:** Preservation of the historic Pawtucket Dam is a major preservation objective of the Lowell National Historical Park. We have communicated on several occasions with the Licensee in response to proposals to install a Bladder Dam system. The Pawtucket Dam is the reason the city of Lowell, MA exists and a fundamental element of the historic resources that justified the creation of a National Park here. The National Park will continue to oppose a Bladder Dam solution on this historic site.

c. **Flashboards & Pins:** As FERC is aware, there are great concerns in the community that the flashboard system is not working in the same manner as in the past and there is a belief that the pins and/or the flashboard system have been strengthened to prevent the purposeful bending over of the flashboards to reduce upstream flooding. We note that Boott Hydro was issued a permit by the Lowell Historic Board in 2000 to drill a new row of flashboard pin holes in the capstones, which Boott Hydro represented in that permit application as "moving the hole location" so as "to decrease or eliminate capstone breaking problems." As actually carried out, it now appears that many more pin holes were made in the new row than in the earlier two rows closer to the face of the dam. In addition to other problems this situation has been causing, we are especially concerned that this practice of more closely spaced pins could result in damage to the capstones of the Pawtucket Dam. The National Park has not been included in any correspondence on this issue locally and request that FERC not take any action to finalize an agreement with regard to the pins and flashboards without consultation with us and a determination as to whether further Section 106 action is needed. We are also concerned that the unilateral change from using smaller boards to plywood sheets as flashboards some years ago occurred without such consultation and may have resulted in higher water levels and the risk of additional damage to historic resources.

On behalf of the Lowell National Historical Park, I would like to thank you for consideration of these issues and would respectfully request a meeting to review them with you or your staff so that proper procedures will be in place going forward to assure that the power generation can occur without the impacts described above. I look forward to hearing from you at your earliest convenience. I may be reached at 978-275-1700 or Michael_creasey@nps.gov

Sincerely,

Michael Creasey
Superintendent

cc: Bernard Lynch, City Manager
U. S. Rep. Niki Tsongas
ENEL/Boott Hydropower, Inc

Document Accession #: 20180814-5118 Filed Date: 08/14/2018

Enel
Energy in tune with you.

BOOTT HYDROPOWER, INC.
A SUBSIDIARY OF ENEL NORTH AMERICA, INC.

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Via eFiling

August 4, 2008

Peter R. Valeri, P.E.
Regional Engineer
Federal Energy Regulatory Commission
19 West 34th Street, Suite 400
New York, NY 10001

Re: Lowell Hydroelectric Project (FERC No. 2790-MA);
Response to National Park Service letter.

Dear Mr. Valeri:

We are in receipt of your letter of June 20, 2008 in which you requested our response to a letter from the National Park Service (NPS) dated June 12, 2008, which raised a number of issues regarding the perceived impact of the Lowell Hydroelectric Project on the NPS' operations at the Lowell National Historical Park. For the record, we note that the NPS' letter is dated the day before the June 13 Operations Inspection of the project by your staff, which inspection was attended by an NPS representative. None the concerns listed in the NPS' letter were voiced by the NPS representative during the inspection.

Our response to each of the concerns raised by the NPS follow:

1. Operation of National Park canal related programs in a safe and responsive manner.

Article 33, Section 7 of the License calls for "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."

Response: There presently are no future actions proposed by BHI which would change the mean seasonal water levels in the canal system, that would impair navigability, or which would otherwise invoke review and comment by the Advisory Council on Historic Preservation under Article 33.

a. ***Maintaining appropriate water levels for tour operations:***
The National Park Service has made considerable public investment in the development of the Canalway that includes public walkways and boat tour operations. The main attraction for visitors to come to Lowell National Historical Park is to experience Lowell by boat via the canals. The park collects a fee for the general public boat tours as well as a school group fee that is charged for school's participating in our daylong programs. The school programs in particular, are programmed well in advance. The inability to use the canals because of unexpected water levels drops causes great concern due to the loss of revenue and credibility to a nationally recognized education experience.

At the current level of the river (June 2008) National Park tour boats cannot enter the river pond for two reasons: 1) because of the removal of the flashboards, the water level is too low to operate above the guard lock chambers of both the Northern and Pawtucket Canals a and in the Merrimack River above the Pawtucket Dam, and 2) the trash boom is still across the mouth of the Pawtucket Canal. Because the water is so low, National Park Maintenance crews cannot get a work boat into the river to open up the boom. If the water levels are not raised soon this will have a major impact in the park tour operation for the beginning of our full summer season.

Response: The Lowell canal system has multiple uses and operating conditions based on river flows and corresponding river elevations which are neither predictable nor constant. BHI manages and maintains canal system water levels to the best of its ability within the limits as agreed to with the NPS. In many cases the target operating band is relatively narrow, constrained by the minimum level necessary to pass tour boats through the locks and the maximum level necessary to allow for safe passage of tour boats under bridges. Any adjustments necessary to maintain the proper water levels and system water balance typically take time to achieve and must be done gradually.

BHI has the right to maintain its project works, including the flashboards, and to the extent feasible attempts to accommodate the needs of other water and canal users, including the NPS, in its operations and maintenance planning. BHI provides ample prior notice of all water level changes to the NPS and other affected parties.

With respect to the low water levels experienced during 2008, BHI removed the flashboards from the crest of the Pawtucket Dam on May 30, 2008 in direct response to a Commission order. BHI expeditiously undertook the necessary corrective measures, and after gaining Commission approval and purchasing new flashboard pins, completed reinstallation of the flashboards on June 20, 2008. BHI immediately began to refill the headpond while maintaining the project's downstream minimum flow requirement, and restored the headpond to normal levels on June 25, 2008. Shortly after refilling the impoundment, damage to the flashboards occurred as a result of elevated river flows and debris impact. Had BHI not repaired the flashboards quickly, the impoundment could not have been maintained near normal levels, due to low river inflows, likely resulting in impacts to recreational use upstream of the Pawtucket Dam. Notifications were made that the impoundment was to be lowered again for the repairs which were accomplished on July 10, 2008.

b. ***Timely Communication of Changing Water Levels for Safe Tour Operations:***
The park is respectful of the operational requirements for Boott Hydro but there needs to be a more formalized agreement/plan in place to ensure that changes in operation that effect water levels are communicated to the park to ensure that there will not be damage to property, injury to park visitors that use the canals, and a loss of revenue and integrity to the visitor's experience. As boat tours expand in the canal system, as they have by the restoration of the Swamp Locks this year, certain bridge clearances have become tighter which requires slower more deliberate changes in the canal surface elevations to help assure the safety of the boat passengers. Unsafe operational procedures which quickly change canal levels without proper notice need to be reduced to a minimum with continual effort made to eliminate them.

Response: BHI keeps the NPS and other affected parties informed of any planned changes in operations that would impact river or canal water levels. Other than for emergencies or in unusual circumstances, BHI provides at least a 24 to 48 hour advance notification of any major water level changes (e.g., drawdowns) by email or telephone. For planning purposes, BHI has requested and obtained the NPS' anticipated event schedule which, to the extent possible, BHI attempts to accommodate by postponing scheduled maintenance canal draw downs to avoid conflicts.

Canal water surface elevations and bridge clearances are addressed in BHI's Revised Report on Recreational Resources, filed pursuant to license Article 38, which included a

canal system water elevation maintenance plan. BHI's Article 38 filing was approved by the Commission on September 12, 1984. As noted above, in many cases the target operating band for the lower canal system is relatively narrow, constrained by the minimum level necessary to pass tour boats through the locks and the maximum level necessary to allow for safe passage of tour boats under bridges. The lower canal system below the Swamp Locks has siphon outlets to assist in maintaining the water surface elevations within this narrow elevation band.

c. ***Impairing Navigability:***

Many of the Boott Hydro owned bridges that the Park visitors pass under are in poor condition. This year the Pawtucket Street Bridge over the Northern Canal by the Hydro Plant is in particularly rough shape with the reinforced concrete walkways on each side sending concrete chunks falling to the lock chamber below. This condition makes it unsafe for the Park to exercise its right to run boat tours and open the walkway under the bridge without some protective scaffolding type structure or heavy duty netting to protect Park visitors from the falling concrete. Similarly, the Pawtucket Street Bridge over the Upper Pawtucket Canal has some exposed reinforcing and deteriorating concrete although not to the extent of the bridge over the Northern Canal. Lastly, the Broadway Street Bridge over the Pawtucket Canal requires constant vigilance in order to prevent an unsafe condition for Park visitors.

Response: BHI owns and maintains several bridges which provide public access across the canal system throughout downtown Lowell. All of these bridges are specifically excluded from the project boundary as shown on the approved Exhibit G-2, and furthermore are not described as project features within the Lowell Project's license. These bridges are therefore not subject to the Commission's jurisdiction.

Nevertheless, BHI has a program of continually monitoring, performing engineering evaluations of and repairing its bridges. As was discussed during a meeting with the NPS in early June, BHI anticipates that repair work will be performed on each of the bridges referenced above during 2008. As it has recently done during previous work on its bridges, BHI will provide the NPS with ample advance notice of its anticipated work schedule, and will ensure that its bridge repair contractors make special provisions to not impede tour boat operations and canal navigability during construction activities.

d. ***Accommodating Public Use; Operation of Surge Gate:***

The Commonwealth of Massachusetts acquired Recreation and Transportation Rights to sections of the Lowell Canal System, which have been made available to the National Park by easements provided by acts of the State Legislature. The National Park and other city and state agencies concurred with installation of a surge gate in the Northern Canal by the Licensee based on a stated, if not written, understanding that adding this structure would increase recreation access. However, Licensee's policy of locking down the surge gate "for safety reasons" whenever there are tours scheduled or walkway access is occurring along that canal negates what we were given to believe was the purpose of the surge gate. In other words, "Why did the surge gate get built if it's not operational when the public has access?" We understood that boating and pedestrian safety would be enhanced by having the surge gate operational at the times of public use and that the time of pedestrian access could potentially be extended as well.

Response: Following the partial failure of the bayboard section of the canal wall in 1994, BHI undertook feasibility studies to determine the best option for surge suppression in the Northern Canal. A hydraulically-activated surge control gate was installed in January, 1997 and was fully automated in 1999. The surge gate is designed to automatically open when the E.L. Field station is tripped off-line to mitigate overtopping of the Great River Wall to provide safe pedestrian access to the wall and island areas, to prevent flooding of the historic Northern Gatehouse, and to prevent undermining and/or weakening of the gatehouse and portions of the Northern Canal. The gate was never intended to enhance boating in the Northern Canal, and in fact raises the safety concern that should the station trip off-line while the NPS is operating tour boats on the Northern Canal, the boat and passengers could be drawn through the open surge gate. Because it has been

demonstrated that the transient wave produced on unit trip is not large enough to overtop the Great River Wall when the Northern Canal flow is less than 3,500 cfs, the gate may be temporarily deactivated under such conditions. Thus, NPS and BHI have agreed that boating tour operations can occur on the Northern Canal only if the canal flow is less than 3,500 cfs and if the surge gate is locked out and tagged out to prevent automatic opening. This lock-out/tag-out procedure is jointly undertaken by BHI and NPS personnel.

There are also circumstances under which BHI can not deactivate the surge gate in order to protect worker safety and/or to ensure compliance with the project's minimum flow requirement. For example, during any work on the crest of the Pawtucket Dam, such as during flashboard maintenance, the surge gate must remain active to prevent spillage from occurring in the event of a unit trip. Likewise, while the impoundment is being refilled following flashboard repairs the gate must remain active to ensure minimum flow compliance should the E.L. Field Station trip off-line. In such situations BHI notifies the NPS and advises against any boat access to the Northern Canal until normal operations resume. BHI has never denied pedestrian access to the Canal Walkway due to inactivation of the surge gate, and has only recommended that the NPS restrict such access due to general safety concerns not related to the surge gate (e.g., lack of appropriate safety fencing).

2. Preservation of the Canal and related structures that make up the Lowell Canal system.

In the Cultural Resources section of the FERC License, mitigation is defined in order to address potential adverse effects of the original plant development to the Locks and Canal Historic District. However, this mitigation does not allow inconsistent actions after the date of the license that could result in adverse effects to the historic resources of the Lowell Canal System. Several past and proposed actions should be subjected to appropriate reviews:

a. Overtopping The Great River Wall:

As a result of running the water at high levels within the Northern Canal, overtopping, extended surcharge loading, and lack of maintenance of the Great River Wall resulted in a failure of a section of that wall March 15, 1994. While repairs were accomplished with historical sensitivity, the National Park Service continues to be concerned that practice could result in further wall failures that would constitute an adverse effect to the historic district. There is a need to adjust the operating levels in this canal to assure that overtopping does not occur and historic resources are protected.

Response: There is no need to adjust the water level in the Northern Canal to prevent overtopping, because overtopping is prevented by the surge gate. Following the 1994 Northern Canal wall failure, BHI installed the surge gate, as described above, to prevent to overtopping of the Great River Wall when the two generating units at the E.L. Field Station are suddenly tripped offline. During normal operations BHI maintains the water level within the Northern Canal at or near El. 91.5 with the surge gate engaged in automatic mode. The only time the Great River Wall can become overtopped is when the Northern Canal flow is greater than 3,500 cfs (i.e., more than the capacity of one unit at the E.L. Field Station) while the surge gate is disengaged from automatic mode. Overtopping of the Great River Wall may also occur when NPS personnel inadvertently leave the lock chamber open at the Northern Gatehouse, which allows the Northern Canal to rise to the same level as the project impoundment.

b. Pawtucket Dam:

Preservation of the historic Pawtucket Dam is a major preservation objective of the Lowell National Historical Park. We have communicated on several occasions with the Licensee in response to proposals to install a Bladder Dam system. The Pawtucket Dam is the reason the city of Lowell, MA exists and a fundamental element of the historic resources that justified the creation of a National Park here. The National Park will continue to oppose a Bladder Dam solution on this historic site.

Response: Historical preservation is but one of many resource areas which would need to be considered in any assessment of installing a "Bladder Dam" or inflatable crest gate system on the crest of the Pawtucket Dam. Such a system would have positive benefits for a wide range of resource areas including water management, fish passage, upstream recreation, reduction of upstream backwatering impacts, worker safety, and most importantly with respect to the NPS' concerns, protection of the historical structure from debris and ice.

BHI does not agree that an inflatable crest gate system would be inconsistent with the historical nature of the Pawtucket Dam. The history of Lowell is founded on continual innovation in hydropower technology, most notably the numerous developments by James B. Francis. The construction of the E.L. Field powerhouse along the historic canal system juxtaposes these historic technologies with more modern technologies. If determined to be feasible, installation of a crest gate system on the Pawtucket Dam would be in keeping with this line of innovation. The compatibility of an inflatable crest gate system mounted on a historic dam is clearly demonstrated immediately downstream at the historic Great Stone Dam at the Lawrence Project (P-2800).

Should BHI actively pursue the installation of an inflatable crest gate system on the Pawtucket Dam in the future, an application for amendment of license would be filed with the Commission. In preparing any such application BHI would conduct the necessary consultation with all appropriate agencies, including the Advisory Council on Historic Preservation, the Lowell Historic Board and the NPS. BHI has already consulted with the NPS on this subject on two separate occasions.

c. ***Flashboards & Pins:***

As FERC is aware, there are great concerns in the community that the flashboard system is not working in the same manner as in the past and there is a belief that the pins and/or the flashboard system have been strengthened to prevent the purposeful bending over of the flashboards to reduce upstream flooding. We note that Boott Hydro was issued a permit by the Lowell Historic Board in 2000 to drill a new row of flashboard pin holes in the capstones, which Boott Hydro represented in that permit application as "moving the hole location" so as "to decrease or eliminate capstone breaking problems." As actually carried out, it now appears that many more pin holes were made in the new row than in the earlier two rows closer to the face of the dam. In addition to other problems this situation has been causing, we are especially concerned that this practice of more closely spaced pins could result in damage to the capstones of the Pawtucket Dam. The National Park has not been included in any correspondence on this issue locally and request that FERC not take any action to finalize an agreement with regard to the pins and flashboards without consultation with us and a determination as to whether further Section 106 action is needed. We are also concerned that the unilateral change from using smaller boards to plywood sheets as flashboards some years ago occurred without such consultation and may have resulted in higher water levels and the risk of additional damage to historic resources.

Response: BHI has previously submitted evidence to the Commission demonstrating that the flashboard and pin materials in use today are the same as those used prior to commercial operation of the Lowell Project in 1985. Furthermore, the NPS' charge that the use of plywood flashboards instead of "smaller boards" may have resulted in higher water levels and damage to the Pawtucket Dam is without basis. The strength of the flashboard system and the height of failure are controlled by the spacing and strength of the supporting pins and have little, if anything to do with the material used for flashboard panels. We note that in their review of BHI's updated flashboard design specifications, Commission staff did not raise any concerns over the use of plywood flashboards on the Pawtucket Dam, and in fact approved same in the Commission's order authorizing re-installation of the flashboards dated June 4, 2008.

Contrary to the NPS's claim there are **fewer**, not more, holes in the row of flashboard pin holes now used by BHI than exist in the original alignment. The flashboard pin socket holes have been re-drilled several times over the dam's 150+ year history as the original holes

have become worn or broken. These holes are generally aligned in three rows running along the dam's axis: 1) the original alignment of 776 holes drilled approximately 6 inches upstream from the downstream face of the capstones; 2) a row of 333 more widely spaced holes drilled approximately 12 inches back from the downstream face of the capstones, which were historically used as a safety measure to tie off workboats when working on the dam crest; and 3) a total of 723 holes in the row currently used by BHI which are drilled approximately 16 inches upstream from the downstream face of the capstones. As noted by the NPS, this latter alignment of pin socket holes includes the 660 holes drilled by BHI in 2000, to prevent damage to the capstones and to preserve the dam. As now installed, BHI has selectively eliminated flashboard pins such that only 588 of the holes in the back row are being used, in order to achieve the 20-inch average pin spacing approved by the Commission.

Thank you for this opportunity to clarify and address the issues raised by the National Park Service. Please do not hesitate to contact me at (978) 681-1900, extension 809 if you have any questions concerning any of the topics addressed above.

Sincerely,
Boott Hydropower, Inc.

/S/

Kevin M. Webb
Environmental Affairs Coordinator

cc: M. Creasey, NPS
V. Engel, BHI

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ATTACHMENT E

Project Scoping Report

Task Order #P17PD03094; Contract #P15PC00036; PMIS #225866

Northern Canal Waste Gatehouse

13 November 2017

EYP/

EYP Architecture & Engineering, PC
Independence Wharf
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NATIONAL PARK SERVICE

Introduction

On 17 August 2017, architects and engineers from EYP (Eric Ward, RA; Rebecca Young, RA; and Mark Kanonik, PE) visited the site to observe the general condition of the Northern Canal Waste Gatehouse. On 19 and 20 October 2017, Mark Kanonik and Chuck Volans of EYP again visited the site to observe the general condition of the building. The Gatehouse is a single-story, heavy-timber-framed building that measures approximately 70' by 15' in plan. The building was built circa 1872 atop a dam that was built circa 1847 and houses the canal gates, including the machinery that operates the gates. Refer to Photograph 1 for additional information.

We understand that the canals and gatehouse structure are owned by the Commonwealth of Massachusetts but maintained by Lowell National Historical Park and that the operational machinery within the gatehouse is controlled and maintained by Enel Green Power North America, Inc. It is our understanding that the wood siding, the roofing membrane, and a portion of the sill at the northeast corner of the building were replaced in the 1980s by NPS staff. At an unknown time in the past, supplemental steel shoring was installed to support both the south and north walls of the building.

Please note that no calculations were performed to determine the load-carrying capacity of any of the elements of the gatehouse building; furthermore, no destructive tests were performed, and no material samples were collected. Lastly, no evaluations of any of the utilities inside or outside of the building were made.

Observations

The Northern Canal Waste Gatehouse is a single-story, heavy-timber-framed, building that measures approximately 70' by 15' in plan. The gatehouse building is built atop a horizontally-curved masonry dam that separates the Northern Canal above from the Merrimack River below. The sills of the sidewalls do not bear directly on the dam; the sill of the north (downstream) wall bears on iron posts which are themselves bolted into the masonry dam, and the sill on the south (upstream) side bears on a wooden ledger that was bolted into the masonry dam. The sills of the endwalls bear directly on the dam.

The roofing is not original and is estimated to be about 30 years old; while it appears to be generally watertight, the edges of the roof membrane are delaminating around the perimeter of the roof. Refer Photograph 2 for additional information. The roofing has reached the end of its useful life and should be replaced. The siding appears to be original, but some siding boards at the eastern end of the north wall were replaced about 30 years ago. The siding is in remarkably good condition except for a few missing siding boards at the eastern end of the north wall. Refer to Photograph 3 for additional information. The paint is reaching the end of its useful life, and the siding should be repainted.

Except for the sills under the north and south walls, the wood framing is in very good condition. The sills themselves are in very poor condition. The eastern end of the north sill was replaced about 30 years ago, but it is now completely missing in some areas. Refer to Photographs 3 and 4 for additional information.

It appears that the normal operating elevation of the Northern Canal was raised when the hydroelectric power plant was installed to the east of the gatehouse building. Photograph 5 (Historic American Engineering Record [HAER] Photograph MA-8C-2, taken in either 1974 or 1975) shows the south face of the dam and gatehouse when the Northern Canal was dewatered and the walkway decking was removed. Photograph 6 is a close-up of the southeast corner of the building, showing the heavy timber ledger which supports the south (upstream) sidewall. Staining of the large masonry units under the gatehouse, as well as vegetation growing in a few masonry joints, indicate that the elevation of the Northern Canal was typically about 4 feet below the top of the dam. However, it appears that the "normal" canal elevation is now only a few inches below the top of the dam, and the heavy timber ledger is now nearly constantly partially submerged. Refer to Photograph 5 for additional information. Not surprisingly, the heavy timber ledger and the wall sill plate atop the ledger are badly deteriorated and are completely missing in some areas. Refer to Photographs 7 and 8 for additional information. At an unknown time in the recent past, 12 shoring posts (with shoring beams and cable ties) were installed throughout the gatehouse building, presumably to redistribute the load away from the deteriorated walls. Given the level of deterioration of the wood framing, it is possible that the building would have partially collapsed if these shoring posts were not installed. Please note that it is impossible to repair the deteriorated heavy timber ledger and south wall sill to match the original design without permanently lowering the elevation of the canal; we assume that this is not feasible, so an alternate method to repair / restore the south (upstream) sidewall will be detailed in the construction documents that are currently progressing.

HAER Photograph MA-8C-2 (Photograph 5) appears to indicate several open joints in the larger masonry units at the top of the dam, directly underneath the eastern half of the gatehouse building. Inside the gatehouse building, the capping stones atop the dam are separated and have settled a couple of inches, and water can be both seen and heard flowing through the open joints. At some time in the recent past, steel staples were installed in the capping stones, presumably to stop the stones from separating further. Refer to Photograph 9 for additional information. Vegetation is growing on the north face of the dam, and a significant quantity of water can be seen flowing through the side of the dam. Refer to Photograph 10 for additional information. It seems very likely that the water flowing through the dam is eroding the mortar joints, thus causing both the lateral movement and the settlement seen in the capping stones at the top of the dam. It seems very unlikely that the issues in the capping stones are caused by uneven settlement of the dam as a whole since bedrock is visible throughout the bed of the Merrimack River. We understand that NPS does not "own" the dam and is not, therefore, responsible for maintaining and/or repairing the dam; however, we recommend that NPS share our concerns expressed in this Report with the Enel Green Power North America, Inc., at which point they may choose to commission a detailed engineering study. Our concerns expressed in this Report are based solely on very limited information; it should be noted that we did not perform an analysis of the dam to determine its load-carrying capacity, nor did we perform any destructive tests or any investigations of the dam.

Recommendations

The deterioration noted in the bases of the walls is adversely affecting the structural stability of the gatehouse building, although it is not yet affecting the operation of the gates. If no action is taken to address these areas of deterioration, the deterioration will continue to worsen until the building settles

or shifts to such an extent that the operation of the canal gates is compromised. Consequently, we recommend the following:

1. Shore the building until all loads are removed from the wall framing and/or the temporary shoring posts.
2. Remove all deteriorated sections of the wall framing (such as wall studs, sill plates, etc.) at the north and south walls, estimated to be about 6 to 12" above the top of the dam.
3. Install new steel framing to support the north wall.
4. Install additional steel framing to support the south wall.
5. Provide wood decking atop the steel framing along both the south and north walls.
6. Remove all temporary shoring posts, beams, and cables.
7. Remove and replace the roofing with an adhered EPDM roof membrane.
8. Repair all windows on the north wall so that the windows may be opened if desired.

No work will be performed to the gates or the gate-operating machinery, including active utilities serving the gate-operating machinery.

Refer to Appendix A for a Class C cost estimate corresponding to the recommended work listed above.

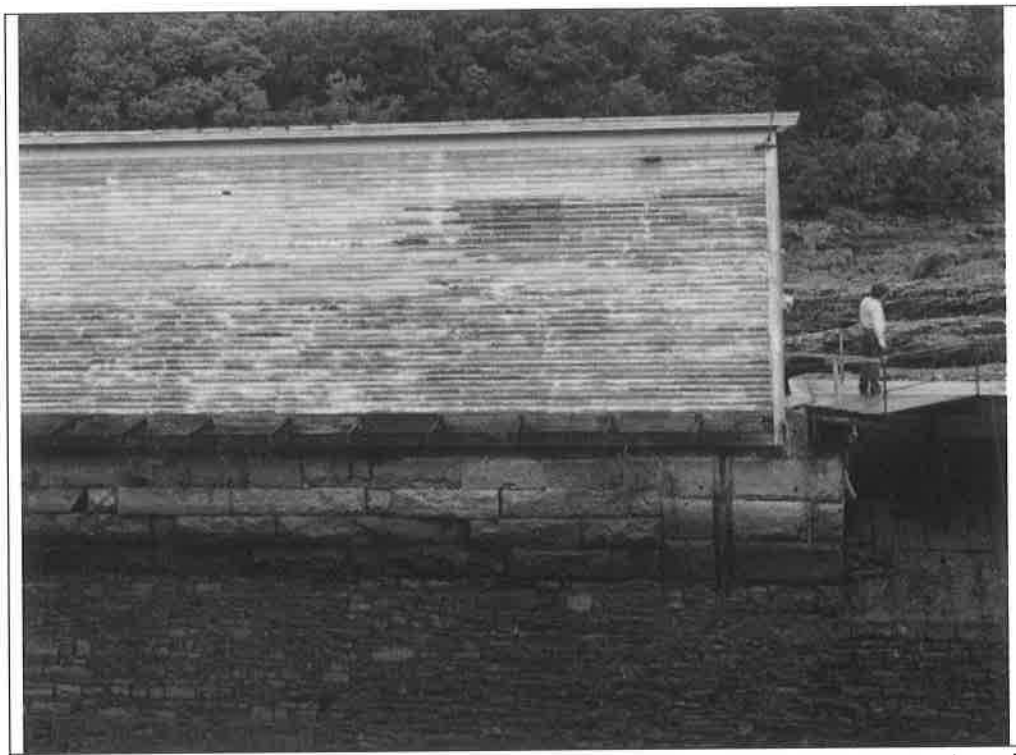
Photographs

Photograph 1 – Northern Canal Waste Gatehouse, viewed from the southeast.

Photograph 2 – Delaminated edge of roof membrane at northeast corner of roof.

Photograph 3 – Deteriorated / missing sill and missing siding boards at eastern end of north wall; entire building has settled in this area, as evidenced by the downward curvature of the siding boards under the left-most window.

Photograph 4 – Deteriorated / missing sill under eastern edge of north wall; note large gap between dam and wall.



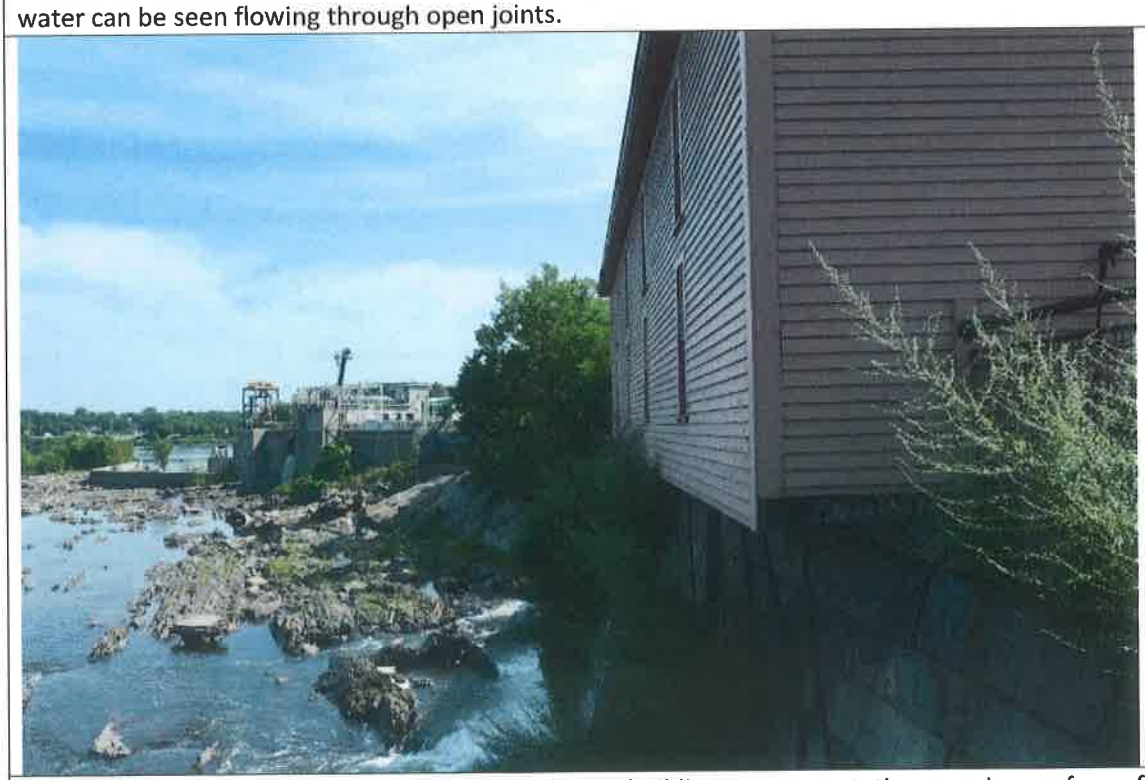
Photograph 5 – HAER Photograph MA-8C-2, taken in 1974 or 1975; note staining in wall and vegetation in joints below gatehouse, indicating that the normal elevation of the Northern Canal was several feet below what it is today. Also, note many open joints in larger masonry units at the top of the dam.

Photograph 6 – Close-up of HAER Photograph MA-8C-2, taken from Photograph 5, showing heavy timber ledger and wall sill.

Photograph 7 – Underside of walkway along south side of gatehouse; the deteriorated sill that is now partially submerged in water is visible in Photographs 5 and 6.

Photograph 8 – Deteriorated heavy timber ledger and wall sill plate at eastern end of south wall.

Photograph 9 – Capping stones atop dam, inside gatehouse building; several units have separated, and water can be seen flowing through open joints.



Photograph 10 – North face of dam and gatehouse building; note vegetation growing on face of dam and significant water flowing through dam.

ATTACHMENT F

PARK PURPOSE

The purpose statement identifies the specific reason(s) for establishment of a particular park. The purpose statement for Lowell National Historical Park was drafted through a careful analysis of its enabling legislation and the legislative history that influenced its development. The park was established when the enabling legislation adopted by Congress was signed into law on June 5, 1978 (see appendix A for enabling legislation and legislative acts). The purpose statement lays the foundation for understanding what is most important about the park.

Lowell National Historical Park preserves and interprets the historic structures and stories of the Industrial Revolution and its legacies in Lowell, serving as a catalyst for revitalization of the city's physical and economic environment and promoting cultural heritage and community programming.

PARK SIGNIFICANCE

Significance statements express why a park's resources and values are important enough to merit designation as a unit of the national park system. These statements are linked to the purpose of Lowell National Historical Park, and are supported by data, research, and consensus. Statements of significance describe the distinctive nature of the park and why an area is important within a global, national, regional, and systemwide context. They focus on the most important resources and values that will assist in park planning and management.

The following significance statements have been identified for Lowell National Historical Park. (Please note that the sequence of the statements does not reflect the level of significance.)

1. Lowell's (economic) success was based in innovation, from manufacturing technology and processes, to new business models, to city planning designed to benefit both industry and the worker. Unique industrial concepts were implemented and demonstrated at a massive scale at the Lowell mills, which served as a model for textile production and industrial cities.

2. A very large proportion of original buildings, structures, and urban landscapes have survived in Lowell's park and preservation district and now are recognized as important historical artifacts. These include the entire 5.6-mile power canal system with its sophisticated dams, locks, and gatehouses, 7 of the original 10 mill complexes, and significant examples of early housing types, institutions, and transportation facilities.

3. The Lowell canal system is nationally recognized as one of the most impressive civil and mechanical engineering achievements of the 19th century because of its grand scale and technological complexity, and is the site of origin for the famed "Francis" turbine. The canal system, used as both a transportation corridor and power source, facilitated the growth of the industrial city.

4. Lowell National Historical Park preserves and interprets the stories and heritage of the people of Lowell, including the early female workforce (aka "mill girls") and those who came from across the globe seeking opportunities. Today, Lowell's residents continue to shape the culture of the city and contribute to its revitalization.

5. The collaboration between Lowell National Historical Park and its partners has resulted in the rehabilitation of almost all of the 5.3 million square feet of historic mill space and hundreds of additional buildings in the downtown historic district. This effort continues to serve as a successful example of leveraging public-private partnerships for economic development through historic preservation.

6. Lowell National Historical Park embraces partnerships as an integral approach to accomplishing park and community goals. Lowell National Historical Park serves as a model for leveraging collaborative public-private partnerships and community engagement.

FUNDAMENTAL RESOURCES AND VALUES

Fundamental resources and values (FRVs) are those features, systems, processes, experiences, stories, scenes, sounds, smells, or other attributes determined to warrant primary consideration during planning and management processes because they are essential to achieving the purpose of the park and maintaining its significance. Fundamental resources and values are closely related to a park's legislative purpose and are more specific than significance statements.

Fundamental resources and values help focus planning and management efforts on what is truly significant about the park. One of the most important responsibilities of NPS managers is to ensure the conservation and public enjoyment of those qualities that are essential (fundamental) to achieving the purpose of the park and maintaining its significance. If fundamental resources and values are allowed to deteriorate, the park purpose and/or significance could be jeopardized.

The following fundamental resources and values have been identified for Lowell National Historical Park:

Water Power System / Canal System. The Lowell National Historical Park boundary includes 9.6 miles of major riverbanks and all 5.6 miles of historic canals in Lowell, all of which comprise the waterpower system that harnessed waters of the Merrimack River to power the city's mills. In fact, the Merrimack River and its natural attributes dictated the location of the city itself. The water power and canal system includes the Pawtucket, Merrimack, Hamilton, Western, Eastern, Lowell, and Northern Canals and canal banks, as well as several associated locks, gatehouses and dams, and Pawtucket Falls. This system, which still operates as a source of hydroelectric power, provides an opportunity to interpret both the historic significance of water in industry, as well as the engineering of a waterpower system. Public access has been expanded over the years to support these interpretive opportunities, including creation of a pedestrian canalway and riverwalk and the development of related exhibits and programs such as the Suffolk Mill Turbine Exhibit.

Boott Cotton Mills Complex. This complex is architecturally and historically the most significant mill site in the city, and the only one with buildings owned and managed by the National Park Service. The millyard was constructed and then adapted over a 100-year period by the Boott Cotton Mills company, one of the 10 major textile corporations in Lowell. Of the city's original millyards, the Boott Cotton Mills complex is the most intact example of Lowell's historic

mill complexes. Changes in technology and production capability influenced the development and appearance of the millyard over time. Its clock tower, completed about 1865, survives today as one of the most distinctive architectural monuments in Lowell and has become a symbol of the park. Today, the restored mill complex houses the park's Boott Cotton Mills Museum, the Tsongas Industrial History Center, and several NPS Northeast Region offices.

Immersive Experience. Lowell National Historical Park provides a variety of hands-on interpretive and educational opportunities that allow visitors to immerse themselves in Lowell's industrial past. Key park experiences include exhibits that feature a working turbine and weave room, as well as boat tours of the canal system and rides through the park on historic replica trolleys, which are among the most popular and unique experiences in the park. The Tsongas Industrial History Center, a partnership between Lowell National Historical Park and the University of Massachusetts Lowell Graduate School of Education, is a hands-on center where students can learn about the American Industrial Revolution through interactive activities such as weaving, working on an assembly line, creating canal systems and testing water wheels, and measuring water quality.

Cultural Heritage and Arts Programming. Immigration and cultural expression were a part of Lowell's story from the beginning—from the Yankee "mill girls" who flocked to the city in search of economic independence to the Irish, French-Canadians, Greeks, Poles, Portuguese, and other ethnic groups that came in search of the American Dream. This cultural heritage, its evolution over time, and its impacts on the cultural character of Lowell today are expressed through programming and exhibitions at the park, including the Mill Girls &Immigrant Exhibit at the Patrick J. Mogan Cultural Center, the Lowell Folk Festival, and the Lowell Summer Music Series. Cultural heritage and arts events are among the most well known and best attended at the park, and feature a range of activities that appeal to local and nonlocal visitors alike.

Historic Urban Industrial Landscape. Lowell is often recognized as one of America's most significant industrial cities, and, as such, the assemblage of buildings, structures, and public spaces that comprise its historic urban industrial landscape are critical to telling the story of the mills and the Industrial Revolution in America. Lowell was an innovative mill town where the focus was on both industry and the worker, and it includes not only extensive mill space and supporting structures but also boardinghouses, churches, and parks. Although the landscape is central to the story of Lowell, many of the buildings, structures, and greenscapes are owned and managed by other entities. Lowell National Historical Park works with the community and partner organizations as well as private owners and developers to ensure continued preservation of the historic urban industrial landscape, including mill buildings and smokestacks. This collaborative preservation effort is fundamental and will continue to be a central focus for Lowell National Historical Park into the future.

Partnerships. Since its establishment Lowell National Historical Park has embraced partnerships as an integral tool for accomplishing park and community goals. Partnerships with entities such as the City of Lowell, the state, and community organizations have allowed the leverage of funds for historic preservation and supported the economic growth of the city. These partners have been critical to meeting the mission of the park, assisting with interpretation, education, and resource stewardship. Through strong, mutually beneficial relationships with its partners, the park has not only succeeded but thrives as a model for community cooperation in the National Park Service.

Museum Collections. The museum collections at Lowell National Historical Park contain more than one-half million artifacts and historical documents, spanning from the early 19th century to

the present. These objects and documents provide a tangible link to the Industrial Revolution in Lowell and its enduring legacies.

INTERPRETIVE THEMES

Interpretive themes are often described as the key stories or concepts that visitors should understand after visiting a park—they define the most important ideas or concepts communicated to visitors about a park unit. Themes are derived from, and should reflect, park purpose, significance, resources, and values. The set of interpretive themes is complete when it provides the structure necessary for park staff to develop opportunities for visitors to explore and relate to all park significance statements and fundamental resources and values.

Interpretive themes are an organizational tool that reveal and clarify meaning, concepts, contexts, and values represented by park resources. Sound themes are accurate and reflect current scholarship and science. They encourage exploration of the context in which events or natural processes occurred and the effects of those events and processes. Interpretive themes go beyond a mere description of the event or process to foster multiple opportunities to experience and consider the park and its resources. These themes help explain why a park story is relevant to people who may otherwise be unaware of connections they have to an event, time, or place associated with the park.

The following interpretive themes have been identified for Lowell National Historical Park:

The creation of the Waltham-Lowell system helped to change the nature and meaning of work by revolutionizing labor relations in the United States and transforming gender, racial, and ethnic identities ultimately leading to socioeconomic opportunity and inequity.

The accumulation of capital led to new investment opportunities in the United States centered on industrialization. Innovations in large-scale production systems in Lowell affected society in social, political, and economic ways and became a model for the future.

Through innovations in textile production, transportation, waterpower, and canal engineering, Lowell became a premier industrial city and helped propel the United States into a new industrial age. Cycles of innovation and technological development shaped, and continue to shape, the city and Lowell's influence on the world.

The commodification and use of abundant natural resources in Lowell, as part of a global Industrial Revolution, changed human relationships with the environment and modernized societies throughout the world but resulted in environmental damage that presents challenges today.

Lowell is a microcosm of the historical and contemporary shifting of cultural identities and tensions brought about by broader social changes such as industrialization, urbanization, and globalization.

From its earliest days as a planned industrial city, through boom and bust economic cycles to today's historic preservation renaissance, Lowell's urban landscape has evolved and now serves as a model of development and revitalization.

Analysis of Fundamental Resources and Values

The fundamental resource or value analysis table includes current conditions, potential threats and opportunities, planning and data needs, and selected laws and NPS policies related to management of the identified resource or value.

Fundamental Resource or Value	Water Power System / Canal System
Related Significance Statements	Lowell's (economic) success was based in innovation, from manufacturing technology and processes, to new business models, to city planning designed to benefit both industry and the worker. Unique industrial concepts were implemented and demonstrated at a massive scale at the Lowell mills, which served as a model for textile production and industrial cities. A very large proportion of original buildings, structures, and urban landscapes have survived in Lowell's park and preservation district and now are recognized as important historical artifacts. These include the entire 5.6-mile power canal system with its sophisticated dams, locks, and gatehouses, 7 of the original 10 mill complexes, and significant examples of early housing types, institutions, and transportation facilities. The Lowell canal system is nationally recognized as one of the most impressive civil and mechanical engineering achievements of the 19th century because of its grand scale and technological complexity, and is the site of origin for the famed "Francis" turbine. The canal system, used as both a transportation corridor and power source, facilitated the growth of the industrial city.
Current Conditions and Trends	**Conditions** ▪ The canal system is in fairly good condition overall. ▪ The canal system actively generates power and houses high-voltage submarine cables. ▪ All canals are within the park boundary. The canal system comprises roughly half of the overall park acreage. ▪ Elements of the canal system are owned and operated by a variety of entities that are responsible for the overall condition of the system. The canal walls and floor and waterpower equipment are owned by Enel Green Power, whereas the buildings and gatehouses, with the exception of the Moody Street Feeder Gatehouse, are owned by the Massachusetts Department of Conservation and Recreation. ▪ The park has easements associated with properties owned by the state and hydropower company, such as the gatehouses, canal walls, and much of the canal margins. These easements enable the park to create walkways, install railings, support trolley tracks, and perform related maintenance. ▪ The public walkways along the canal are in fairly good condition. ▪ Water flow through the canal affects the overall condition of the canal infrastructure, including walls that support NPS-owned assets (e.g., walkways, trolley, Boott Mill). ▪ There are 52 interpretive waysides. As areas are added to the park, additional waysides will be needed. **Trends** ▪ Use of the canalway system is increasing as additional disparate segments are connected. ▪ Visitation to the canalway system is increasing as community efforts to bring new events to the canalway increase. ▪ Use of the canalway system will increase as downtown development continues.

Fundamental Resource or Value	Water Power System / Canal System
	▪ Activation of a new canal lighting system by the City of Lowell has increased attention to the canalway. If proposals by the public to expand the lighting system are implemented, visitation could increase.
Threats and Opportunities	**Threats** ▪ There is a negative public response to trash in and around the canal system. The cleanup of debris remains a challenge due to the active power generation function and subsequent limitations on access authorized by Enel Green Power. ▪ Some perceive the canalways to be unsafe, particularly at night, and poor lighting is often identified as a concern. ▪ Gatehouses are sometimes broken into and vandalized. ▪ Clear lines of jurisdictional law enforcement authority have not been defined for much of the canal's resources (see key issue on "Jurisdictional Challenges"). ▪ Lack of maintenance of the canal walls, which are not owned by the National Park Service, can threaten the stability of canal walkways and the trolley system, much of which runs adjacent to the canalway. ▪ Vegetation growing along the canal walls can cause structural deterioration over time and poses an ongoing maintenance challenge, especially as NPS staff levels decrease. ▪ The park is monitoring environmental containment efforts to manage the lasting effects of prior industrial uses along the canal. These effects are most prominent along the Upper Pawtucket Canal adjacent to the former location of a coal/gas plant. ▪ Water flow and levels are controlled by Enel Green Power. Fluctuating water levels directly affect public access, historic structures, the natural environment, and the overall visitor experience (e.g., presence of visible debris). ▪ Modernization of the historic dam, approved by the Federal Energy Regulatory Commission, has changed a system used for more than 200 years. The effects of the new crestgate system on water levels in the canal system, and on the scenic wonder of the falls over the dam, remain to be seen. **Opportunities** ▪ Continue dialogue with Enel Green Power on how it could work with the park and its partners to allow for increased public use and/or interpretation. ▪ Work with independent volunteer groups to clean up the canal system. ▪ Expand recreational access through walkways along all of the canal system. ▪ Explore new recreational opportunities through increased use of surface water, such as kayaking and paddle boating and ice skating in the winter. ▪ Expand signage along walkways, which could increase visitation. ▪ Consider offering science-based programming along the canals. This programming could include expanded discussions about the tradeoffs between industrial uses and the environment and the effects of climate change. ▪ Collaborate with community partners on an anti-litter campaign to discourage littering along and in the canalway. ▪ Engage the community in discussions related to safety along the canals. Explore opportunities to install LED lighting along canalways as that technology improves. ▪ Install additional lighting and retrofit existing lighting to LED to reduce energy footprint. Additional lighting would probably attract visitors and improve public perception of threats to safety. ▪ Advocate for an overlook at Pawtucket Falls within the preservation district. ▪ Advocate for completion of the final section of the canalway along the Upper Pawtucket Canal.
Data and/or GIS Needs	▪ Visitor surveys. ▪ Visitor counts. ▪ Population survey. ▪ GIS data for jurisdictional inventory and cooperative management. ▪ Customized high-water study.

Fundamental Resource or Value	Water Power System / Canal System
	▪ Mapping of List of Classified Structures data related to the canal system. ▪ Wayfinding study. ▪ List of roles and responsibilities related to maintenance, leasing agreements, special events, and jurisdiction. ▪ Administrative history. ▪ Historic resource study.
Planning Needs	▪ Updated Downtown Lowell Historic District Design Review Standards (in collaboration with Lowell Historic Board). ▪ Lighting plan for canalways. ▪ Comprehensive interpretive and education plan. ▪ Planning for adaptation to climate change. ▪ Accessibility self-evaluation and transition plan. ▪ Preservation advocacy and funding strategy.
Laws, Executive Orders, and Regulations That Apply to the FRV, and NPS Policy-level Guidance	**Laws, Executive Orders, and Regulations That Apply to the FRV** ▪ Clean Air Act (42 USC 7401 et seq.) ▪ Clean Water Act (33 USC 1251-1387,33 USC 1151) ▪ Historic Sites Act of 1935 (54 USC 320101 et seq.) ▪ National Environmental Policy Act of 1969 (42 USC 4321) ▪ National Historic Preservation Act of 1966, as amended (54 USC 300101 et seq.) ▪ Secretarial Order 3289, "Addressing the Impacts of Climate Change on America's Water, Land, and Other Natural and Cultural Resources" **NPS Policy-level Guidance (NPS *Management Policies 2006* and Director's Orders)** ▪ NPS *Management Policies 2006* (§4.1) "General Management Concepts" ▪ NPS *Management Policies 2006* (§4.1.4) "Partnerships" ▪ NPS *Management Policies 2006* (§4.7.2) "Weather and Climate" ▪ NPS *Management Policies 2006* (chapter 7) "Interpretation and Education" ▪ NPS *Management Policies 2006* (chapter 8) "Use of the Parks" ▪ NPS *Management Policies 2006* (chapter 9) "Park Facilities" ▪ Director's Policy Memorandum 12-02, "Applying National Park Service Management Policies in the Context of Climate Change" ▪ Director's Policy Memorandum 15-01, "Addressing Climate Change and Natural Hazards for Facilities"

Fundamental Resource or Value	Immersive Experience
Related Significance Statements	A very large proportion of original buildings, structures, and urban landscapes have survived in Lowell's park and preservation district and now are recognized as important historical artifacts. These include the entire 5.6-mile power canal system with its sophisticated dams, locks, and gatehouses, 7 of the original 10 mill complexes, and significant examples of early housing types, institutions, and transportation facilities. The Lowell canal system is nationally recognized as one of the most impressive civil and mechanical engineering achievements of the 19th century because of its grand scale and technological complexity, and is the site of origin for the famed "Francis" turbine. The canal system, used as both a transportation corridor and power source, facilitated the growth of the industrial city.

Fundamental Resource or Value	Immersive Experience
	Lowell National Historical Park preserves and interprets the stories and heritage of the people of Lowell, including the early female workforce (aka "mill girls") and those who came from across the globe seeking opportunities. Today, Lowell's residents continue to shape the culture of the city and contribute to its revitalization. The collaboration between Lowell National Historical Park and its partners has resulted in the rehabilitation of almost all of the 5.3 million square feet of historic mill space and hundreds of additional buildings in the downtown historic district. This effort continues to serve as a successful example of leveraging public-private partnerships for economic development through historic preservation.
Current Conditions and Trends	**Conditions** ▪ A wide variety of well-received, full-sensory experiences are offered at the park, including canal boat tours, Lowell Folk Festival, Tsongas Industrial History Center programs, weave room, and Lowell Summer Music Series. ▪ The Tsongas Industrial History Center provides popular programs targeted at providing students with curriculum-based, place-based immersive experiences. ▪ Overall, visitors report consistently high levels of satisfaction with immersive experiences at the park. ▪ Existing signage does not provide consistent or adequate direction to visitors navigating to and through the park. ▪ Educational offerings at the Tsongas Industrial History Center continue to be responsive to changing curriculum standards. **Trends** ▪ Visitation by different grade levels varies at the Tsongas Industrial History Center because of changing curriculums and educational standards. For example, visitation by fourth grade classes has increased because of the current framework for social studies education, whereas visitation by eighth grade classes has decreased because the topic of industrialization is now addressed in the high school curriculum. ▪ Visitation for external partner-led/coordinated programs is increasing. ▪ The need for science, technology, engineering, and mathematics educational programs is increasing. ▪ The park's immersive experiences meet the needs of 21st-century learners who desire more engaging, free-choice, and self-directed learning environments.
Threats and Opportunities	**Threats** ▪ Immersive experiences are generally staff intensive, requiring more personnel with specialized skills than other interpretive experiences. Thus, these experiences can be difficult to sustain as employees retire and staff levels decrease. ▪ Immersive experiences have high operating costs and require ongoing infrastructure improvements and maintenance. ▪ Hiring uniquely skilled employees (e.g., trolley operators and maintenance staff, weavers and loom fixers, museum curators, bilingual interpreters) can be challenging. ▪ Immersive experiences require attention to safety and related training, staffing, and equipment, including the operation of heavy equipment and machinery (e.g., boats, trolleys, looms) and the movement and management of large numbers of people during bigger events (e.g., Tsongas Industrial History Center programs, Lowell Summer Music Series, Lowell Folk Festival). ▪ There are challenges associated with offering immersive experiences in an urban environment such as traffic, noise, etc. ▪ Immersive experiences are considered the primary driver for attracting audiences, but their use is not up to date with trends in delivering immersive and other interpretive experiences to new and diverse audiences.

Fundamental Resource or Value	Immersive Experience
	▪ Fluctuations in canal levels, which are managed by the power company, limit the park's ability to use the canals for immersive experiences. **Opportunities** ▪ Continue to update and evolve programming to ensure relevancy. Examples include updating exhibits using 21st-century practices, co-leading programs with community members to explore contemporary topics, and conducting evening programming that uses park resources in creative ways (e.g., open-mic nights based on park themes and tied to community-relevant topics). ▪ Continue to explore and evolve business models and partnerships that support operational costs, needs, and staffing required by immersive programming. ▪ Continue to develop community engagement and partner-led initiatives that use immersive experiences to attract new audiences and build the next generation of park stewards. ▪ Research and institute new techniques to improve current immersive experiences and develop new experiences at Lowell National Historical Park and the Tsongas Industrial History Center. These could include greater emphasis on audience-centered learning, family learning, audio tours and experiences, and bilingual offerings. ▪ Leverage assistance of nonprofit groups, partners, and volunteers to help meet staffing needs. ▪ Adapt programs and facilities at the Tsongas Industrial History Center to engage nonstudent visitors. ▪ Develop succession plan and training opportunities to maintain skilled staffing levels necessary to offer immersive experiences. ▪ Pursue phased design and funding strategy to introduce 21st century immersive experiences to park exhibits. ▪ Engage with partners to expand awareness of park's immersive experiences and attract new audiences. ▪ Continue to develop creative programming in response to shifts in visitation and/or other trends. ▪ Consider ways in which the National Park Service might certify canal boat operators for watercraft use as an alternative to the U.S. Coast Guard certification process.
Data and/or GIS Needs	▪ Visitor surveys. ▪ Visitor counts. ▪ Wayfinding study. ▪ Customized high-water study. ▪ Population survey. ▪ Administrative history. ▪ Trolley system condition assessment.
Planning Needs	▪ Marketing plan and visitation/tourism plan. ▪ Comprehensive interpretive and education plan. ▪ Wayfinding/sign plan. ▪ Succession plan. ▪ Collection management plan (update). ▪ Accessibility self-evaluation and transition plan.
Laws, Executive Orders, and Regulations That Apply to the FRV, and NPS Policy-level Guidance	**Laws, Executive Orders, and Regulations That Apply to the FRV** ▪ Americans with Disabilities Act (42 USC 12101 et seq.) ▪ Architectural Barriers Act (42 USC 4151 et seq.) ▪ Rehabilitation Act of 1973 (29 USC 701 et seq.) ▪ "Architectural Barriers Act Accessibility Guidelines" (36 CFR1191.1) **NPS Policy-level Guidance (NPS *Management Policies 2006* and Director's Orders)**

Fundamental Resource or Value	Immersive Experience
	▪ NPS *Management Policies 2006* (chapter 7) "Interpretation and Education" ▪ NPS *Management Policies 2006* (chapter 8) "Use of the Parks" ▪ NPS *Management Policies 2006* (chapter 9) "Park Facilities" ▪ Director's Order 6: *Interpretation and Education* ▪ Director's Order 42: *Accessibility for Visitors with Disabilities in National Park Service Programs and Services*

Identification of Key Issues and Associated Planning and Data Needs

This section considers key issues to be addressed in planning and management and therefore takes a broader view over the primary focus of part 1. A key issue focuses on a question that is important for a park. Key issues often raise questions regarding park purpose and significance and fundamental resources and values. For example, a key issue may pertain to the potential for a fundamental resource or value in a park to be detrimentally affected by discretionary management decisions. A key issue may also address crucial questions that are not directly related to purpose and significance, but that still affect them indirectly. Usually, a key issue is one that a future planning effort or data collection needs to address and requires a decision by NPS managers.

The following are key issues for Lowell National Historical Park and the associated planning and data needs to address them:

Jurisdictional Challenges. Lowell National Historical Park has complicated boundaries and multiple jurisdictions. As a result, there can be confusion regarding ownership, boundaries, and law enforcement jurisdiction. It can be difficult to determine ownership of key parcels and identify areas lacking lands processing. Continued collaboration with partners to update agreements specifically regarding law enforcement and maintenance jurisdictions is needed. The park should continue to work with the NPS Northeast Region to advocate that the state legislature update designated national park lands in Massachusetts to concurrent law enforcement jurisdiction.

Associated data needs:
Updating and digitization of park segment maps
GIS data for jurisdictional inventory and cooperative management
Jurisdictional inventory (update)

Outreach and Relevancy. Lowell National Historical Park has evolved with the city of Lowell, and it is a challenge to effectively communicate that changing story in an inclusive and relevant way. Conveying the historic context of Lowell and the national historical park to community members is particularly challenging because some exhibits are outdated. It is essential to connect with people and their stories more effectively, including updating interpretative media to provide information to nonnative English speakers. Tourism should be promoted more broadly to increase visitation and overcome the negative perception of Lowell that began during the city's post-industrial decline.

Associated planning needs:
Marketing plan and visitation/tourism plan
Wayfinding/sign plan

Comprehensive interpretive and education plan
Exhibit plan for Mill Girls & Immigrant Exhibit and Boott Cotton Mills Museum

Associated data needs:
Visitor surveys
Visitor counts
Population survey
Wayfinding study
Historic resources study: *Lowell, A City of Spindles* (update)

Maintenance/Preservation of Park-Owned Resources and Facilities. The park owns and operates a variety of resources and assets that require significant staffing and funding, including historic mill buildings, boardinghouses, boats, trolleys, and associated infrastructure. Collaboration with park partners to identify ways to leverage funding for maintenance is essential. Reclassification of maintenance positions would allow greater flexibility within the park's diminishing workforce (e.g., maintenance mechanics vs. specialists). Continued creative thinking about appropriate paths for hiring, as well as effective ways to attract and retain maintenance staff, is necessary, including using University of Massachusetts Lowell work-study students and partnering with the local vocational technical high school, social services agencies, and the Student Conservation Association.

Associated planning need:
Comprehensive management and maintenance plan

Associated data needs:
List of roles and responsibilities related to maintenance, leasing agreements, special events, and jurisdiction
Trolley system condition assessment

Loss of Specialized Skills and Knowledge. The nature of the resources of the park requires a large number of staff having specialized skills, such as loom fixers, masons, and woodworkers. Many staff members have worked with the park since its establishment or were part of the Lowell Historic Preservation Commission. They have knowledge of the park and city that is irreplaceable, including the history of preservation and changes in park management over time. As those individuals retire or otherwise move on from the park, specialized skills and knowledge will be lost and must be replaced if possible or somehow captured.

Associated planning needs:
Succession plan
Record management plan
Collection management plan (update)

Associated data needs:
Administrative history
Oral history project on development/preservation

Private Ownership in the Park and Preservation District. Many lands and buildings within the park and preservation district are privately owned but are major components of the historic urban industrial landscape. Their preservation, maintenance, and integrity of design are critically important to the park. Although there are certain mechanisms in place to ensure historic and new buildings in the district meet design and preservation standards, such as city design review

processes, maintaining historic integrity is a continual challenge. As the economy has improved and development pressures have increased, challenges increase. The City of Lowell and the commonwealth are exempt from the Lowell Historic Board standards and controls. Additionally, development of structures on nonpark land could encroach on historic resources (e.g., gatehouses and canalways) and diminish the visitor experience. Review of the Lowell Historic Board standards and new, creative approaches to preservation and design control might provide new solutions to these challenges.

Associated planning needs:
Updated Downtown Lowell Historic District Design Review Standards (in collaboration with Lowell Historic Board)
Preservation advocacy and funding strategy

Renewal of Enel Green Power License. The water power license, issued by the Federal Energy Regulatory Commission to Enel Green Power, is near its renewal date. Use of the canal system, a major component of the park experience and interpretation, is subject to terms in that agreement, and the National Park Service should be involved in renewal conversations. Terms should be sought that allow for expanded recreational use of the canalways. Through proactive NPS involvement, the needs of both Enel Green Power and the National Park Service could be met.

Associated data need:
Customized high-water study

Climate Change. Some parts of the park, including the Boott Mill No. 6 building and Counting House, are within a designated floodplain that primarily is related to the canal system surrounding the central part of the city of Lowell. As a result, a majority of park buildings, structures, and other resources are at risk to the effects of climate change, with the threat of increased storm incidents and more regular flooding. Resources most at risk include those associated with the water power system / canal system, which is identified as a fundamental resource. Planning is needed to determine potential impacts and provide mitigation strategies.

Associated planning need:
Planning for adaptation to climate change

Associated data need:
Customized high-water study

ATTACHMENT G

National Park Service
Study Requests

NPS Boott Study Request #1

Resources, Ownership, Boundaries and Land Rights Study
(Lowell, P-2790)

Goals and Objectives

Ownership and use of the canal system in Lowell is very complex. In any given area, there could be several entities with land rights or other entitlements granting authority to access, maintain, or utilize the canal system. The objectives of a boundary study would be to determine current ownership of resources within the canal system in a comprehensive manner, record maintenance responsibilities and obligations to those resources, clarify FERC jurisdiction, and document recreational, educational, or other land access rights to resources within the canal system. The study should also project future conditions for the terms of the license. Decommissioning downtown power stations could result in impairment to historic resources. The large historic water power infrastructure will continue to require costly maintenance, but risks disinvestment if it is no longer needed for on-going project operations and remains under the licensee's ownership. Decommissioning of canal infrastructure and other reasonably foreseeable changes in project operations that could result in changes in ownership or maintenance liabilities should also be considered within the study.

The ultimate goal of this study would be to denote which entity is ultimately responsible for specific resources, in light of overlapping jurisdictions and to serve as a factual baseline document to update the MOU for Canal Maintenance Responsibilities in the Project Area with Boott Hydropower Inc., Lowell National Historical Park, the Department of Conservation and Recreation, and the City of Lowell as signatories.

Resources Management Goals

See Attachment E from September 2017 Foundation Document.

Public Interest

Requester is a Federal Resource Agency.

Existing Information

NPS has a complete record of its land rights and can provide this for the study. Land rights obtained by Boott Hydropower Inc., Massachusetts Department of Conservation and Recreation, City of Lowell, and private entities would also need to be accessed for this study.

Nexus to Project Operations and Effects

Property ownership and less than fee easement rights are directly related to the ongoing maintenance and preservation of the historic canal system. Identifying which parties have authority to maintain and use and/or an obligation/right to maintain/use the canal system will inform the development of license requirements as well as roles and responsibilities of any future MOUs for the historic canals. Boott also needs the rights necessary to comply with license requirements; a firm understanding of what rights Boott has or may need to acquire will be essential to the licensing determination.

Methodology Consistent with Accepted Practice

The information from this study can be pulled from title and land records, existing legislation, and other legal documents.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

This type of study can be completed at a reasonable cost within the FERC study period.

NPS Boott Study Request #2

Water Level and Flow Effects on Historic Resources
(Lowell, P-2790)

Goals and Objectives

Changes to the elevation of water or flow rates throughout the system directly affect the condition of historic resources. Abnormally high water levels in the Northern Canal, for example, have caused damage to wooden structural elements of the Northern Canal Waste Gatehouse and structural undermining of the Great River Wall. Conversely, extended drain downs and low water levels have caused damage to historic turbines and waterwheels made of wood and leather elsewhere in the system. The effects of the Crest Gate operation are unstudied and may include acute or prolonged impacts to historic resources throughout the system. Decommissioning downtown power stations may also result in changes to water levels and flows in some areas of the canal system and the effects are unstudied and unknown.

The objectives of this study should include evaluating how project operations, including manipulation of the newly installed Crest Gate, canal headgates, spillways, locks, fish passage structures, and generating units will change water levels in any location within the canal, and determine the extent to which water flows or elevations can be modified and or controlled to diminish loss of historic resources. The study would:

- Document impacts of current project operations on nationally significant historic resources, including a structural engineering assessment of the Great River Wall.
- Project future water levels and flows as a result of reasonably foreseeable changes to the project operation such as operating the Crest Gate system, decommissioning certain facilities, or modifying operations for fish passage.
- Evaluate impact of on-going and future project operations on nationally significant historic resources.
- Develop 100 and 500-year flood plans to protect nationally significant historic resources.

Resources Management Goals

See Attachment E from September 2017 Foundation Document.

Public Interest

Requester is a Federal Resource Agency.

Existing Information

NPS can provide an architectural and engineering evaluations of historic structures at multiple locations as well as maintenance records for previous repairs. Boott Hydro Power may have existing data on the impacts high and low water flows and elevations have on historic resources, but new data demonstrating how the new Crest Gate System effects water levels and flows would also need to be analyzed.

Nexus to Project Operations and Effects

Understanding the impacts water levels and flows will have on nationally significant historic resources will directly inform the development of license requirements and will inform future MOUs. The study data can also be used to better understand public and dam safety threats.

Methodology Consistent with Accepted Practice

The study would compare existing conditions of structures associated with canal operations and identify potential changes in conditions that may result from changes in project operations and resulting water and flow levels. This study would require an engineering assessment of the Great River Wall and may require additional structural assessment of other historic properties damaged by current project operations.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

This type of study can be conducted within the study period.

NPS Boott Study Request #3

Water Level and Flow Effects on Recreation Study:
(Lowell, P-2790)

Goals and Objectives

Water levels and flows directly affect public recreational access to and within the canals. The elevation and flow rates currently limit the number of days canal walkways are safely accessible to the public, particularly the Northern Canal Walkway which opens seasonally when flow rates are lower than 3,500 cubic feet per second (cfs). For years, NPS has received numerous complaints regarding the walkway's closure and the public has repeatedly requested increased access to the Northern Canal Island and Great River Wall. This study would assess if changes to project operations can be made to increase recreational access and whether 3,500 cfs is an appropriate threshold for the walkway's closure.

NPS boat passage is another recreational issue affected by water level and flows. NPS boats barely pass under the Pawtucket Street Bridge over Pawtucket Canal and the Central Street Bridge over the Lower Pawtucket Canal. With even 1 foot elevation rise to the crest pool, NPS boats would be unable to pass under the Pawtucket Street Bridge. A study is needed to determine the effects the Crest Gate system on on-going project operations will have on NPS tour boats and other potential future on-water recreational uses.

Additionally, NPS partners and the public have expressed interest in new, different, and expanded recreational access to and within the canals. The canal system should be evaluated to determine which segments are most suitable for various recreational opportunities (paddle boarding, ice skating, kayaking, etc.) so that recreational and economic development partners develop plans only where deemed compatible with on-going project operations and preservation of nationally significant historic resources.

The objectives of this study should include evaluating how project operations, including manipulation of the newly installed Crest Gate, canal headgates, spillways, locks, fish passage structures, and generating units will change water levels in any location within the canal, determine the extent to which water flows or elevations can be modified and or controlled to diminish public access restrictions to recreational amenities. Information to be obtained would come from photos, videos and direct observations of flows under different levels, magnitude and duration. The study would address the following issues:

- Effect of water levels and flow rates on existing recreational facilities and activities, including the Northern Canal Walkway and NPS Boat Operations
- Potential for future recreation within or adjacent to the canal system.

Resources Management Goals

See Attachment F from September 2017 Foundation Document.

Public Interest

Requester is a Federal Resource Agency.

Existing Information

Boott Hydro Power may have existing data on the impacts high and low water flows and elevations have on historic resources and recreation, but new data demonstrating how the new Crest Gate System effects water levels and flows would also need to be analyzed.

Nexus to Project Operations and Effects

Understanding the impacts water levels and flows will have on recreational opportunities and nationally significant historic resources will directly inform the development of license requirements and will inform future MOUs.

Methodology Consistent with Accepted Practice

The study would compare existing conditions on structures associated with canal operations and identify potential changes in conditions that may result from changes in project operations and resulting water and flow levels.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

This type of study can be conducted within the study period.

NPS Boott Study Request #4

Vegetation and Aquatic Trash Management Study
(Lowell, P-2790)

Goals and Objectives

Study the impact of vegetation growth on historic canal walls and propose appropriate techniques and schedules for vegetation removal to prevent deterioration and obviate long term capital needs. Review the current waterborne trash removal operation, determine the extent to which the operation can be changed to prevent damage to historic resources, improve access to recreation, aesthetics, and public safety.

Resources Management Goals

See Attachment E from September 2017 Foundation Document.

Public Interest

Requester is a Federal Resource Agency.

Existing Information

The study could pull maintenance records from stakeholders to determine the baseline cyclical vegetation and trash management activities and use condition assessment data to determine asset condition. The study could also involve a public feedback component to better understand areas of particular concern.

Nexus to Project Operations and Effects

The results of the study will have a direct impact on the terms of the license agreement and corresponding updates to the canal maintenance MOU among stakeholders.

Methodology Consistent with Accepted Practice

The study would use baseline vegetation and trash removal activities as a no action alternative and develop at least two alternatives to demonstrate how changes in frequency or level of effort would result in changes to the condition of historic resources, the total dollar amount of deferred maintenance, access to recreation, canal aesthetics, and public safety. Results of the study will enable stakeholders to determine an optimal and appropriate maintenance reoccurring maintenance schedule for clearing vegetation and trash which would hopefully result in fewer major capital investments towards stabilizing canal walls and increased protection of the historic resources, and increased public safety.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

This type of study can be conducted within the study period.

NPS Boott Study Request #5

Historically Significant Water Power Equipment Study
(Lowell, P-2790)

Goals and Objectives

The objectives of this study are to identify historically significant water power equipment and develop plans to preserve the equipment and provide public access for their future enjoyment or make use of scrap parts from the equipment. The ultimate goal of this study is to diminish loss of historic property. Protection of historically significant water power equipment is complicated by boundary issues. Vertical ownership is current set at 101 ft. MSL. Historic hoisting equipment, gates, and control equipment that are not used for modern operations fall into a state of disrepair and can be abandoned or thrown away without communication. For example, two hydraulic cylinders at Guard Locks were discarded and NPS would have liked to interpret them to visitors. As power buildings are decommissioned, NPS may want to evaluate equipment for exhibit potential or for scrap equipment to maintain and operate other historic machinery.

Resources Management Goals

See Attachment E from September 2017 Foundation Document.

Public Interest

Requester is a Federal Resource Agency.

Existing Information

The study could reference Lowell National Historical Park's Scope of [Museum] Collections.

Nexus to Project Operations and Effects

The results of the study will have a direct impact on the terms of the license agreement and corresponding updates to the canal maintenance MOU among stakeholders. It will also be essential information in the Commission's consultation under the NHPA.

Methodology Consistent with Accepted Practice

The study would photograph existing mechanical equipment, provide documentation of the history of that equipment, and document current equipment ownership. This information would be used in subsequent meetings between the applicant and the National Park Service so that historical equipment worthy of preservation and interpretation may be saved for the enjoyment of current and future generations.

Level of Effort/Cost, and Why Alternative Studies Will Not Suffice

This type of study can be conducted within the study period.

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