APPENDIX A

Figures & Tables

Concord River Diadromous Fish Restoration Feasibility Study

List of Figures & Tables

Figure 2.1.1-1: Merrimack River Watershed

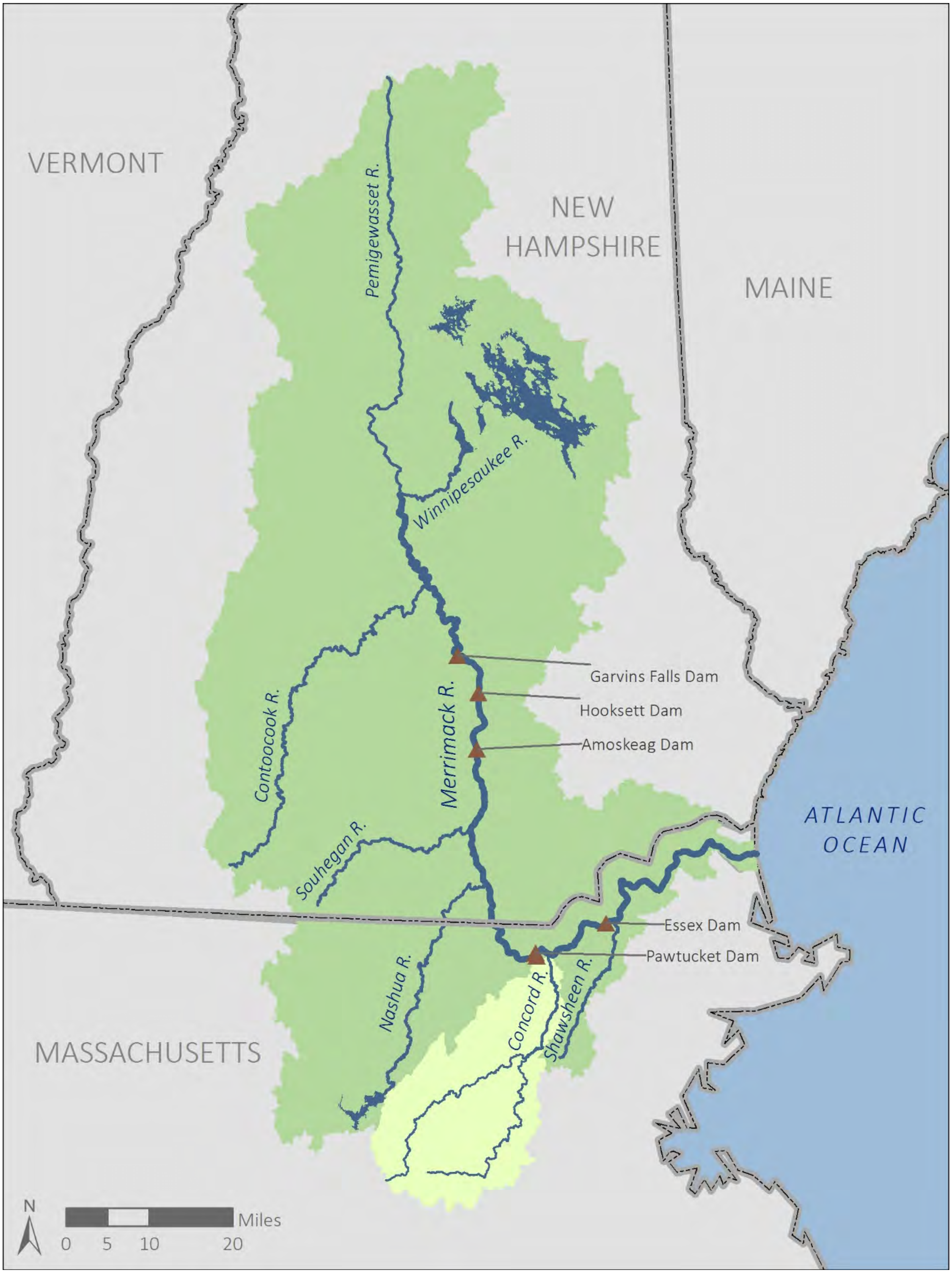


Figure 2.1.1-2: Concord River Basin

Figure 2.1.1-3: Wild and Scenic River Designation on the Sudbury, Assabet, & Concord Rivers

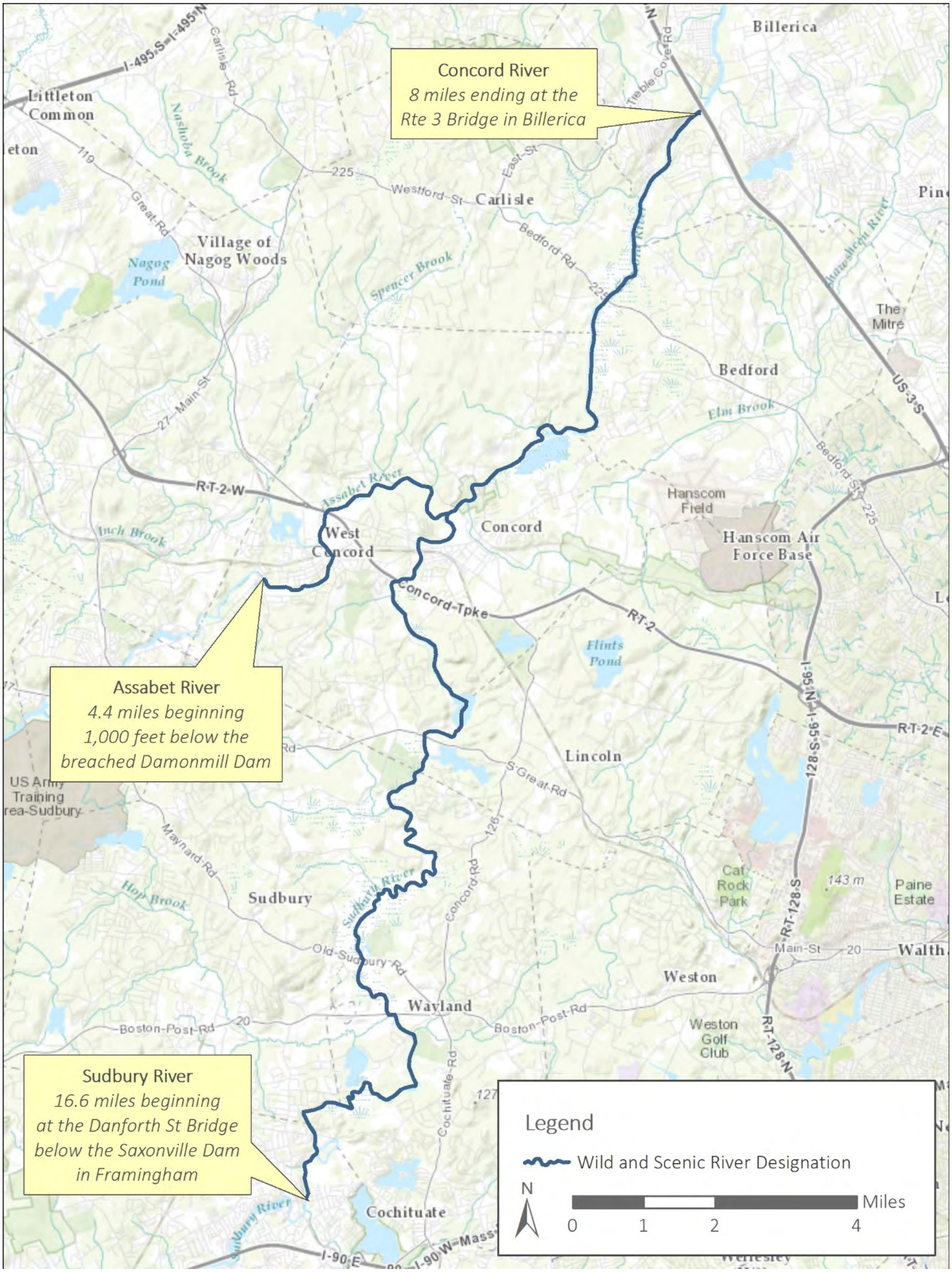
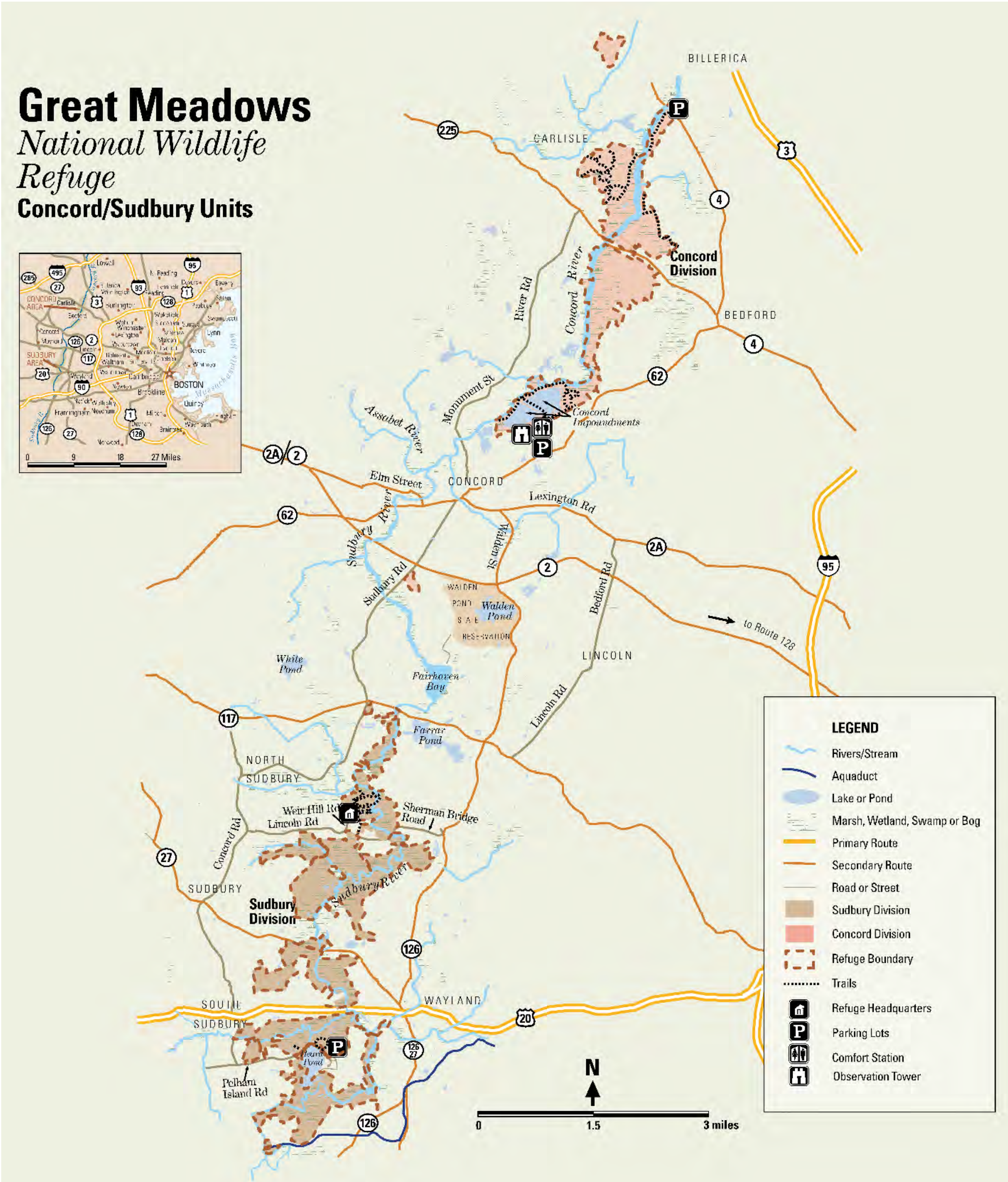


Figure 2.1.1-4: Great Meadows National Wildlife Refuge



Source: USFWS, 2011.

Figure 2.1.1-5: Fish Passage Obstacles on the Concord River

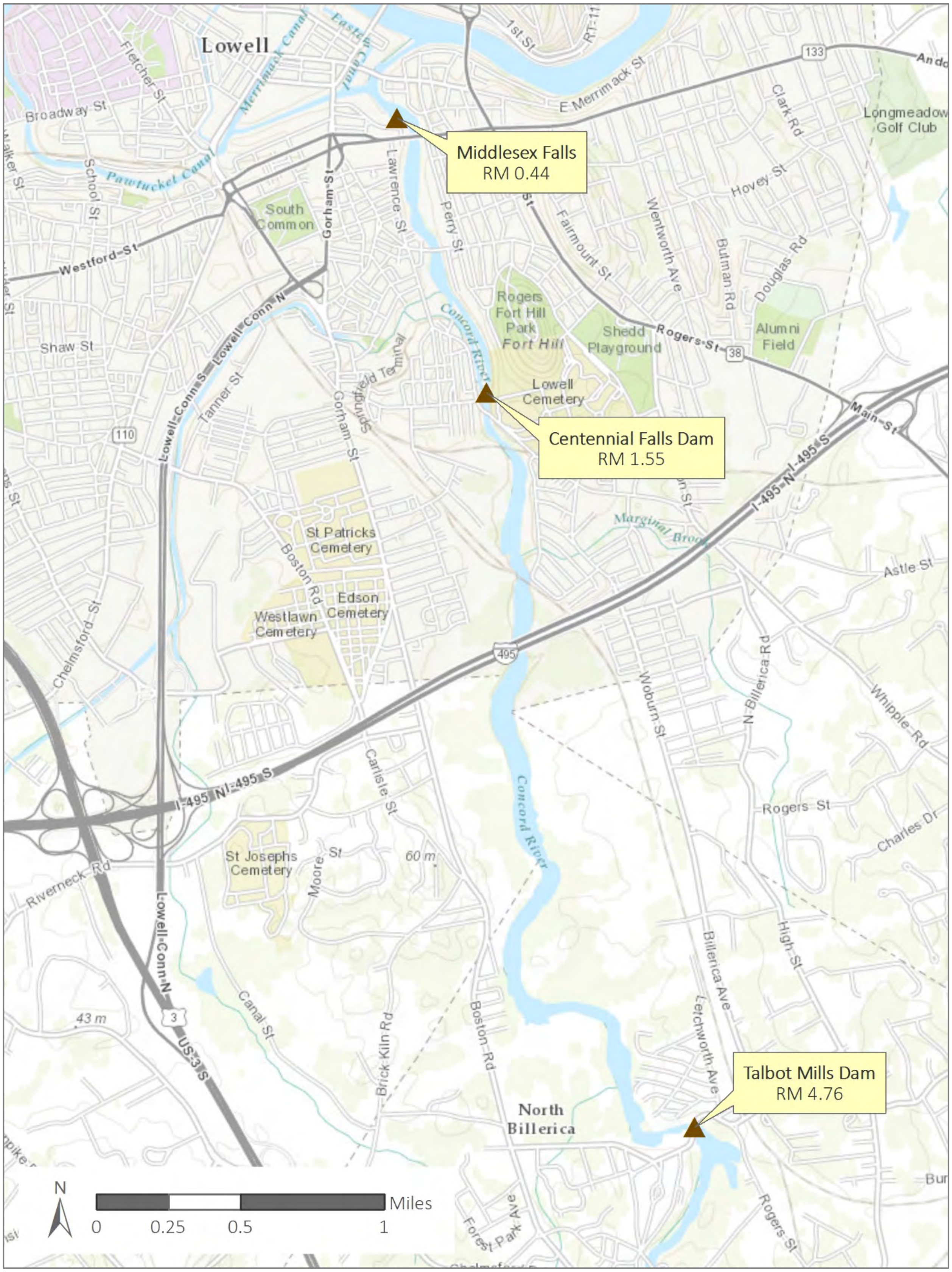
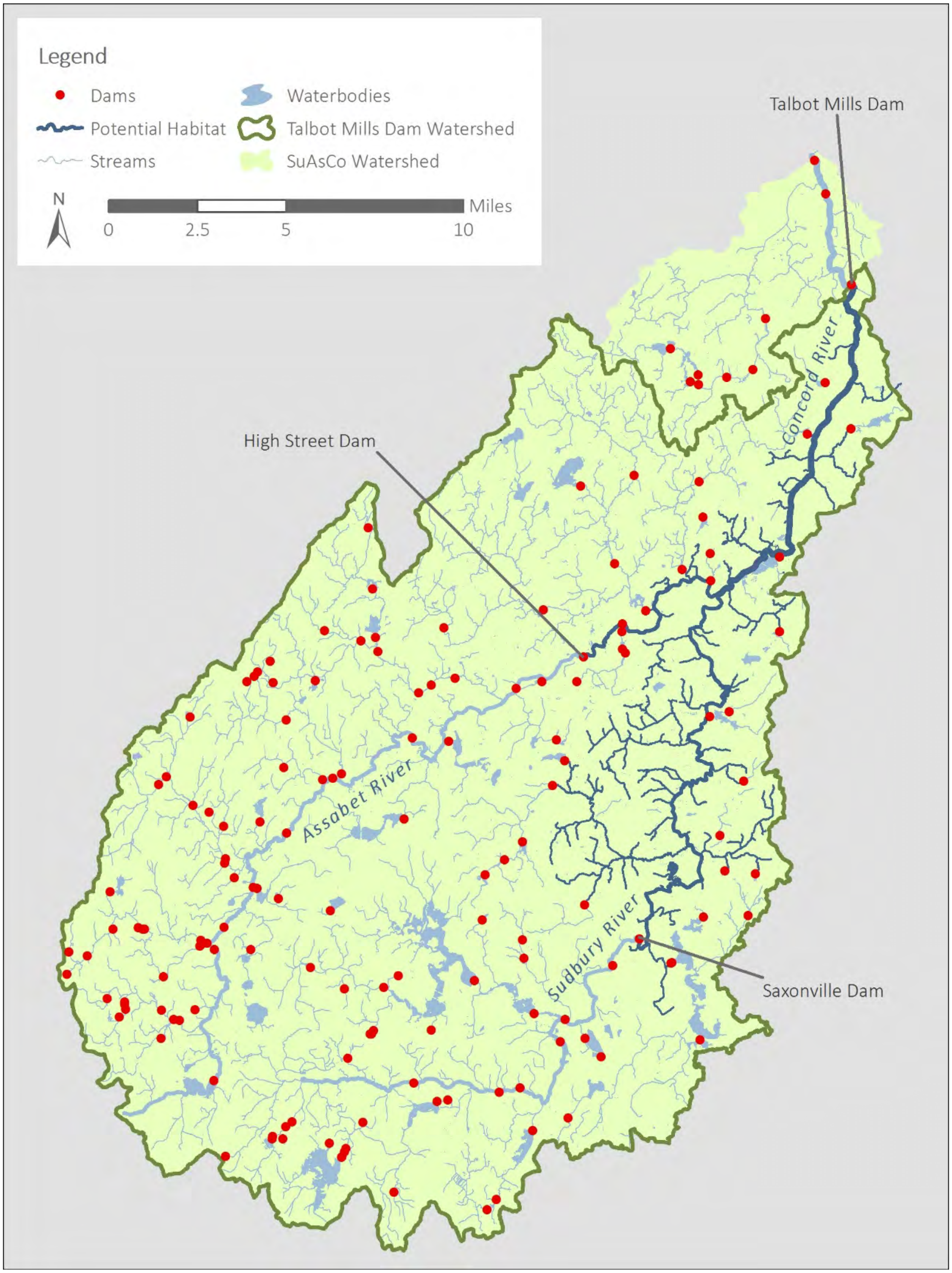


Figure 2.1.1-6: Potential Diadromous Fish Habitat upstream of Talbot Mills Dam

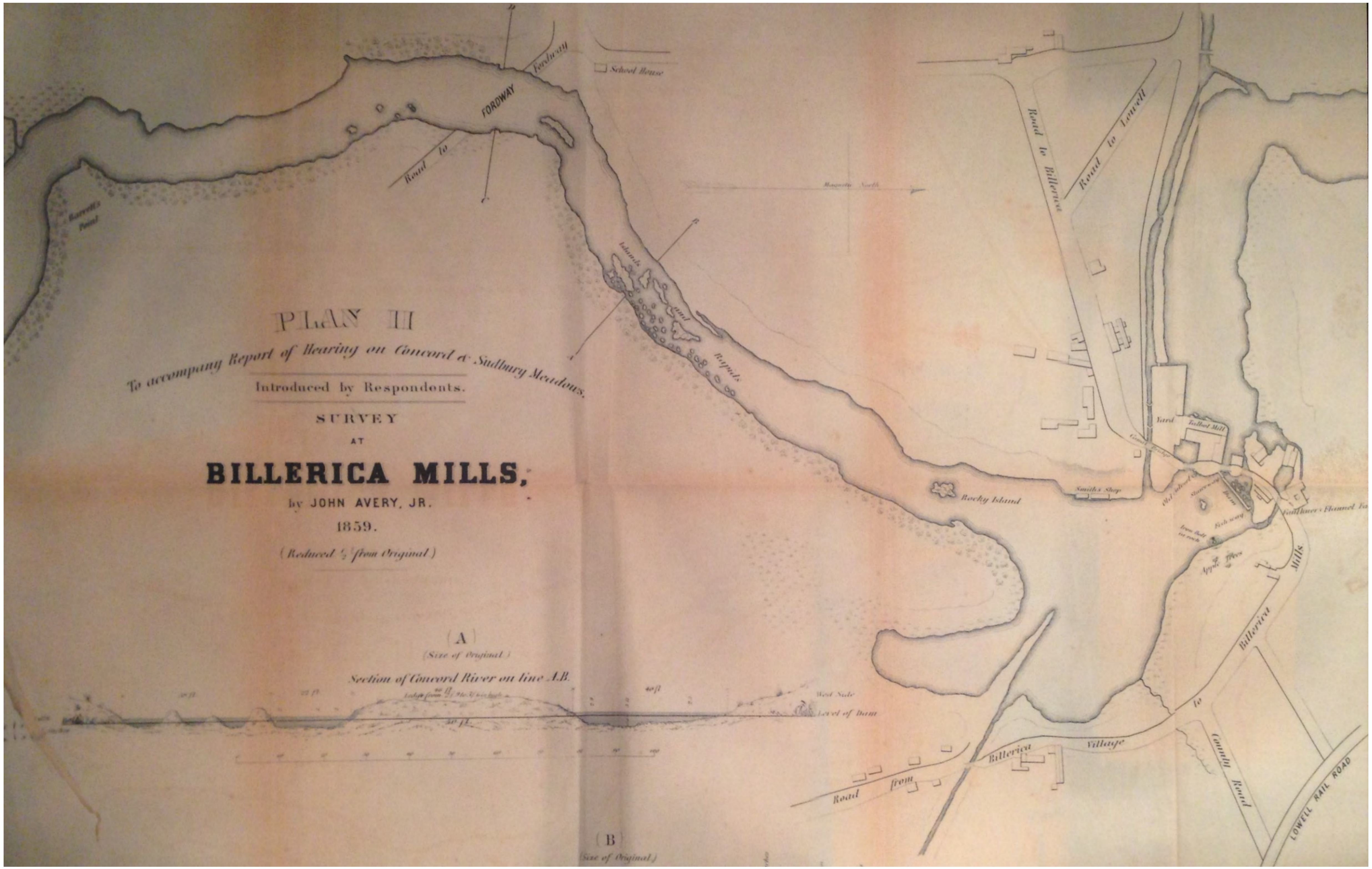


Note: This analysis included available habitat between the Talbot Mills Dam and the next upstream dam on the Assabet River, Sudbury River, and tributaries. It did not consider other potential barriers to fish passage such as culverts. Data Sources: Streams, waterbodies, and SuAsCo watershed from the USGS National Hydrography Dataset (NHD); dams from a database maintained by the ODS available from MassGIS; Talbot Mills Dam watershed delineated from the USGS StreamStats program.

Figure 2.1.2-1: Historical Plan & Profile of the Concord & Sudbury Rivers in the Vicinity of the Great Meadows

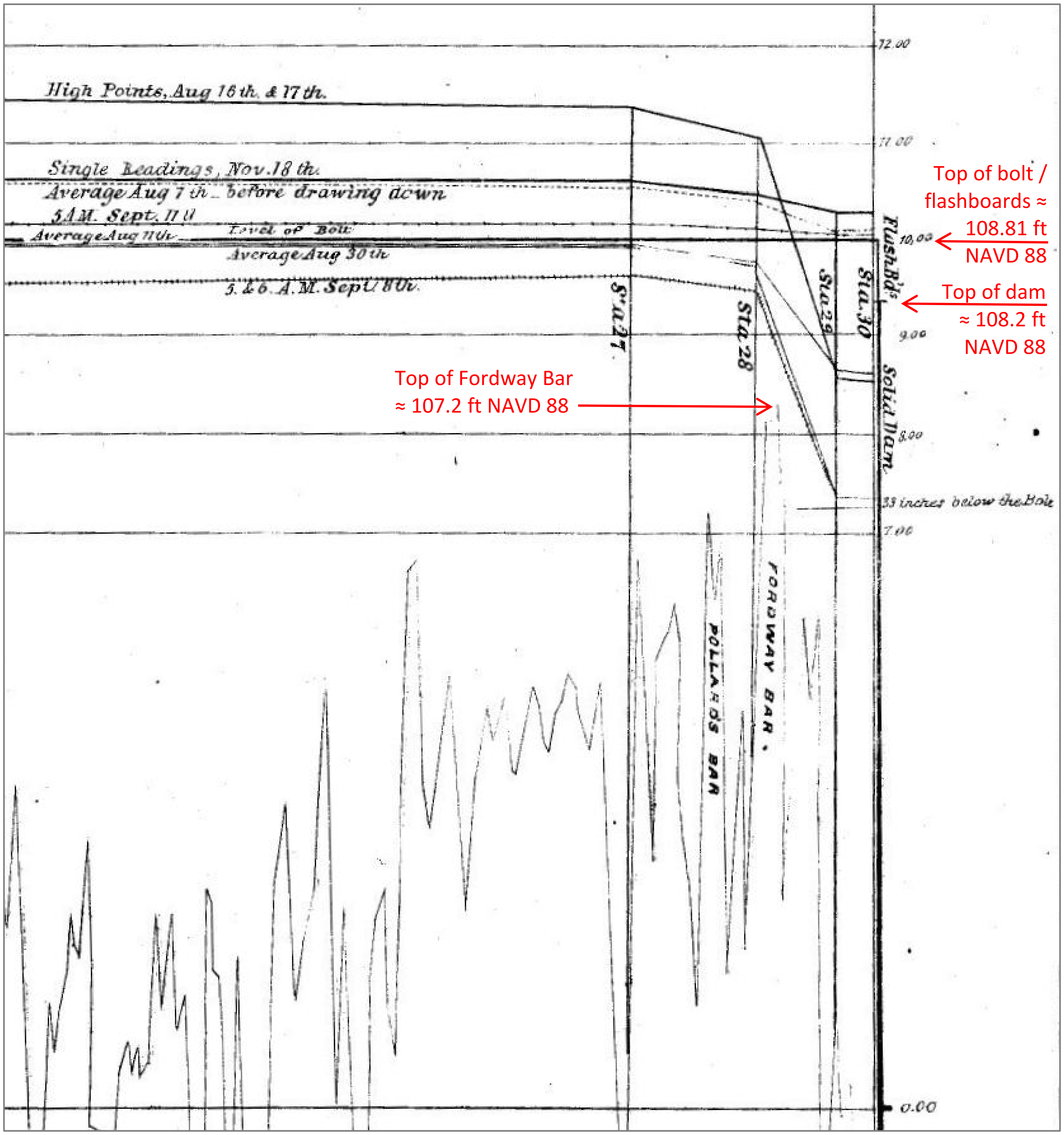
Source: Baldwin, 1834

Figure 2.1.2-2: Historical Plan of Billerica Mills Showing Cross-Section of Rapids below Fordway Bar



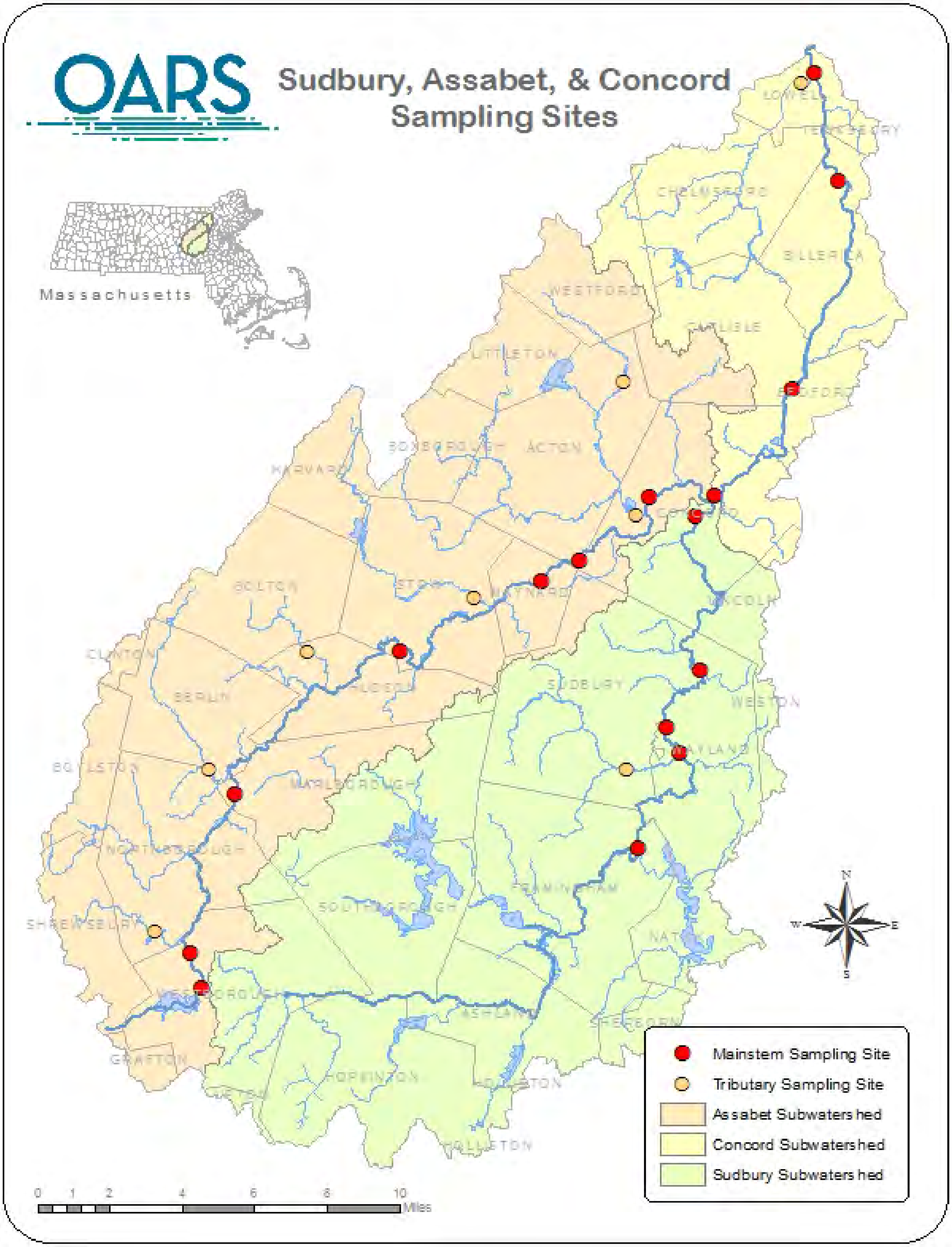
Source: On display at the Middlesex Canal Museum in North Billerica. Note locations of the Fordway Bar and rapids downstream. Detail [B] showing the cross-section through the Fordway Bar was not included on the copy of the plan obtained for this report. Also note the location of the former fishway at the dam, and the iron bolt used as a benchmark.

Figure 2.1.2-3: Historical Profile of the Concord River showing the Fordway Bar



Cropped from "Profile of the Concord & Sudbury Rivers, 1861" (Alvord et al., 1862). The 1861 survey used a zero datum 10.00 feet below the top of an iron bolt that had been placed in 1825 at an elevation equal to the top of the flashboards at the dam. In the 1861 study, the elevation of the bolt top was reported as 115.35 feet above the Boston base datum (or mean low water in Boston Harbor), which is 5.65 feet above NVGD 29 and 6.477 feet above NAVD 88, which would make it 108.87 feet NAVD 88. The bolt still exists today and in 2013 its top elevation was re-measured as 108.81 feet NAVD 88 from a temporary benchmark set in 2000 from the 1965 US monument MY0308 (Breen, 2013). Using this reference, elevations for the spillway crest (108.2 feet NAVD 88) and top of the Fordway Bar (107.2 feet) were estimated by scaling from the above profile.

Figure 2.1.4-1: OARS Water Quality Sampling Sites



Source: OARS, 2015

Table 2.1.4-1: Stream Health Index Ratings (2014)

	Stream Health Index Reading				
	5/18/2014	6/15/2014	7/20/2014	8/24/2014	9/14/2014
Assabet River Headwater, Mill Rd, Westborough (ABT-312)					
Water Quality Index	76	77	61	71	71
Flow Index	92	83	14	13	13
Habitat Index	100	80	55	40	35
Stream Health Index	88	80	28	26	24
Danforth Brook, Rte 85, Hudson (DAN-013)					
Water Quality Index	79	76	77	73	95
Flow Index	92	77	45	16	23
Habitat Index	80	75	55	35	15
Stream Health Index	83	76	56	28	21
Hop Brook, Otis St, Northborough (HOP-011)					
Water Quality Index	66	72	54	79	81
Flow Index	92	86	50	40	40
Habitat Index	100	80	70	55	45
Stream Health Index	83	79	57	54	50
Nashoba Brook, Commonwealth Ave, W. Concord (NSH-002)					
Water Quality Index	77	71	59	66	72
Flow Index	92	86	77	59	49
Habitat Index	100	95	65	70	45
Stream Health Index	89	83	66	65	53
Nashoba Brook, Wheeler Ave, Acton (NSH-047)					
Water Quality Index	78	69	64	78	87
Flow Index	92	85	69	12	24
Habitat Index	100	100	80	70	45
Stream Health Index	89	83	70	27	40
North Brook, Whitney Ave, Berlin (NTH-009)					
Water Quality Index	76	84	65	79	77
Flow Index	92	85	67	43	38
Habitat Index	95	90	75	45	45
Stream Health Index	87	86	69	51	49

Key:	81 – 100 = Excellent	61 – 80 = Good	41 – 60 = Fair	21 – 40 = Poor	1 – 20 = Very Poor

Source: OARS, 2015

Table 2.1.4-2: Water Quality Indices for Selected Mainstem Sites and Hop Brook (2014)

Site	Date	Water Quality Parameter Reading						Water Quality Index
		NO3	TP	TSS	DO	pH	Temp	
Assabet at Rte 9 Westboro (ABT-301)	5/18/2014	2.5	0.05	1	8.24	7.15	16.52	49
	6/15/2014	3.5	0.03	1.5	7.57	7.19	17.79	39
	7/20/2014	8.7	<0.01	1	6.61	7.51	20.47	6
	8/24/2014	12.9	0.05	3	6.34	7.30	19.69	6
	9/14/2014	12	0.01	1	5.57	7.30	18.87	6
Assabet at Rte 27 Maynard (ABT-077)	5/18/2014	1.4	0.04	5.5	8.25	6.67	19.12	58
	6/15/2014	1.7	0.05	4.5	8.53	7.34	19.35	56
	7/20/2014	0.76	0.03	1.50	7.38	7.68	23.63	70
	8/24/2014	1	0.02	<1	7.67	7.78	20.47	71
	9/14/2014	0.96	<0.01	<1	8.63	7.78	18.34	75
Concord at Lowell Rd Concord (CND-161)	5/18/2014	0.10	0.01	2.5	7.74	7.40	19.02	93
	6/15/2014	0.14	0.04	7.5	7.16	7.04	19.32	78
	7/20/2014	0.46	0.03	7.5	7.01	7.39	23.85	70
	8/24/2014	0.54	0.03	8	7.59	7.43	20.72	70
	9/14/2014	0.69	<0.01	2.00	8.23	7.54	17.90	78
Concord at Rogers St Lowell (CND-009)	5/18/2014	0.34	0.05	6.5	8.18	7.07	19.08	74
	6/15/2014	0.67	0.06	7	---	7.24	20.06	65
	7/20/2014	0.52	0.07	10	7.10	7.29	24.74	63
	8/24/2014	1.2	0.02	8	9.50	7.56	21.6	63
	9/14/2014	1.8	0.02	5	8.33	7.64	19.26	57
Sudbury at Sudbury Landing Framingham (SUD-144)	5/18/2014	0.18	<0.01	3	9.52	7.16	18.15	92
	6/15/2014	0.17	0.03	1.4	8.81	7.14	19.57	89
	7/20/2014	0.12	<0.01	1	7.74	7.16	22.58	95
	8/24/2014	0.14	<0.01	1	8.13	7.15	19.73	96
	9/14/2014	0.19	<0.01	<1	7.9	6.95	16.49	94
Sudbury at Main St Concord (SUD-005)	5/18/2014	0.09	0.04	3.5	6.76	6.94	19.38	83
	6/15/2014	0.12	0.05	6.5	---	7.06	19.52	78
	7/20/2014	<0.05	0.06	10.5	6.75	7.23	24.86	71
	8/24/2014	<0.05	0.02	10	7.23	7.15	21.90	80
	9/14/2014	<0.05	0.02	8	7.74	7.47	19.34	84
Hop Brook at Landham Rd Sudbury (HBS-016)	5/18/2014	0.3	0.02	1	3.63	6.76	16.47	56
	6/15/2014	0.28	0.07	1.5	2.41	6.55	17.01	9
	7/20/2014	1.1	0.08	19.5	1.80	6.84	20.25	5
	8/24/2014	0.37	0.04	2	3.35	6.91	17.48	47
	9/14/2014	0.45	0.07	14	3.63	6.70	14.73	46

Key:	81 – 100 = Excellent	61 – 80 = Good	41 – 60 = Fair	21 – 40 = Poor	1 – 20 = Very Poor

Source: OARS, 2015

Table 2.1.4-3: Water Quality Designations for SuAsCo Mainstem Rivers

River	Segment	Mile Range	Class	Qualifiers
Concord River	Confluence of Assabet and Sudbury to Billerica Water Supply Intake	15.4 - 5.9	B	Warm Water Treated Water Supply
	Billerica Water Supply Intake to Rogers Street	5.9 - 1.0	B	Warm Water
	Rogers Street to confluence with Merrimack River	1.0 - 0.0	B	Warm Water Combined Sewer Overflow
Sudbury River	Source to Fruit Street Bridge in Hopkinton	29.1	B	Warm Water Outstanding Resource Water
	Fruit Street Bridge to Outlet to Saxonville Pond	29.1 - 16.2	B	Warm Water High Quality Water
	Outlet Saxonville Pond to Hop Brook confluence	16.2 - 10.6	B	Aquatic Life High Quality Water
	Hop Brook confluence to Assabet River confluence	10.6 - 0.00	B	Aquatic Life
	Denney Brook, Jackstraw Brook, Picadilly Brook, Rutters Brook, and Whitehall Brook	-	B	Outstanding Resource Water
Assabet River	Source to Westborough WWTF	31.8 - 30.4	B	Warm Water High Quality Water
	Westborough WWTF to outlet to Boones Pond (Lake Boon)	30.4 - 12.4	B	Warm Water
	Outlet of Boones Pond to confluence with Sudbury River	12.4 - 0.0	B	Warm Water

Source: DEP, 2013

Table 2.1.4-4: Physical, Chemical, & Biotic Criteria for River Herring Spawning and Nursery Habitat

Variables	Suitable *(SWQS or BPJ*)*	Minimally Impacted *(25th percentile)*	Notes/Source
REFERENCE			
Temperature (°C) (July-Oct, nursery)	≤ 28.3		Maximum limit (DEP, 2007)
Temperature (°C) (May-Jun, spawning)	≤ 26.0		Scientific literature and BPJ
	≤ 20.0 (7-day mean)		7-day mean of daily max from logger data (DEP, 2007)
pH	≥ 6.5 to ≤ 8.3		(DEP, 2007)
DO (mg/L)	≥ 5.0		(DEP, 2007)
Secchi disc depth (m)		≤ 2.0	75th percentile; EPA Ecoregion 14, sub-84 (USEPA, 2000b)
Turbidity (NTU)		≤ 1.7 (rivers only)	EPA Ecoregion 14, sub-59 (USEPA, 2000a)
TN (mg/L)		≤ 0.32	EPA Ecoregion 14, sub-59 (USEPA, 2000b)
TP (ug/L)		≤ 8.0	EPA Ecoregion 14, sub-59 (USEPA, 2000b)
Chlorophyll a (ug/L) (Fluorometric)		≤ 4.2	EPA Ecoregion 14, sub-59 (USEPA, 2000b)
QUALITATIVE			
Fish Passage	BPJ		Section 4.0 of QAPP (Chase, 2010a)
Stream Flow	BPJ		Section 4.0 of QAPP (Chase, 2010a)
Eutrophication	BPJ		Section 4.0 of QAPP (Chase, 2010a)

**BPJ – Best professional judgment*

Notes: Water chemistry parameters relate to Massachusetts Class B SWQS for protecting Aquatic Life (DEP, 2013). EPA reference conditions are recommendations and are reported here for the Northeast Coastal Zone sub-ecoregion 59, with the exception of sub-ecoregion 84 (includes Cape Cod) for secchi disc depth (EPA, 2000). Additional references (75th percentile) and criteria (optimal, unsuitable) may be developed following the application of projects under Section 4.0 of the Quality Assurance Project Plan (QAPP) for water quality measurements for diadromous fish habitat monitoring, from which this table was taken (Chase, 2010).

Figure 2.1.5-1: Oil and Hazardous Material Release Sites in the SuAsCo Watershed

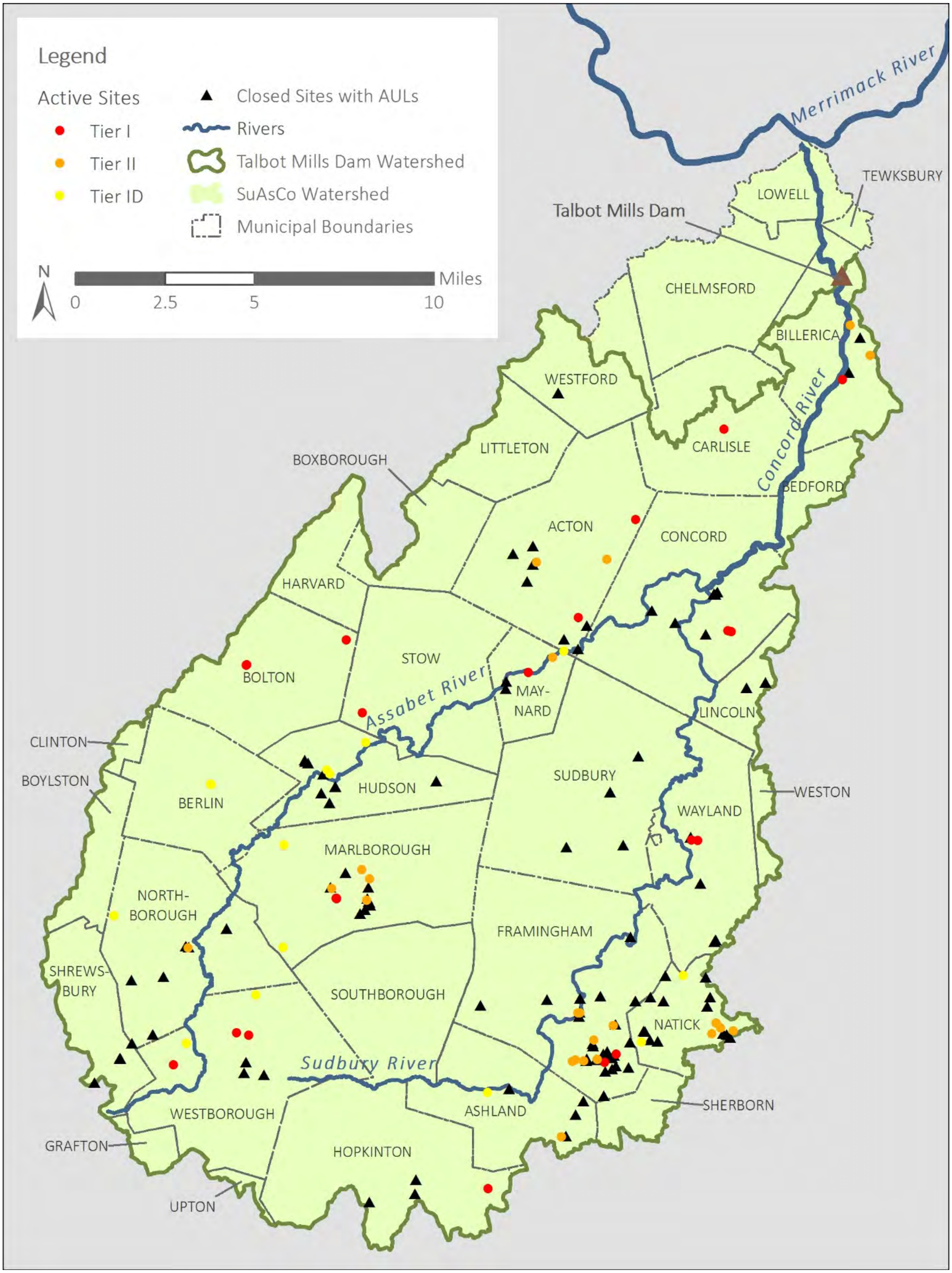


Table 2.1.5-1: Oil and Hazardous Waste Sites within 1,000 Feet of Concord River Bank

Release Tracking No. (RTN)	Site Name	Street Address	Town	Distance		Official Notification Date	Site Type	Chemical(s)	Amount
				From Concord River Bank	*Upstream of Talbot Mills Dam*				
3-0026097 *(primary)*	VFW Solomon Post #8819	12 Phiney St	Billerica	450 ft	1.6 mi	7/26/2006	Active (Tier II)	Aroclor 1254 PCB	77.9 mg/kg 78 mg/kg
3-0026273 *(secondary)*						9/27/2006	Closed	Arsenic	21 mg/kg
3-0000238	Cabot Corp. Research & Devel.	157 Concord Rd	Billerica	700 ft	3.0 mi	1/15/1987	Closed with AUL	Unknown	-
3-0029898 *(primary)*	Building No. 3	129 Concord Rd	Billerica	450 ft	3.3 mi	3/28/2011	Active (Tier I)	Perchlorate	262 mg/L 1800 mg/kg
3-0029963 *(secondary)*	CR Bard Facility					4/29/2011	Closed	Perchlorate	10 ug/L 490 mg/L

Source: MassDEP, 2016. More information and documents available by searching by RTN at http://public.dep.state.ma.us/SearchableSites2/Search.aspx.

Figure 2.1.5-2: Map of Talbot Mills Dam Impoundment Sediment Probes & Cores (2005)

*Source: Breault et al., 2013 (data provided by J. Sorenson). Delineation of approximate edge of major sediment deposits and extent of mobile sediment discussed in **Section 3.2.1**.*

Table 2.1.5-2: Contaminant Concentrations in Talbot Mills Dam Impoundment Sediment (2005)

Parameter	Screening Benchmarks			Dam Impoundment Sample
(Important: Units listed by category below)	**MCP S1/GW1** *Human Health*	**TEC** *Freshwater*	**PEC** *Freshwater*	
Metals [mg/kg]				
Arsenic	20.0	9.79	33.0	13
Cadmium	70.0	0.99	4.98	0.5
Chromium (TOTAL)	100.0	43.4	111.0	77
Copper		31.6	149.0	50.6
Lead	200.0	35.8	128.0	63
Nickel	600.0	22.7	48.6	16
Zinc	1,000.0	121.0	459.0	143
SVOCs (PAHs)[ug/kg]				
Acenaphthene	4,000.0			34
Acenaphthylene	1,000.0			140
Anthracene	1,000,000.0	57.2	845.0	180
Benzo[a]anthracene	700.0	108.0	1,050.0	460
Benzo(a)pyrene	2,000.0	150.0	1,450.0	480
Benzo[b]fluoranthene	7,000.0	27.3	13,400.0	740
Benzo[g,h,i]perylene	1,000,000.0			230
Benzo[k]fluoranthene	70,000.0			290
Chrysene	70,000.0	166.0	1,290.0	570
Dibenz[a,h]anthracene	700.0	33.0	260.0	80
Fluorene	1,000,000.0	77.4	536.0	90
Naphthalene	4,000.0	176.0	561.0	53
Phenanthrene	10,000.0	204.0	1,170.0	470
Pyrene	1,000,000.0	195.0	1,520.0	990
Total PAHs (calculated)		1,610.0	22,800.0	3513
PCBs (ug/kg)				
Total PCBs (calculated)	1,000.0	59.8	676.0	50
Pesticides (ug/kg)				
Aldrin	80.0			1.5
alpha-BHC				1.5
beta-BHC				1.5
gamma-BHC (Lindane)		2.4	5.0	1.5
Chlordane	5,000.0	3.2	17.6	1.5
4,4'-DDD	4,000.0	4.88	28.0	4
4,4'-DDE	3,000.0	3.16	31.3	4
4,4'-DDT	3,000.0	4.16	62.9	3
Total DDTs (calculated)		5.28	572.0	11
Dieldrin	80.0	1.9	61.8	1.5
Endosulfan I				1.5
Endrin	10,000.0	2.2	207.0	3
Methoxychlor				7.5

Key (see notes on following page)

- X Exceeds freshwater Threshold Effects Concentration (TEC)
- X Exceeds freshwater Probable Effects Concentration (PEC)
- X Exceeds Massachusetts Contingency Plan (MCP) Soil 1 / Groundwater 1 (S1/GW1) standards
- X Below the laboratory detection limit (BDL); a value of 1/2 the detection limit is provided

Table 2.1.5-2: Contaminant Concentrations in Talbot Mills Dam Impoundment Sediment (2005)
(continued)

Notes: Data from three composited sediment cores collected in the Talbot Mills Dam impoundment on November 3, 2005 by the USGS and the DER as part of a study on impounded sediment quantity and quality at 32 dams throughout Massachusetts (Breault et al., 2013). Mercury concentration was not reported. No TEC or PEC values exist for 4'4 DDD, DDE, or DDT. This sheet used the TEC and PEC values for the SUM of DDE, DDD, and DDT, respectively, to provide a conservative value for comparison. Total PCBs are calculated as the sum of aroclors; total PAHs are similarly calculated by summing values. TEC values are expected to be exceeded in a developed watershed such as the Concord River, but are provided in this table for reference.

Figure 2.2.1-1: Aerial Image of Middlesex Falls Area

Figure 2.2.1-2: Middlesex Falls Existing Topographic Plan

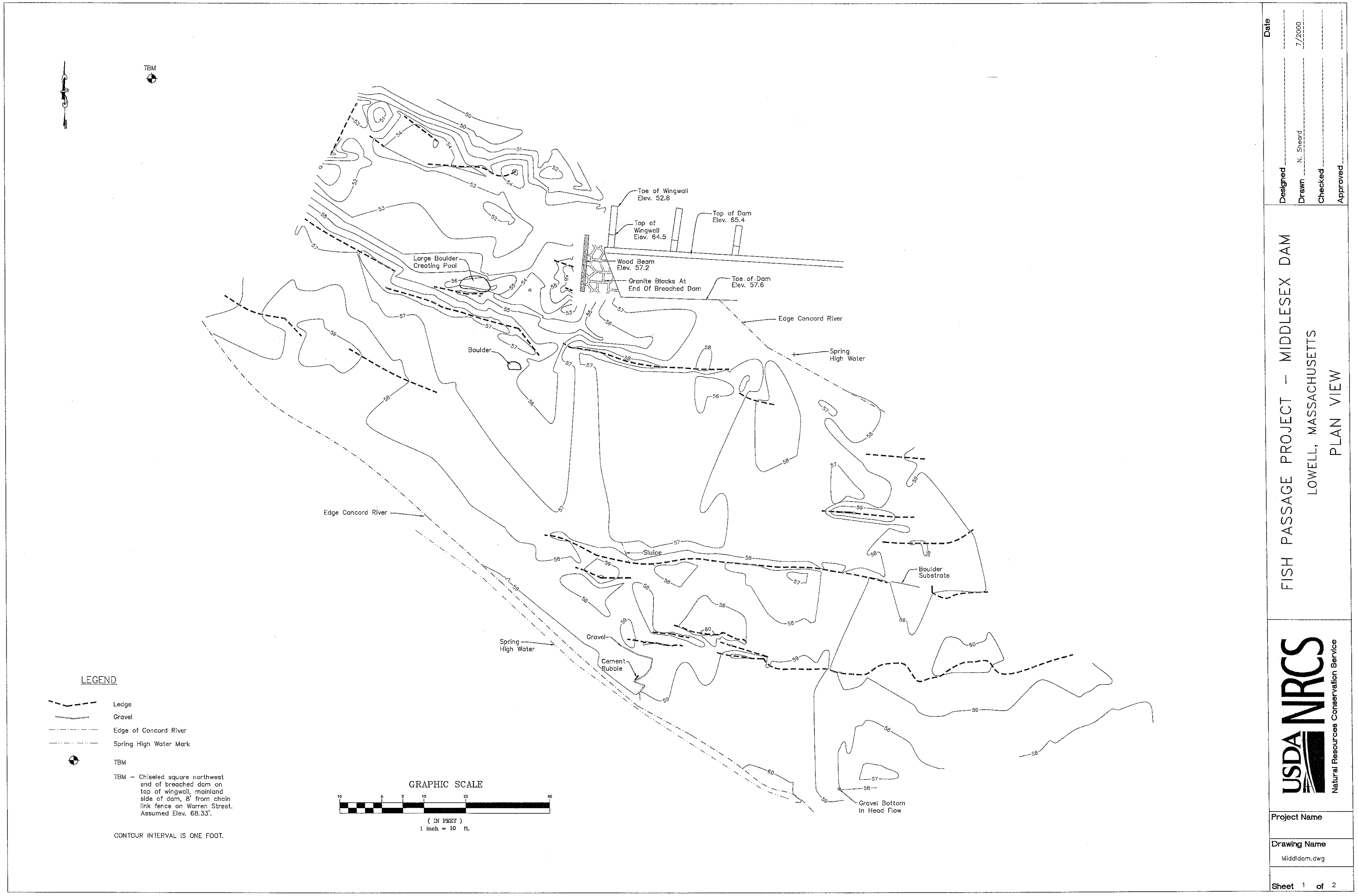


Figure 2.2.1-3: Middlesex Falls Existing Topographic Plan and Sections

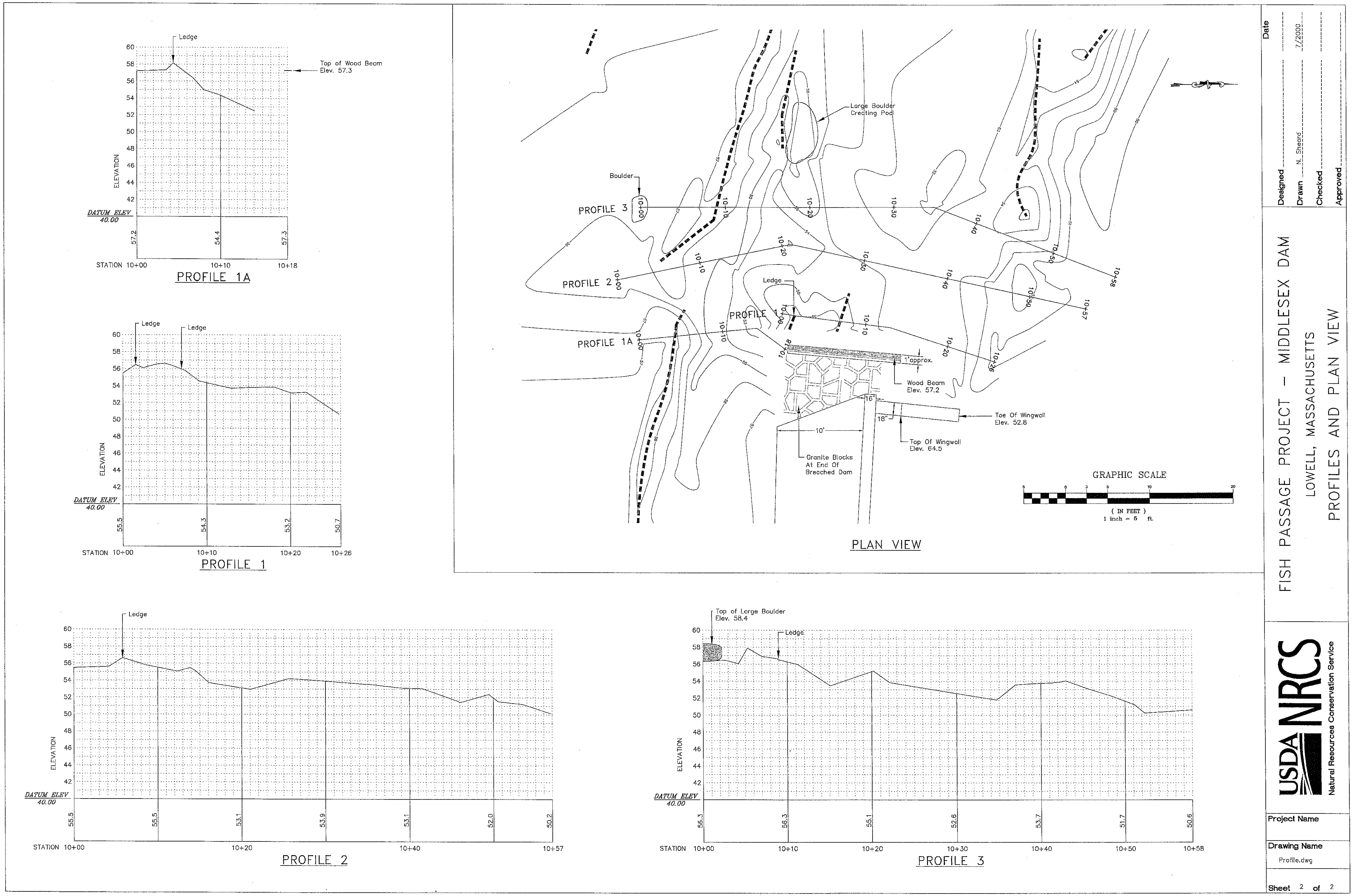
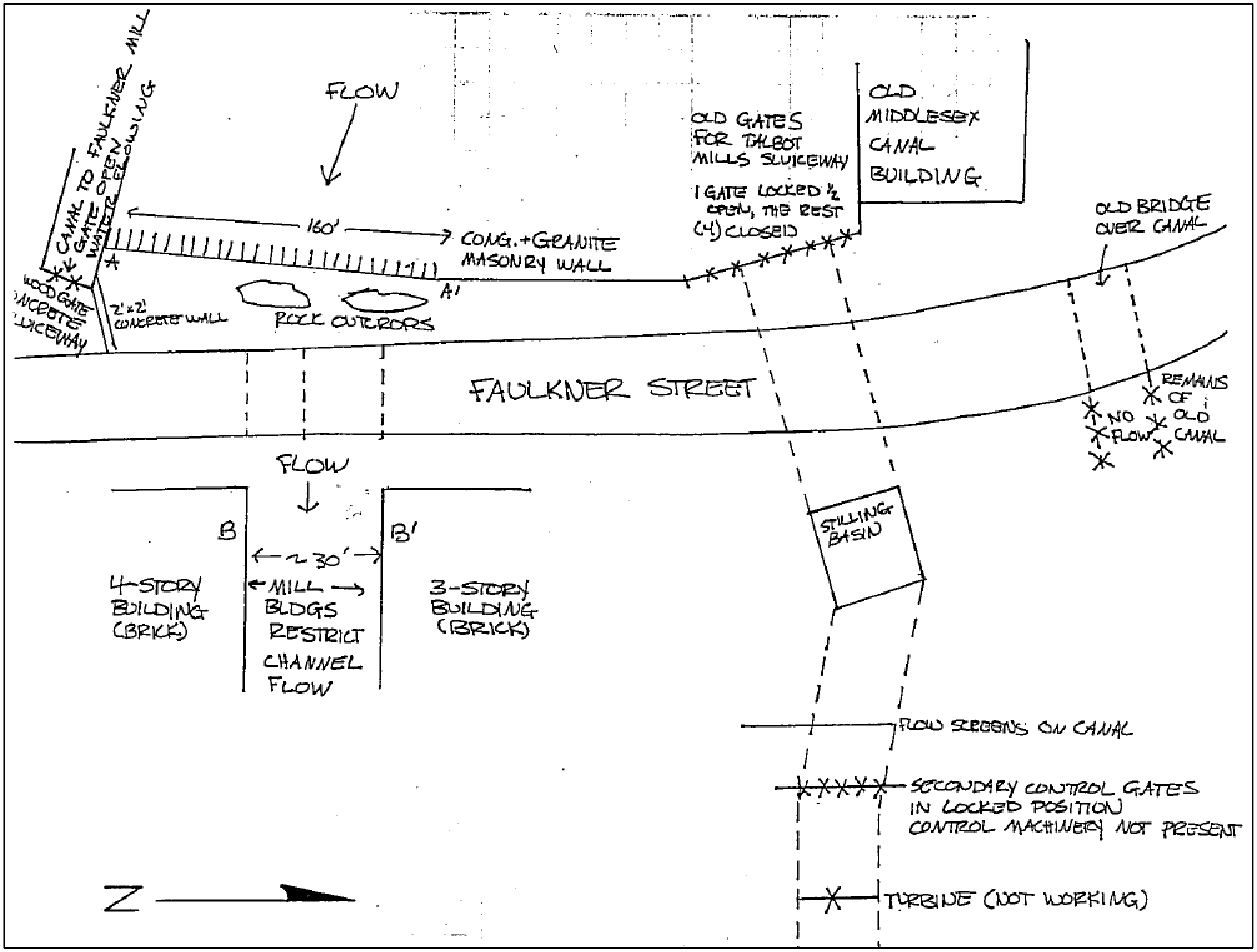


Figure 2.2.2-1: Aerial Image of Centennial Falls Dam Area

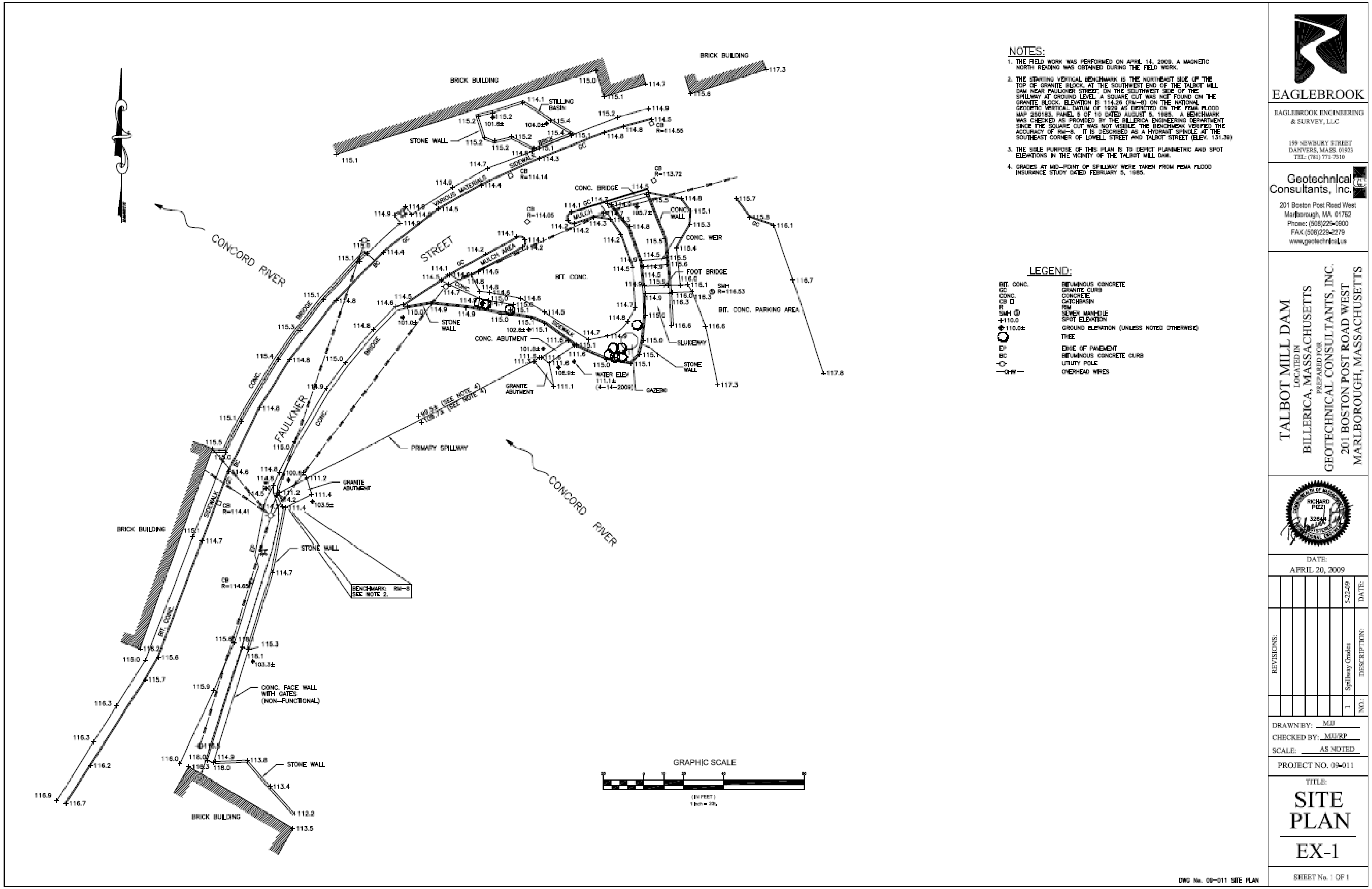
Figure 2.2.3-1: Aerial Image of Talbot Mills Dam Area

Figure 2.2.3-2: Schematic Plan of Talbot Mills Dam Features



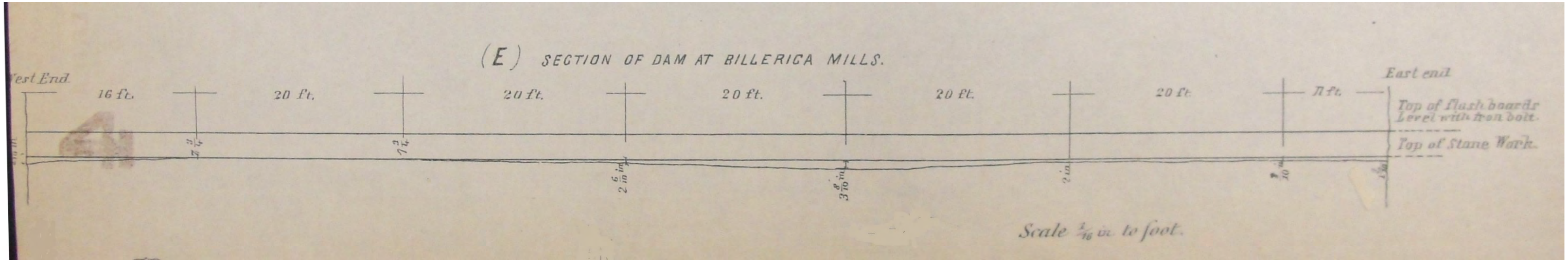
Source: Geotechnical Consultants, 2015.

Figure 2.2.3-3: Existing Survey Plan of Talbot Mills Dam



Note: Elevations in NGVD 29. The datum shift to convert to NAVD 88 for the coordinates at Talbot Mills Dam (the conversion is location specific) is -0.827 feet (with NGVD 29 being the higher elevation). Source: Geotechnical Consultants, 2015.

Figure 2.2.3-4: Historical Section of Dam at Billerica Mills



Note: Obtained from MCA; source unknown. Although a date is not specified, this appears to be a section of the current (1828) structure due to the note on the right referring to "stone work," as the previous dams were of wood construction.

Figure 2.2.3-5: Key Features of the Talbot Mills Dam Lower Impoundment

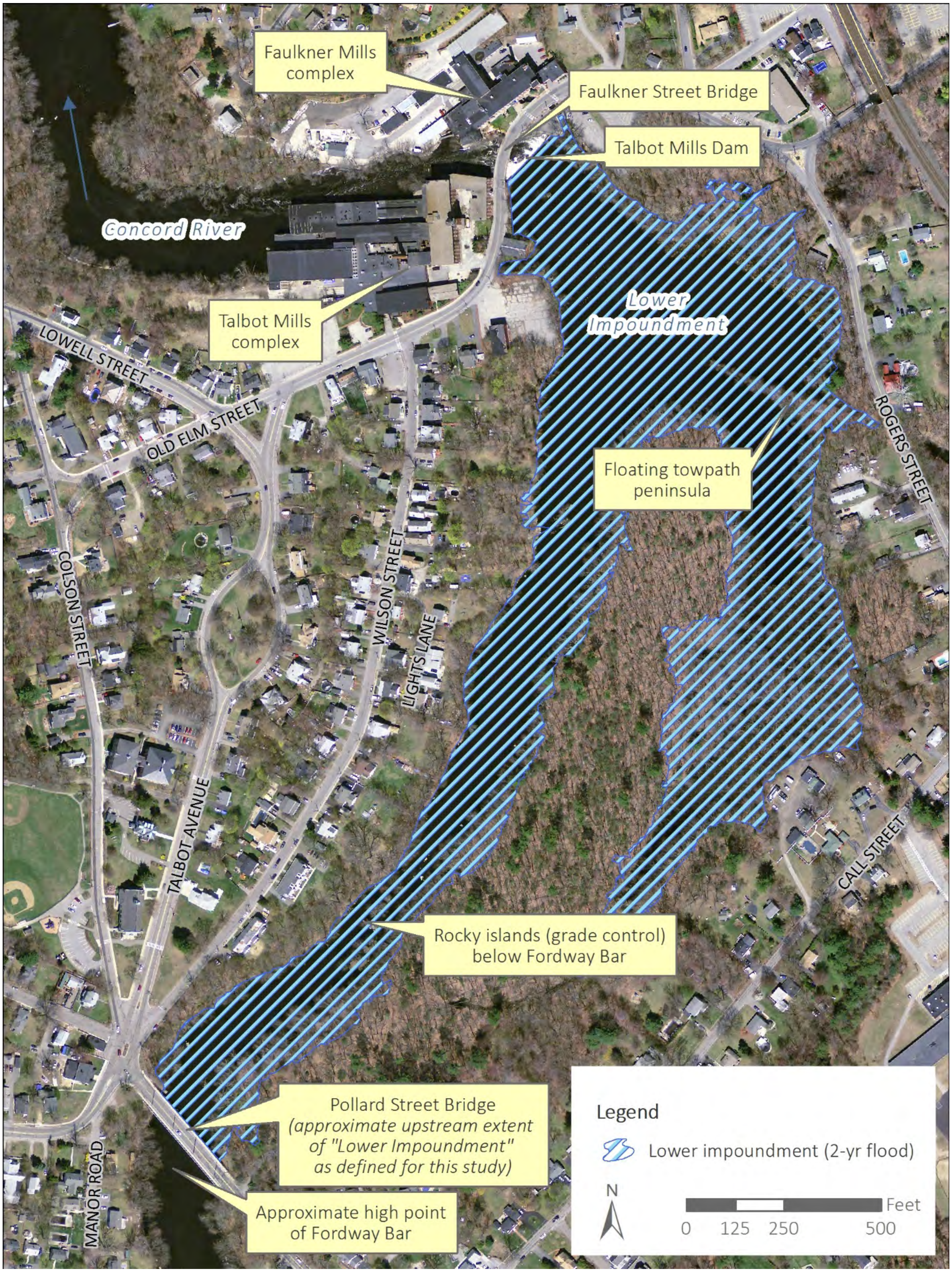
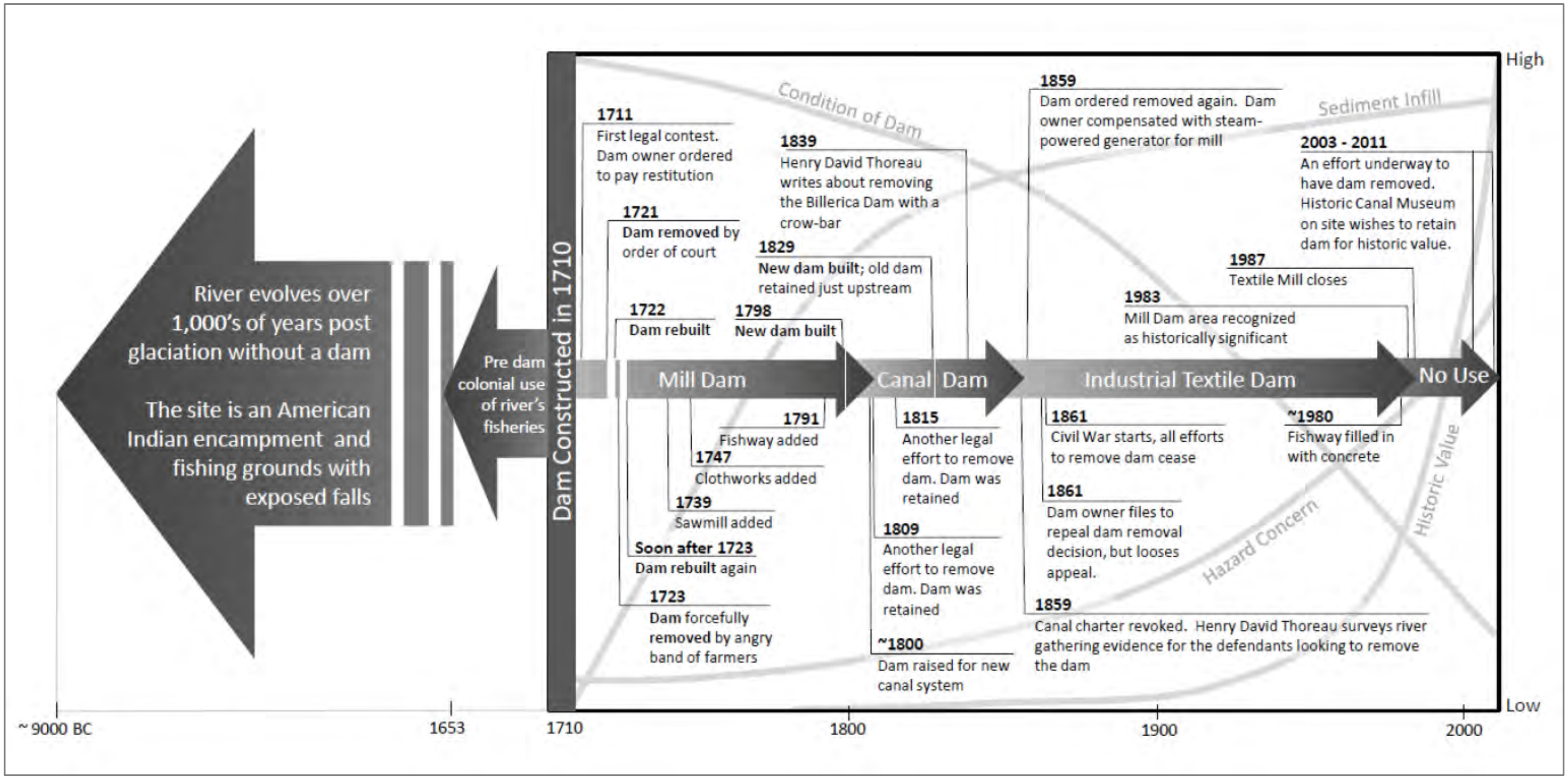
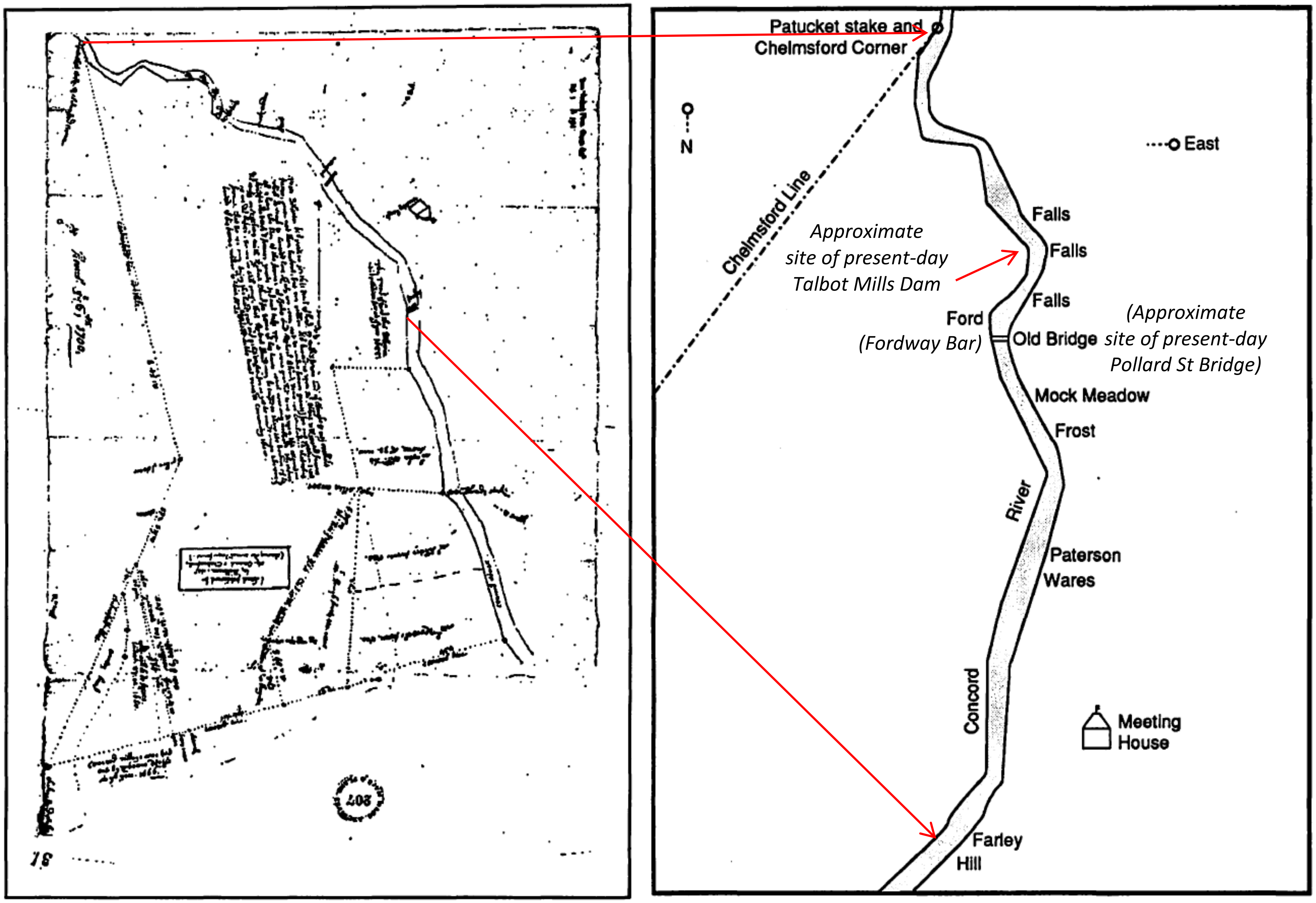


Figure 2.2.3-6: Timeline of Historical Events for the Talbot Mills Dam Site



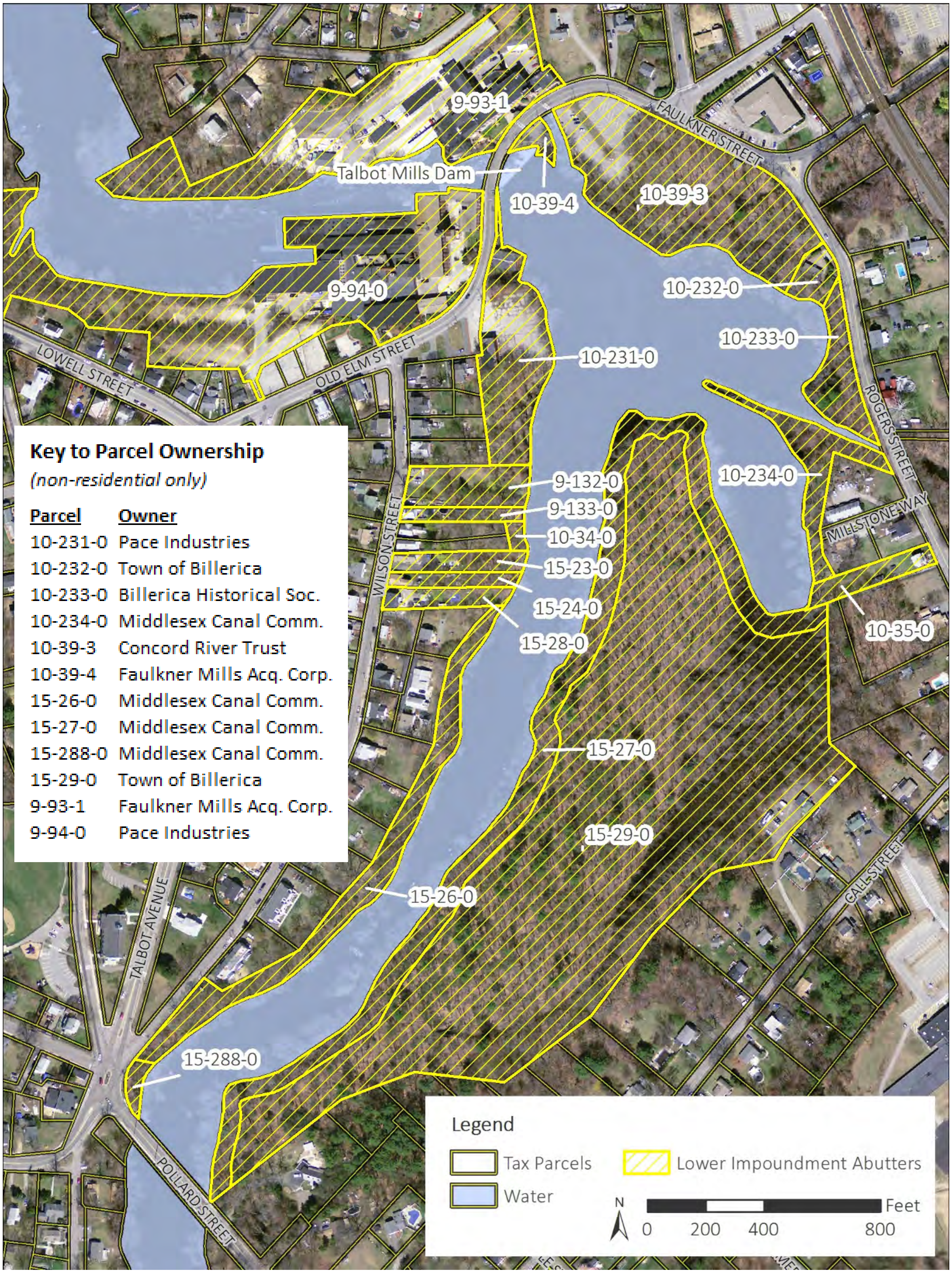
Note: Some dates and/or events may vary slightly from those described in this report. Where discrepancies occur, the report shall represent the most accurate information available for this study. Source: Wildman, 2013

Figure 2.2.3-7: Historical Map Showing Falls Prior to Damming of Concord River



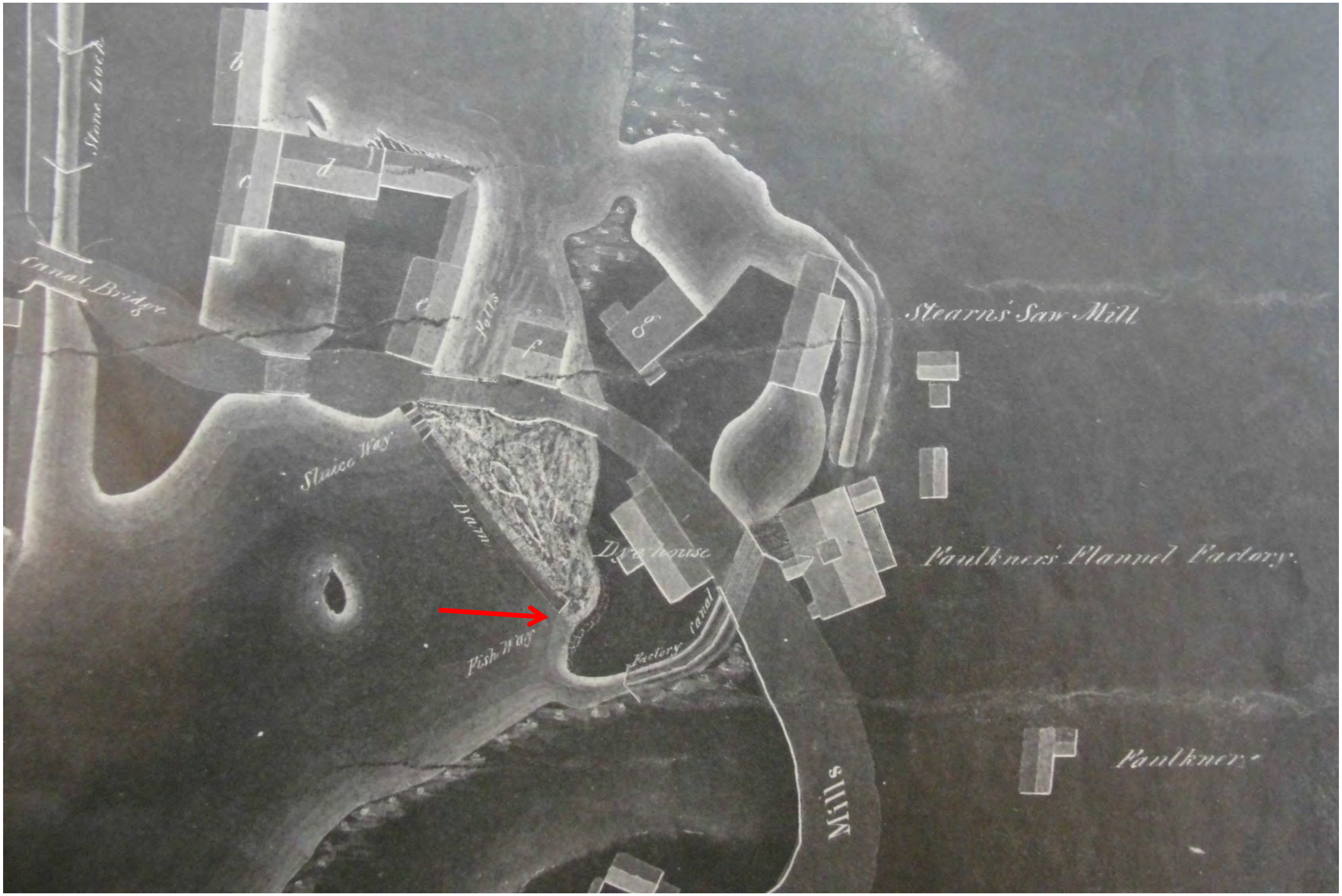
This early map of Billerica (left), prepared in 1700, indicates the existence of a series of falls in the Concord River between the present-day Pollard Street and Faulkner Bridges, as shown in the reproduced extract at right (Ingraham, 1995).

Figure 2.2.3-8: Property Ownership in the Vicinity of Talbot Mills Dam and Lower Impoundment



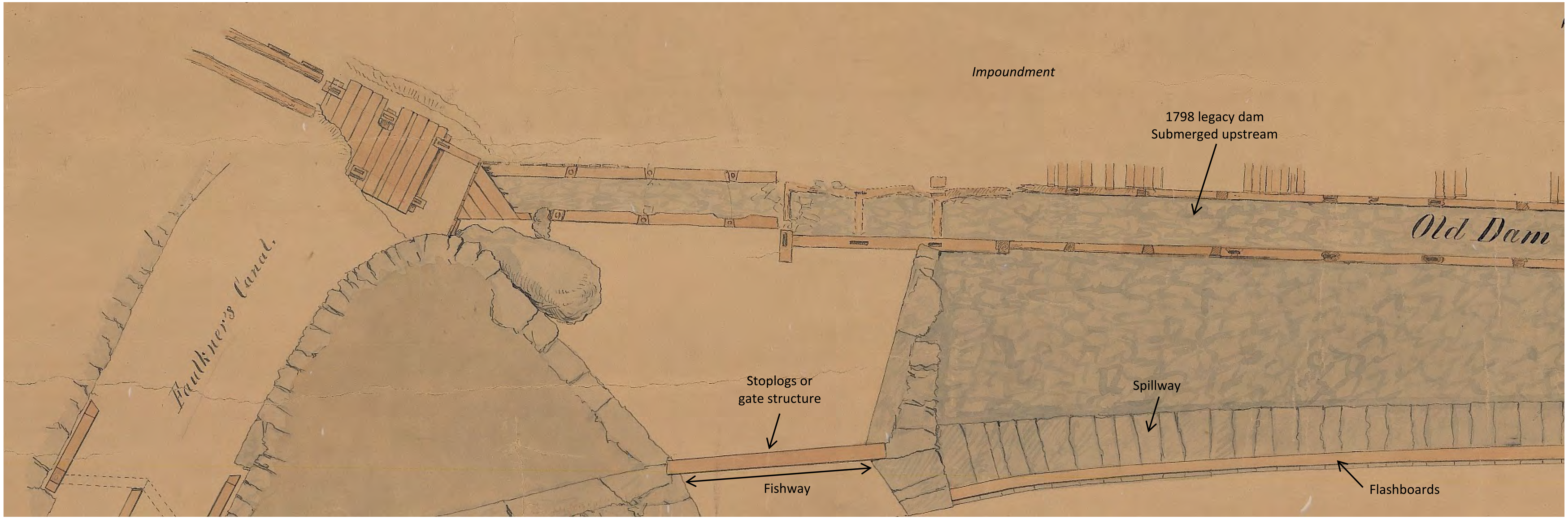
Note: Former Talbot cloth warehouse building on parcel 10-231-0 granted to the MCA in 2014.

Figure 2.2.3-9: Historical Plan of Dam Area Showing Fishway



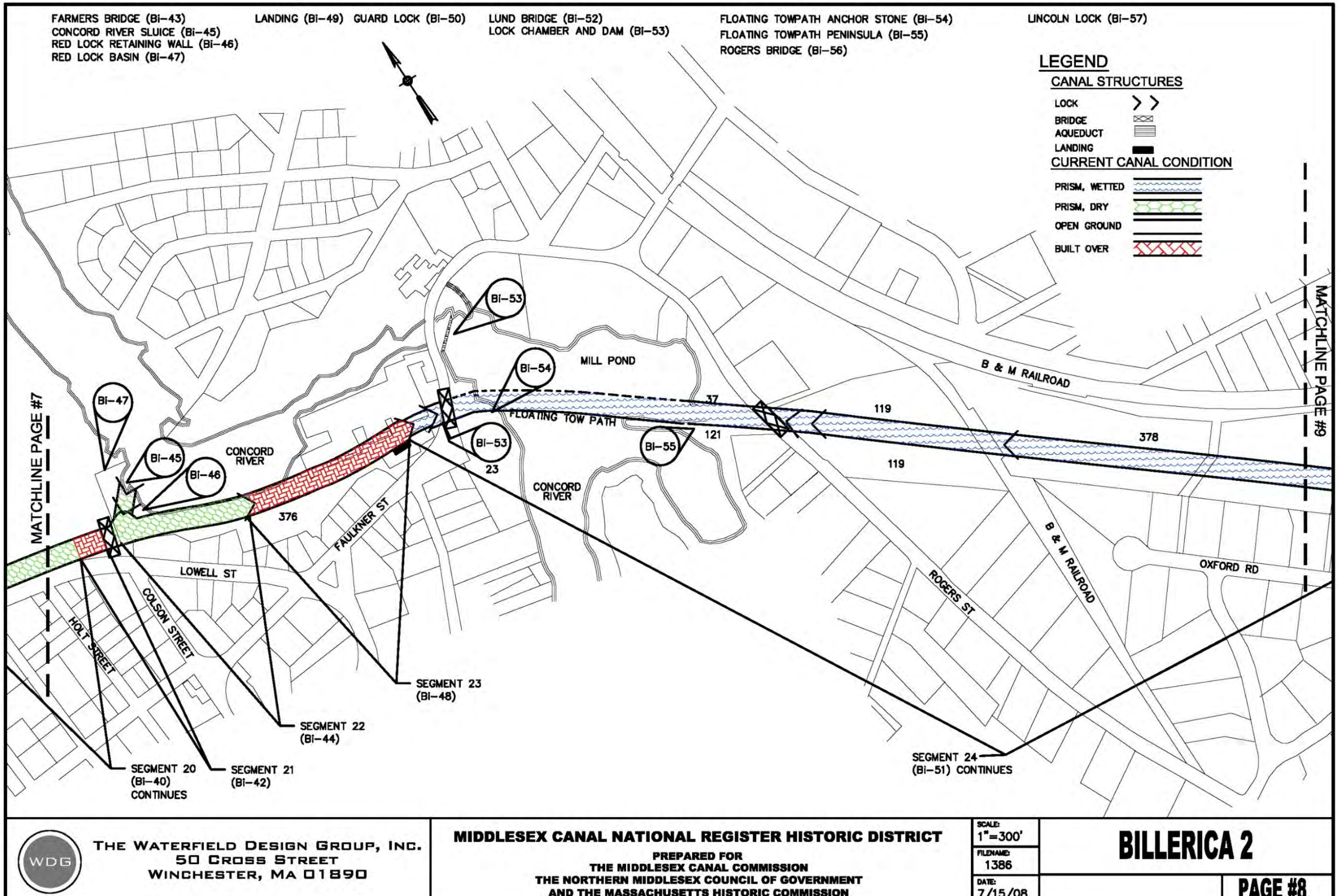
Note: Obtained from MCA; source/date unknown.

Figure 2.2.3-10: Historical Plan Detail Showing Fishway Location



Note: Obtained from MCA; source unknown. Note the location of the former (1798) wooden dam, which was submerged when the stone dam was built in 1828 (pictured at bottom edge of detail).

Figure 2.3.1-1: Map of Old Middlesex Canal in Vicinity of Talbot Mills Dam

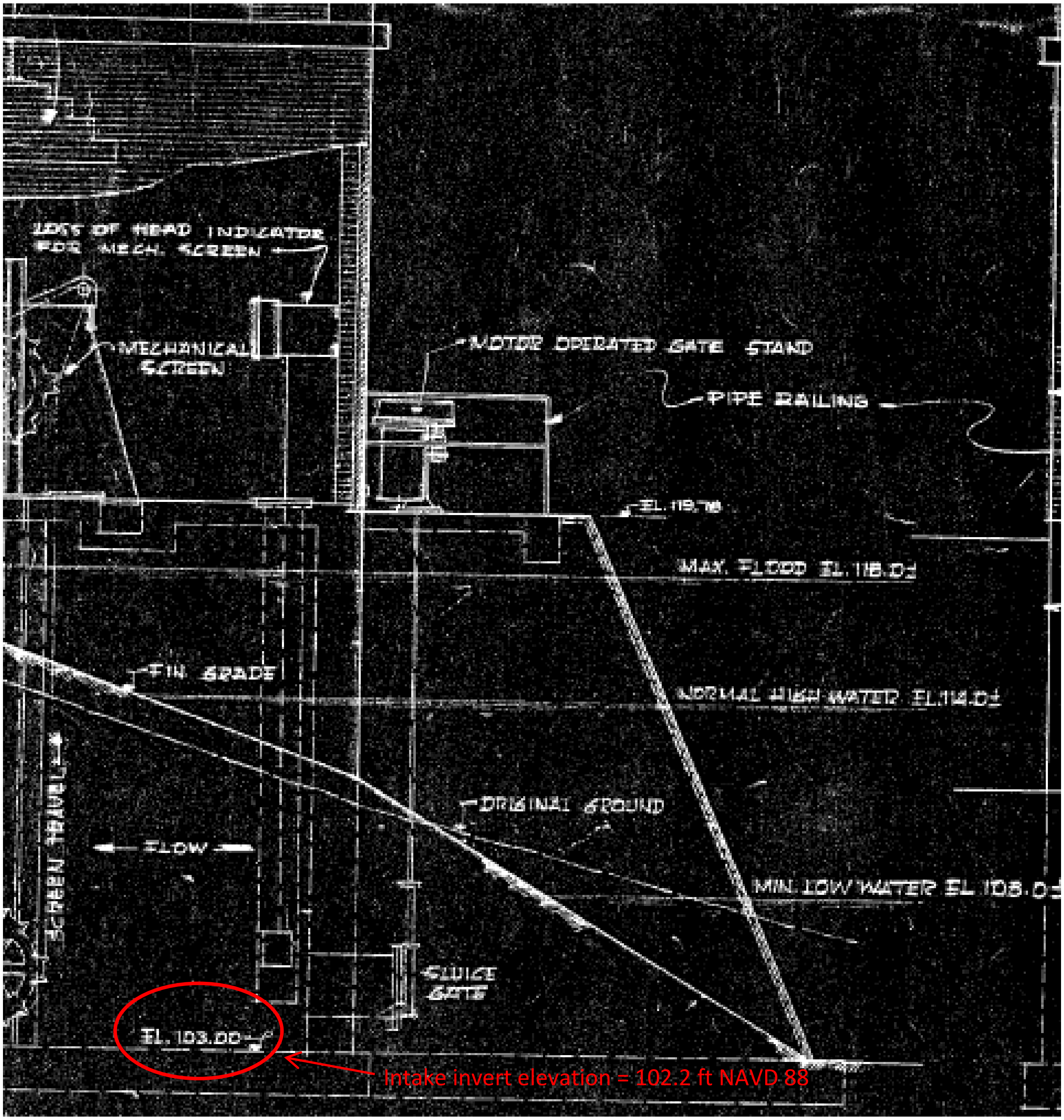


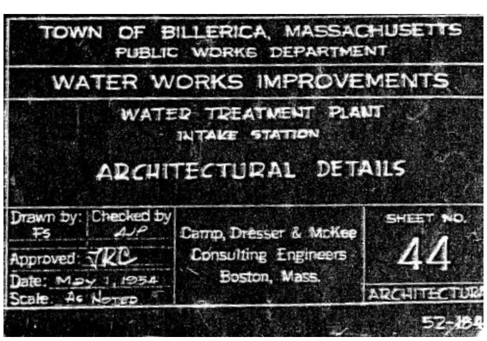
Source: Waterfield Design Group, 2008a

Figure 2.3.1-2: Proposed Middlesex Canal Mill Pond / Canal Park

Source: Waterfield Design Group, 2008b

Figure 2.3.2-1: Billerica Water Supply Intake Elevation Detail





Note: Elevations assumed to be in feet NGVD 29. Conversion factor to feet NAVD 88 is -0.827.

Figure 2.3.2-2: Billerica Water Main Crossing Plan

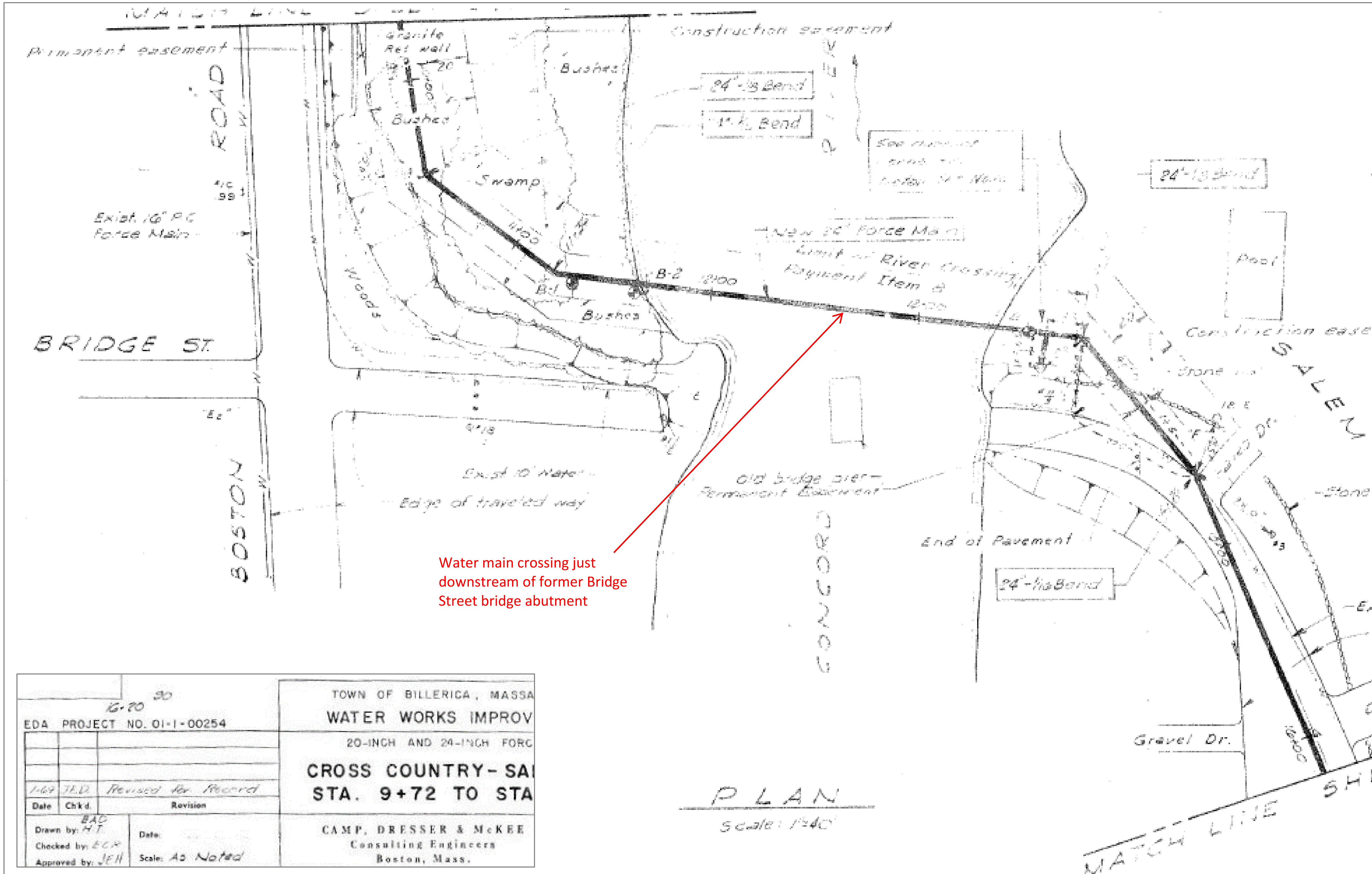


Figure 2.3.2-3: Billerica Water Main Crossing Profile

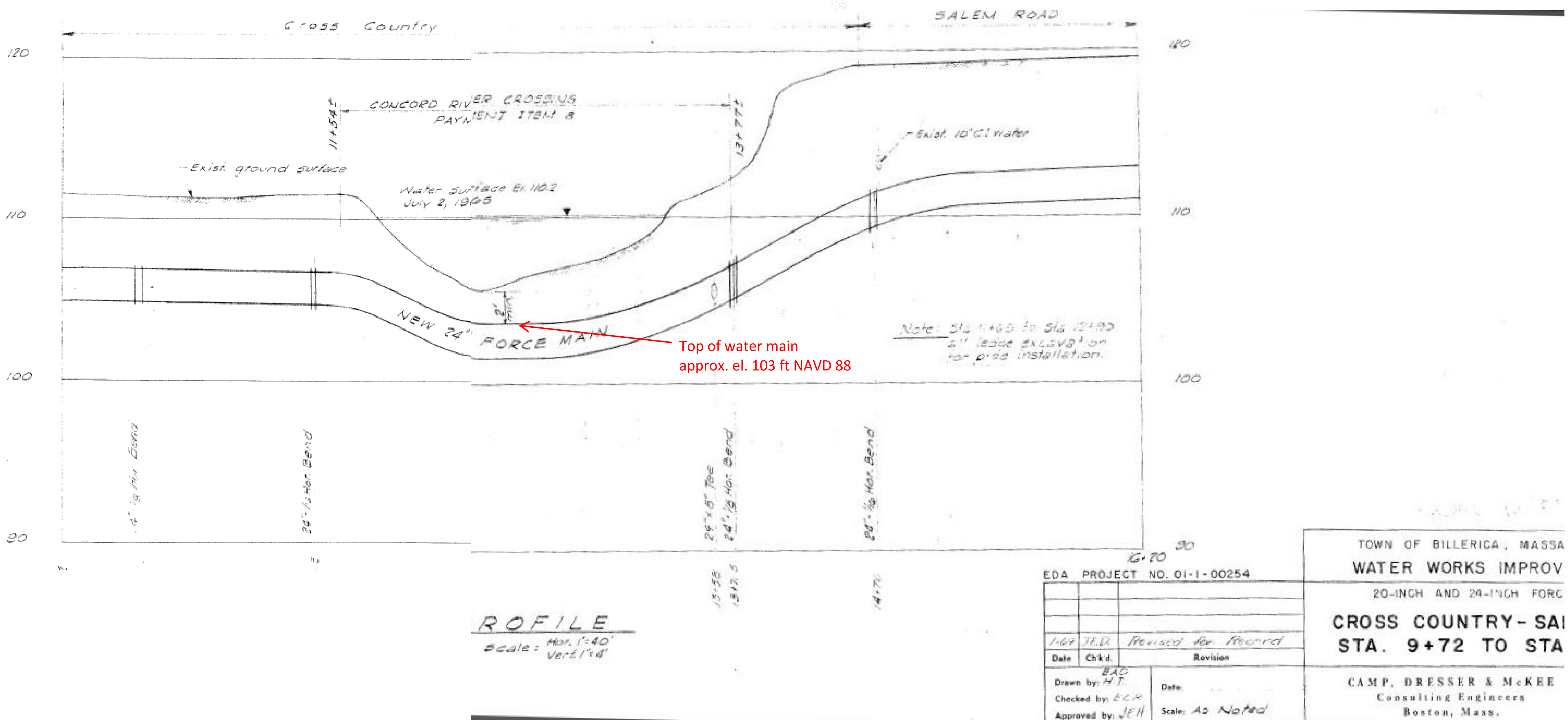


Figure 2.3.2-4: Billerica Sewer Main Crossing Plan and Profile

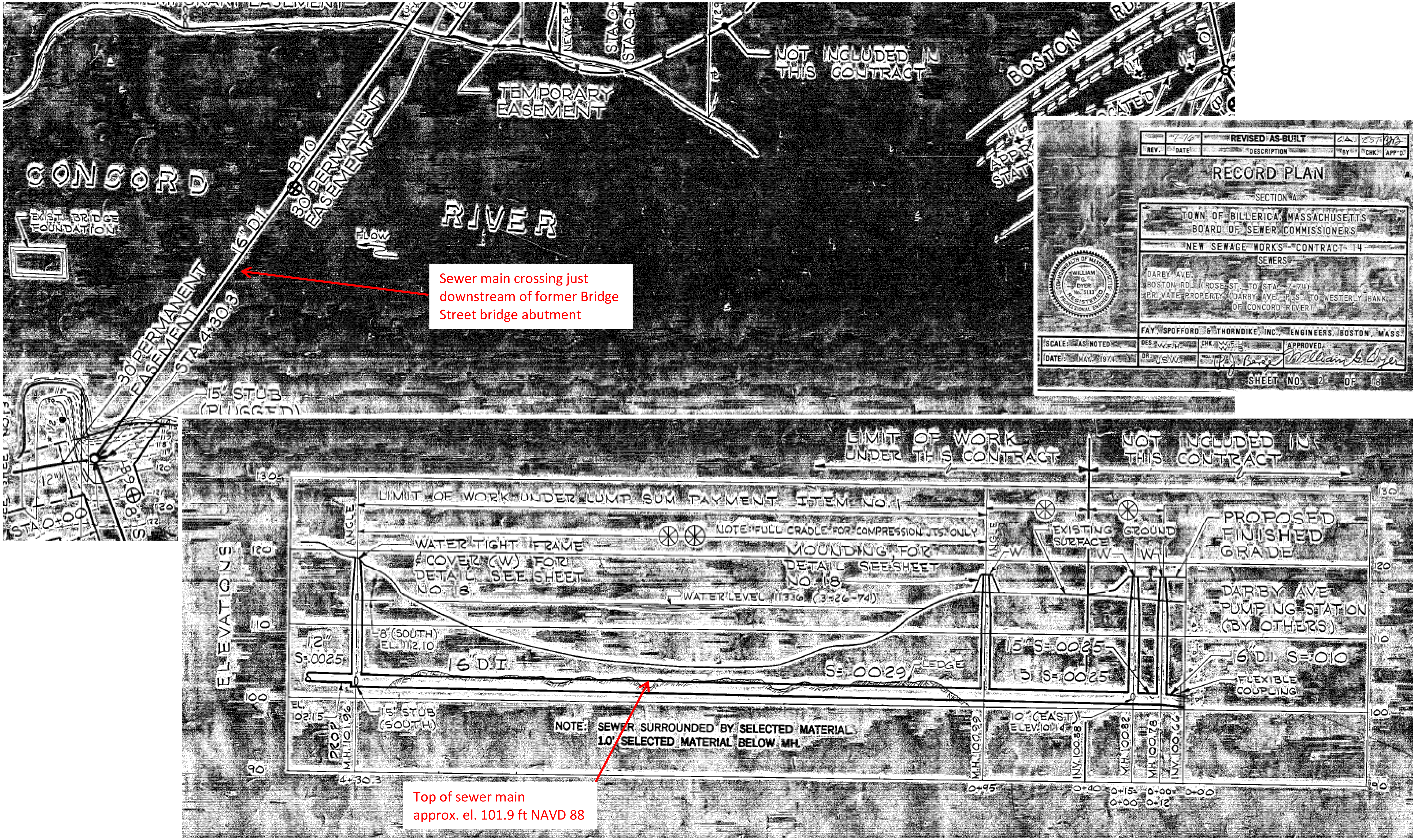
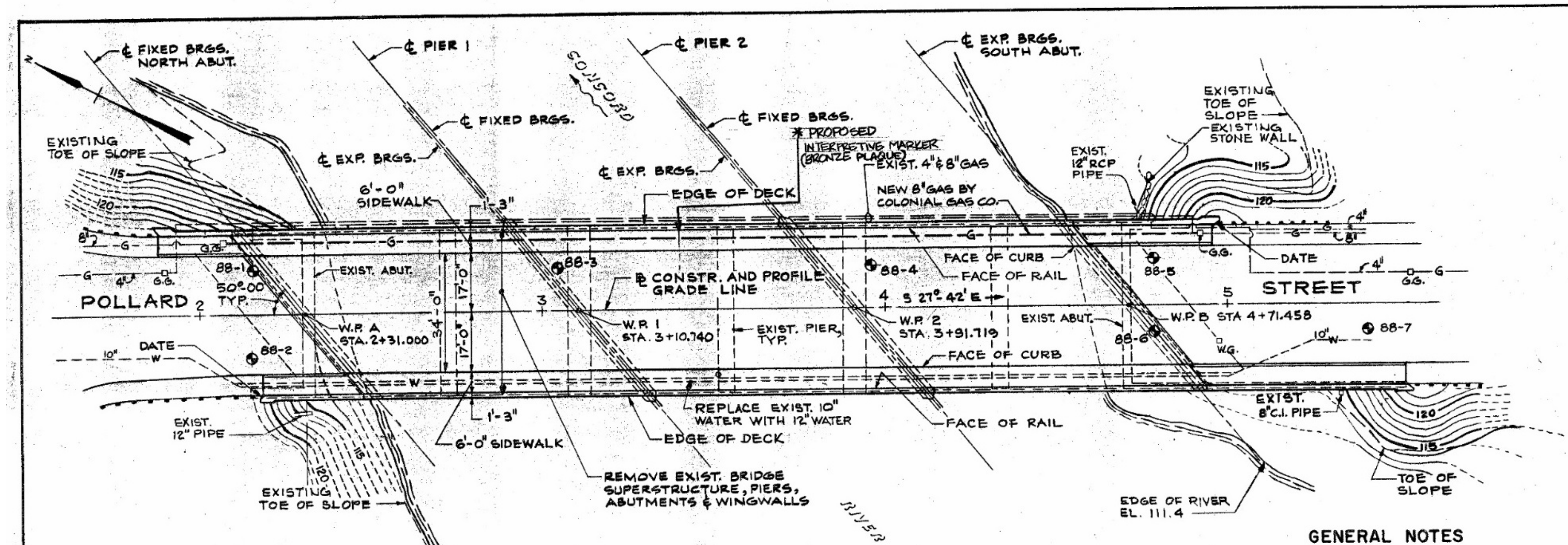


Figure 2.3.3-1: Pollard Street Bridge Plan and Profile Drawing

BILLERICA
POLLARD STREET

F.H.W.A. REG. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
1	MASS.	BRM-5395(001)	1995	4	17

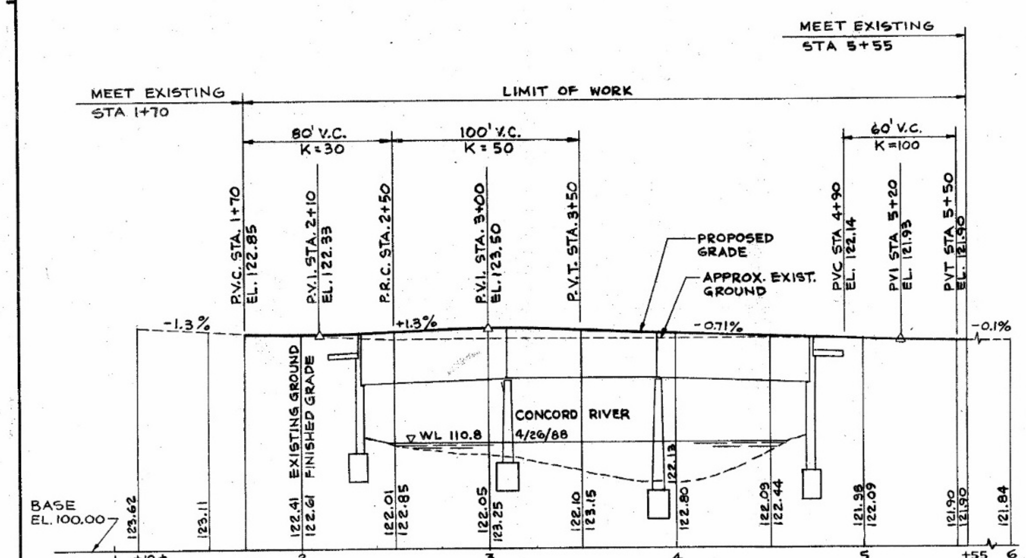
PROJECT FILE NO. 058020



LEGEND

—115—	FINISHED GRADE
- - -120- - -	APPROX. EXIST. GROUND
88-1	BORING LOCATION AND NUMBER

KEY PLAN
SCALE: 1" = 20'



PROFILE
SCALE: HOR. 1" = 40' VERT. 1" = 8'

ESTIMATED QUANTITIES
(NOT GUARANTEED)

ITEM	QUANTITY	UNIT
DEMOLITION OF BRIDGE STRUCTURE NO. B-12-5	1	L.S.
BRIDGE EXCAVATION	1,520	C.Y.
CLASS B ROCK EXCAVATION	70	C.Y.
GRAVEL BORROW FOR BACKFILLING STRUCTURES AND PIPES	820	C.Y.
CRUSHED STONE FOR BRIDGE FOUNDATIONS	230	TON
CLASS 1 BIT. CONCRETE PAVEMENT, TYPE I-1	82	TON
CLASS 1 DENSE BINDER COURSE FOR BRIDGES	82	TON
ASPHALTIC DECK JOINT	89	L.F.
SPECIAL END SHOE FOR STEEL BEAM HIGHWAY GUARD	4	EA.
CONTROL OF WATER - STRUCTURE NO. B-12-5	1	L.S.
BRIDGE STRUCTURE, BRIDGE NO. B-12-5	1	L.S.

GENERAL NOTES

DESIGN:

IN ACCORDANCE WITH THE 1992 STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES OF THE AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS FOR HS-20 LOADING, INCLUDING ALL CURRENT INTERIMS THROUGH 1993.

BENCH MARK:

CHISEL CUT " □ " ON RAIL AT NORTHWEST END POST OF EXISTING BRIDGE, EL. 125.43. A NEW BENCH MARK SHALL BE ESTABLISHED PRIOR TO DEMOLITION OF END POST.

ELEVATIONS ARE BASED ON NATIONAL GEODETIC VERTICAL DATUM OF 1929.

DATE:

DATE TO BE PLACED ON THE INSIDE FACE AT THE WEST END POST OF THE NORTH ABUTMENT AND AT THE EAST END POST OF THE SOUTH ABUTMENT.

SCALES:

SCALES NOTED ON THE PLANS ARE NOT APPLICABLE TO REDUCED SIZE PRINTS. DIVIDE SCALES BY 2 FOR 1/4 SIZE PRINTS (11" X 18").

FOUNDATIONS:

FOUNDATIONS MAY BE ALTERED, IF NECESSARY, TO SUIT CONDITIONS ENCOUNTERED DURING CONSTRUCTION, WITH THE APPROVAL OF THE ENGINEER.

UNSUITABLE MATERIAL:

ALL UNSUITABLE MATERIAL SHALL BE REMOVED WITHIN THE LIMITS OF THE FOUNDATIONS OF THE STRUCTURE, AS DIRECTED BY THE ENGINEER.

CONCRETE:

CEMENT SHALL CONFORM TO AASHTO DESIGNATION M85.

ANCHOR BOLTS:

ALL ANCHOR BOLTS SHALL BE SET BY TEMPLATE BEFORE THE CONCRETE IS PLACED AND SHALL CONFORM TO THE REQUIREMENTS OF ASTM DESIGNATION A449.

REINFORCEMENT:

REINFORCING STEEL SHALL CONFORM TO THE REQUIREMENTS OF ASTM A615 GRADE 60. ALL #4 BARS SHALL BE LAPPED 24" AND ALL #5 BARS SHALL BE LAPPED 30". FOR HORIZONTAL BARS WITH 12" OR MORE OF CONCRETE BELOW THE BAR, THE LAP LENGTHS SHALL BE 33" FOR #4 BARS AND 41" FOR #5 BARS. ALL REINFORCEMENT IS TO BE EPOXY COATED.

IF THE ABOVE BARS ARE SPACED 6" OR MORE ON CENTER, THE LAP LENGTH SHALL BE 80% OF THE LAP LENGTH GIVEN ABOVE. ALL OTHER BARS SHALL BE LAPPED AS SHOWN ON THE PLANS.

PLACE REINFORCEMENT TO CLEAR ANCHOR BOLTS AND WATERSTOPS.

PLACE REINFORCEMENT A CLEAR DISTANCE OF 2" FROM FACE OF CONCRETE UNLESS NOTED OTHERWISE. STEEL REINFORCEMENT MATS SHALL BE FIRMLY SECURED AGAINST DISPLACEMENT BY TYING EVERY OTHER INTERSECTION POINT WITH A MAXIMUM OF TWELVE (12); INCHES BETWEEN TIED JOINTS.

DIMENSIONS:

ALL DIMENSIONS SHOWN ON THE PLANS ARE HORIZONTAL AND ARE FOR THE STRUCTURE AT 68°F, UNLESS OTHERWISE NOTED.

STRUCTURAL STEEL:

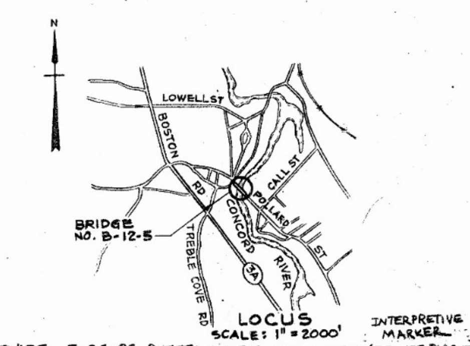
ALL STRUCTURAL STEEL SHALL CONFORM TO THE REQUIREMENTS OF ASTM DESIGNATION A709 GRADE 36, EXCEPT AS NOTED. WELDED FABRICATION SHALL BE IN ACCORDANCE WITH THE BRIDGE WELDING CODE, ANSI/AASHTO/AWS D1.5 AND ALL INTERIM REVISIONS PUBLISHED BY AASHTO AS OF THE BID OPENING DATE.

HYDRAULIC DATA:

DRAINAGE AREA:	370 SQ. MILES
DESIGN DISCHARGE:	4,660 C.F.S.
DESIGN FREQUENCY:	50 YEAR
DESIGN VELOCITY:	3.8 F.P.S.
DESIGN HIGH WATER:	ELEV. 114.4
WATER LEVEL 4/26/88	ELEV. 110.8

BASIC FLOOD DATA:

Q(100 YEAR) = 5,675 C.F.S.
WATER SURFACE ELEV. 115.0



LOCUS
SCALE: 1" = 2000'

* REVISE 3-26-96 SHEETS 1 OF 14 AND 14 OF 14 (BRONZE PLAQUE) INTERPRETIVE MARKER

12-24-94 ISSUED FOR CONSTRUCTION

MASS HIGHWAY

PROPOSED BRIDGE

BILLERICA

POLLARD STREET OVER CONCORD RIVER

THE COMMONWEALTH OF MASSACHUSETTS
MASSACHUSETTS HIGHWAY DEPARTMENT
10 PARK PLAZA BOSTON, MASS.

BRIDGE ENGINEER   CHIEF ENGINEER

FAY, SPOFFORD & THORNDIKE, INC.
DESIGN ENGINEER BURLINGTON, MASS.

SHEET 1 OF 14 SHEETS BRIDGE NO. B-12-5

Figure 2.3.3-2: Pollard Street Bridge Boring Log

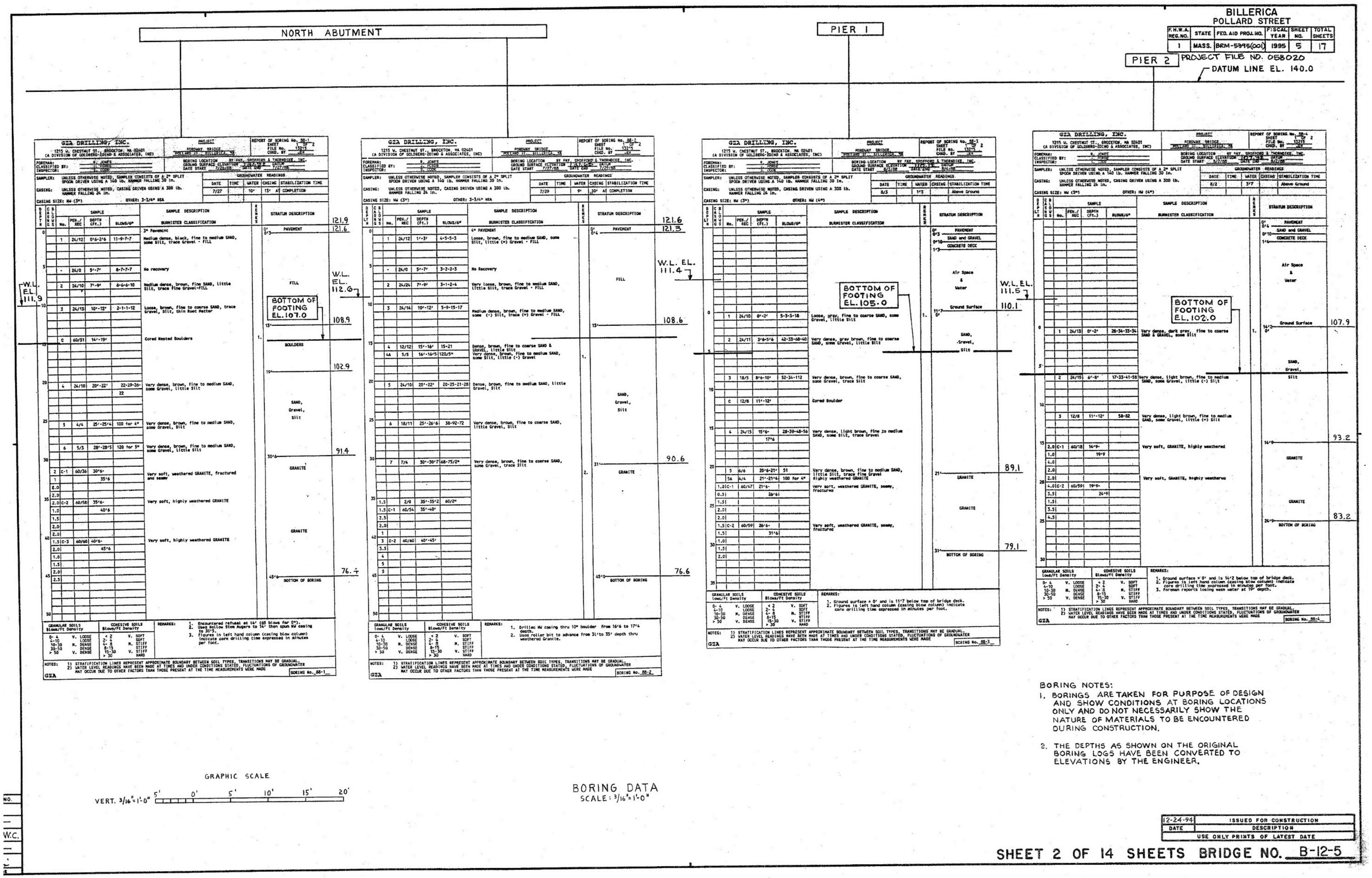


Figure 2.3.3-2: Pollard Street Bridge Boring Log *(continued)*

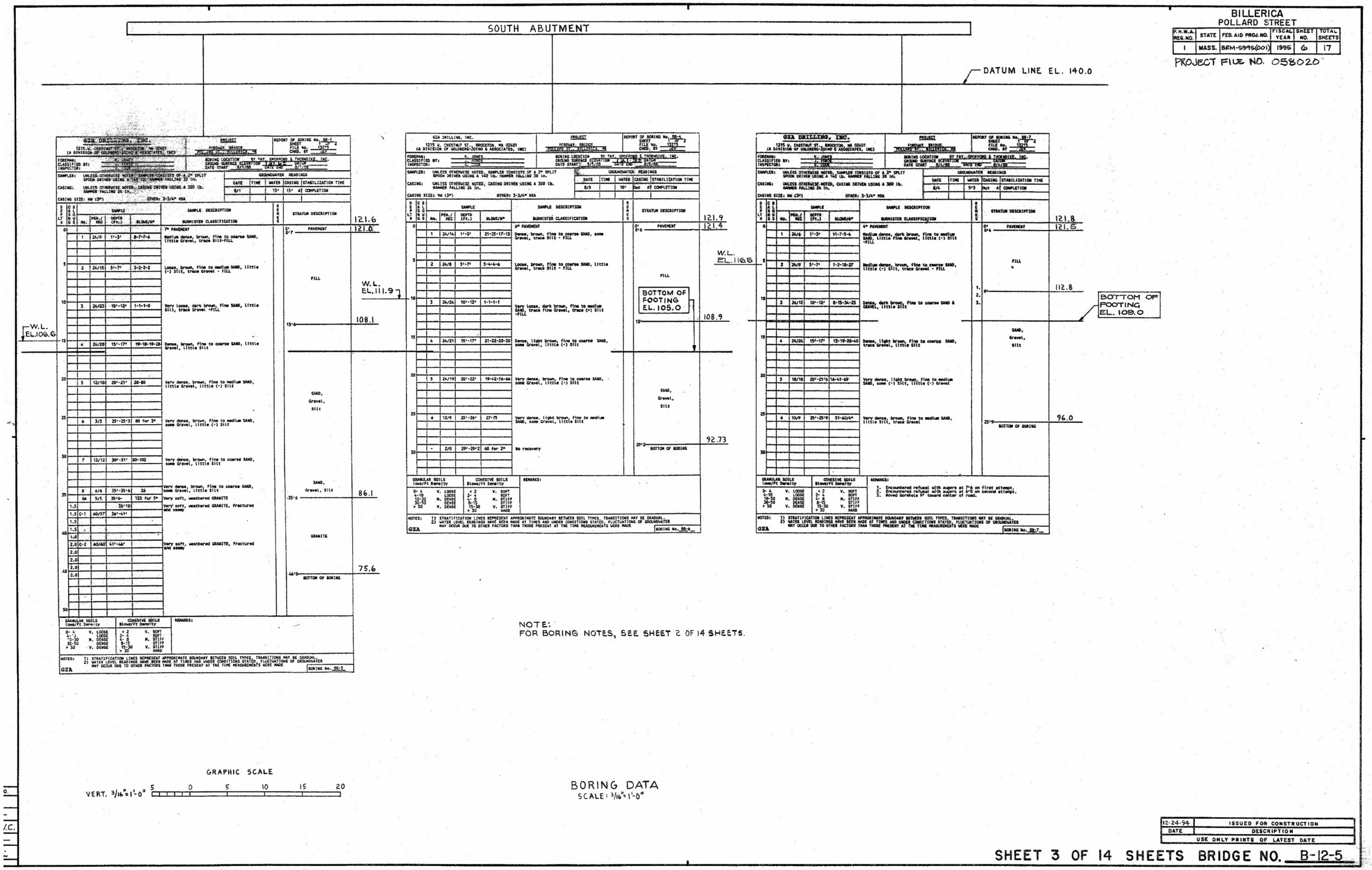


Figure 2.3.3-4: Boston Road/Route 3A Bridge Plan and Profile Drawing

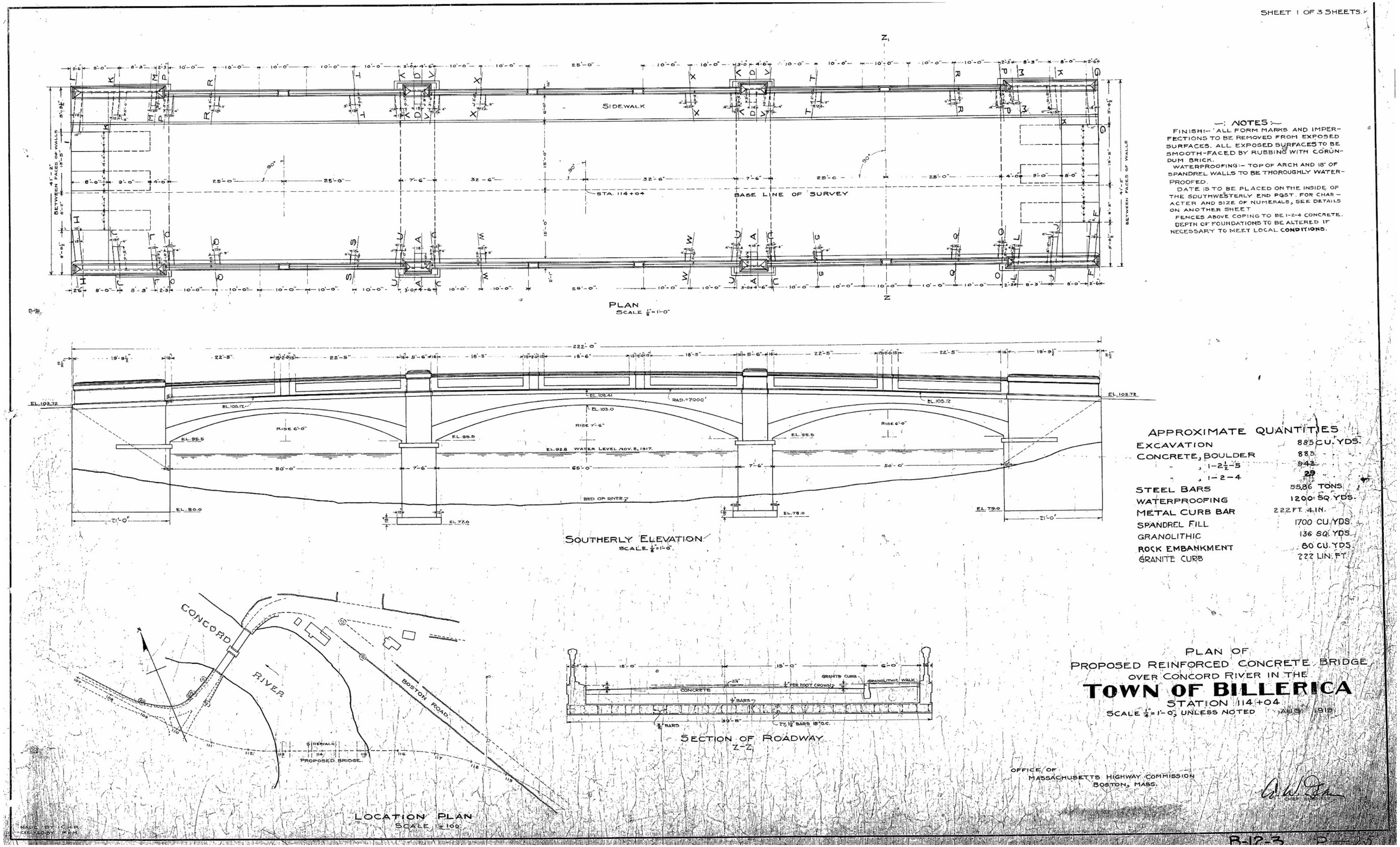


Figure 2.3.3-5: Boston Road/Route 3A Bridge Boring Log

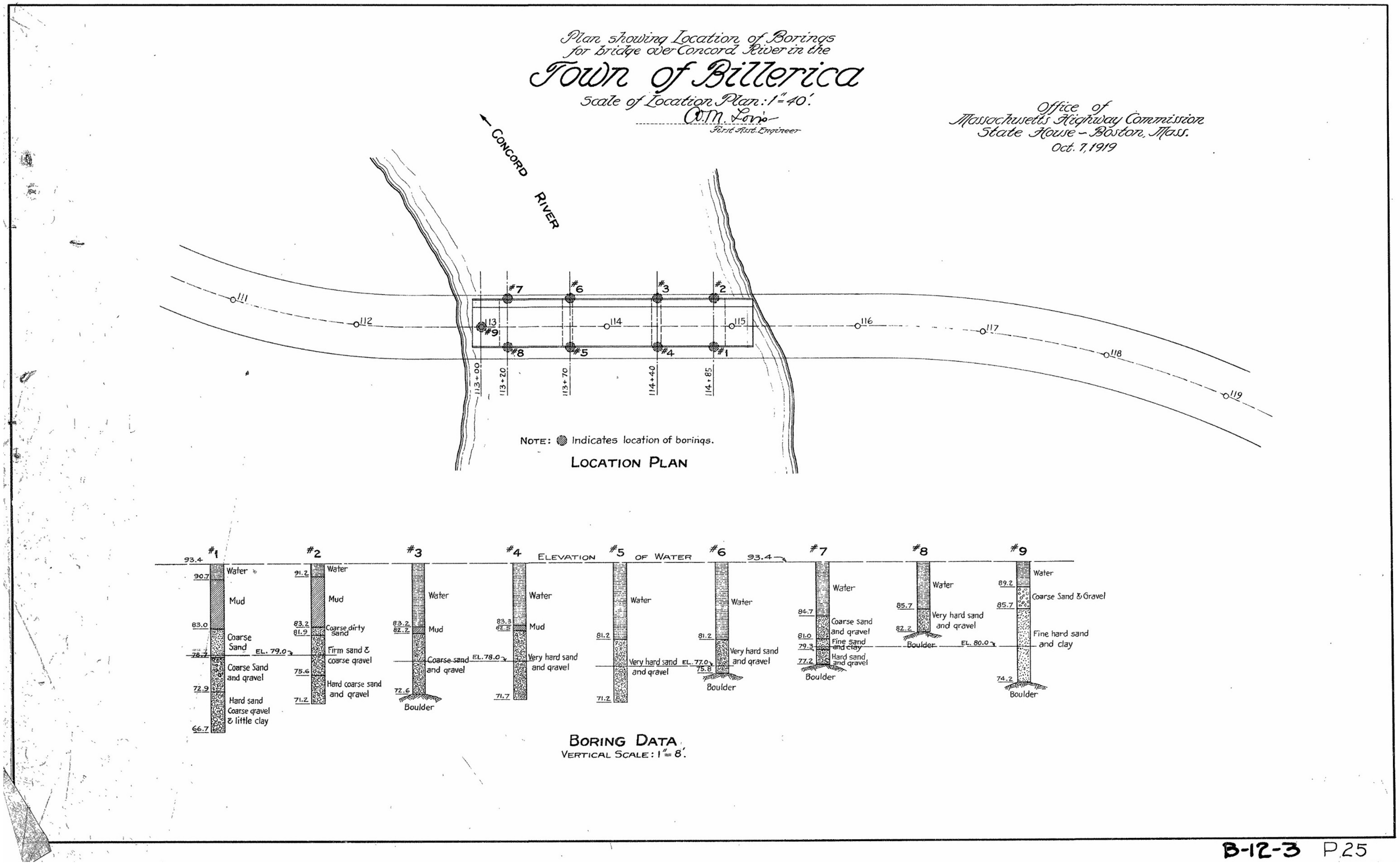
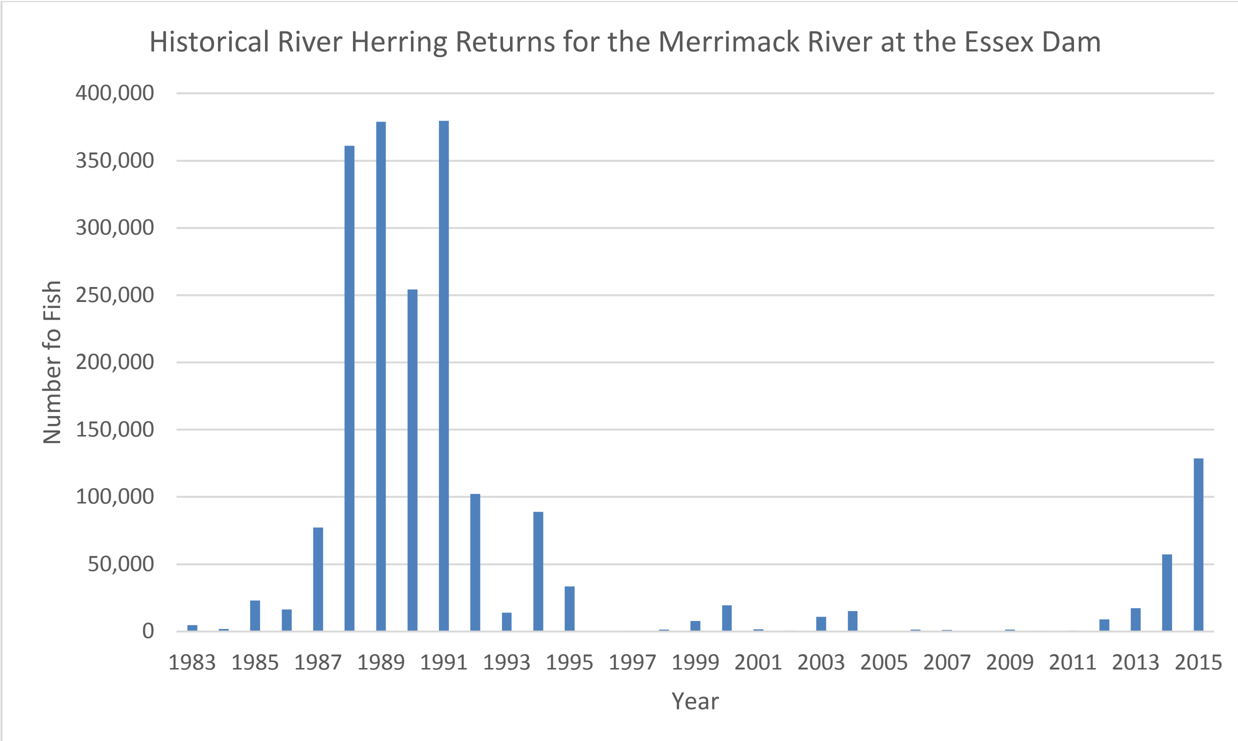


Table 2.4.1-1: Historical Diadromous Fish Returns for the Merrimack River at the Essex Dam

Year	Species				
	*River herring**	*American shad*	*Atlantic salmon*	*Sea lamprey*	*American eel***
2015	128,692	86,857	12	5,035	14,771
2014	57,213	38,107	75	4,923	4,388
2013	17,359	37,149	22	548	3,565
2012	8,992	21,396	137	2,067	45,738
2011	740	13,835	402	2,571	541
2010	518	10,442	85	3,433	2,764
2009	1,456	23,199	81	2,041	-
2008	108	25,116	119	4,873	-
2007	1,169	15,876	74	1,399	-
2006	1,257	1,205	91	-	-
2005	99	6,382	34	848	-
2004	15,051	36,593	129	6,700	-
2003	10,866	55,620	147	2,200	-
2002	526	54,586	56	8,100	-
2001	1,550	76,717	83	3,700	-
2000	19,405	72,800	82	11,000	-
1999	7,898	56,461	185	9,700	-
1998	1,362	27,891	123	4,000	-
1997	403	22,661	71	8,600	-
1996	51	11,322	76	3,600	-
1995	33,425	13,861	34	4,000	-
1994	88,913	4,349	21	5,000	-
1993	14,027	8,599	61	11,000	-
1992	102,166	20,796	199	18,000	-
1991	379,588	16,098	332	10,000	-
1990	254,242	6,013	248	8,300	-
1989	378,973	7,875	84	12,000	-
1988	361,012	12,359	65	8,900	-
1987	77,209	16,909	139	18,000	-
1986	16,265	18,173	103	13,000	-
1985	23,112	12,793	213	18,000	-
1984	1,769	5,497	115	2,000	-
1983	4,794	5,629	114	2,800	-
1982	-	-	23	-	-
Total	**2,010,210**	**843,166**	**3,835**	**216,338**	**71,767**

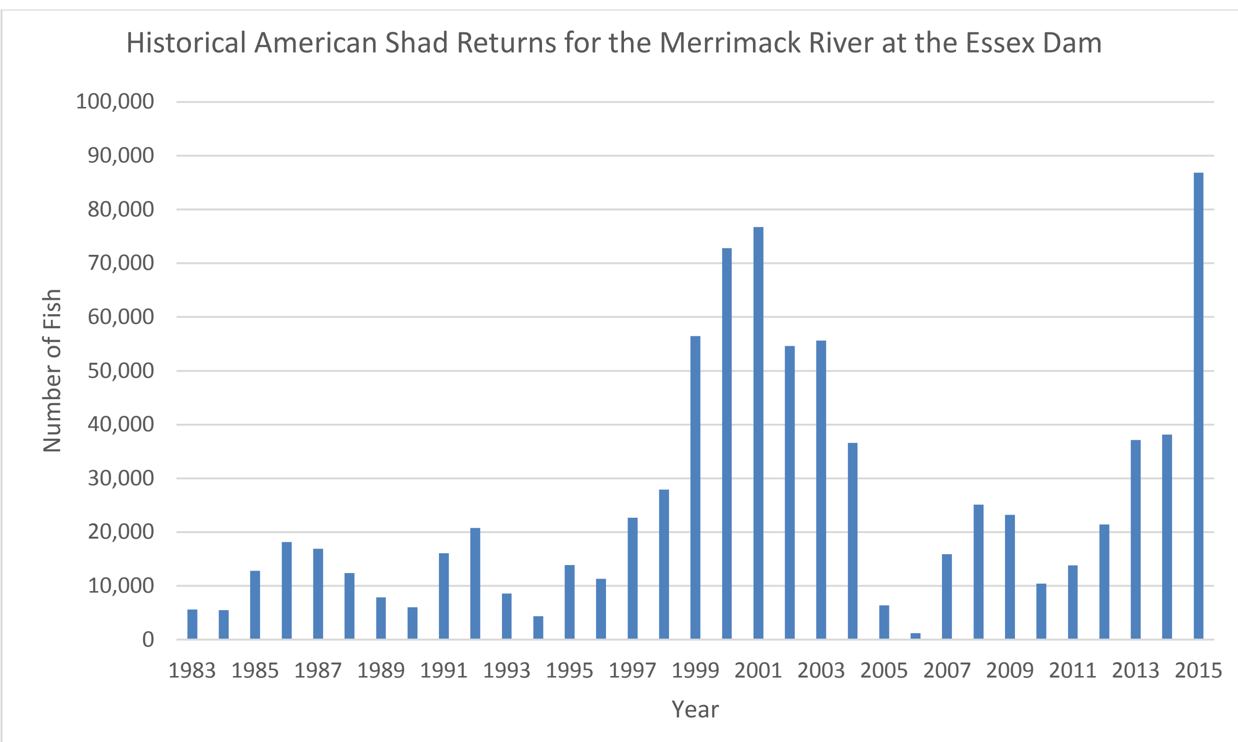
Source: USFWS, 2015
**River herring refers collectively to two fish species: blueback herring and alewife.*
***Eel totals are a sum of counts from a fish lift and a permanent eel ladder installed in 2013. However, the installation of a new crest gate in 2009 and the eel ladder (and subsequent adjustments of the ladder) have led to highly variable and unreliable numbers.*

Figure 2.4.1-1: Historical River Herring Returns for the Merrimack River at the Essex Dam



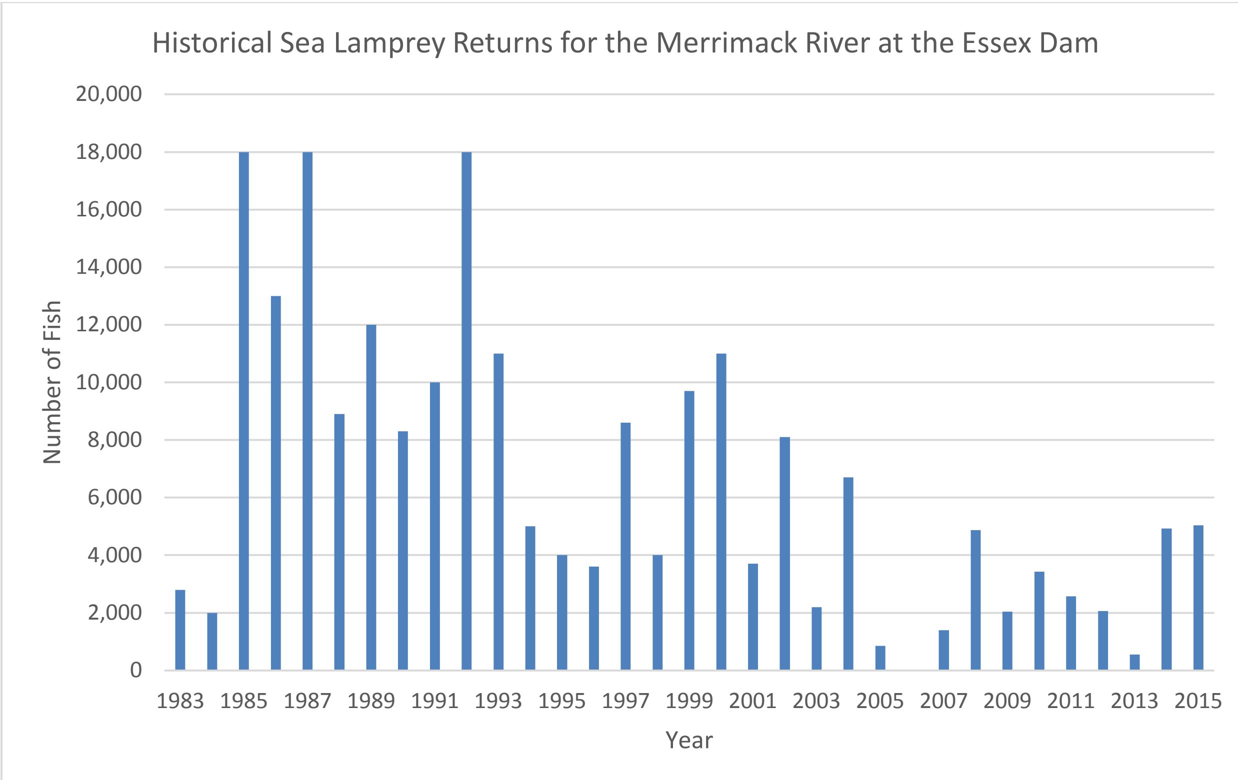
Source: USFWS, 2015. River herring refers collectively to two fish species: blueback herring and alewife.

Figure 2.4.1-2: Historical American Shad Returns for the Merrimack River at the Essex Dam



Source: USFWS, 2015.

Figure 2.4.1-3: Historical Sea Lamprey Returns for the Merrimack River at the Essex Dam



Source: USFWS, 2015.

Table 2.4.2-1: Timing of Important Life Cycle Events for Target Species

Species	Life Stage	Event	Month									
			MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
River herring	adults	*upstream migration*		4/15		6/15						
	juveniles	*downstream emigration*					7/1				11/30	
American shad	adults	*upstream migration*			5/1		7/15					
	juveniles	*downstream emigration*					7/1				11/30	
American eel	glass eels & elvers	*upstream migration*		4/1						10/31		
	silver eels	*downstream emigration*							9/1			12/31
Sea lamprey	adults	*upstream migration*			5/1	6/30						
	trans-formers	*downstream emigration*							9/1			12/31

Table 2.4.2-2: Summary of Swimming Speeds for Target Species

Species*	**Swimming Speed** (ft/s)		
	Cruising	*Sustained*	*Burst*
Alewife Blueback herring	0-3	3-5	5-7
American shad	0-3	3-7	8-13.5
American eel (glass eels & elvers)**	-	0.25-0.5	1-5
Sea lamprey**	0-1	1-3	3-7

**Swimming speeds are reported for the upstream migrant life stage.*

***Climbing and/or attachment behaviors may help eel and lamprey pass through difficult obstacles.*

Sources: All swimming speeds estimated from table in Bell, 1991 except American eel burst speeds, which are from Gulf of Maine Council on the Marine Environment, 2007.

Figure 3.2.1-1: Map of Talbot Mills Dam Impoundment Sediment Transects & Samples

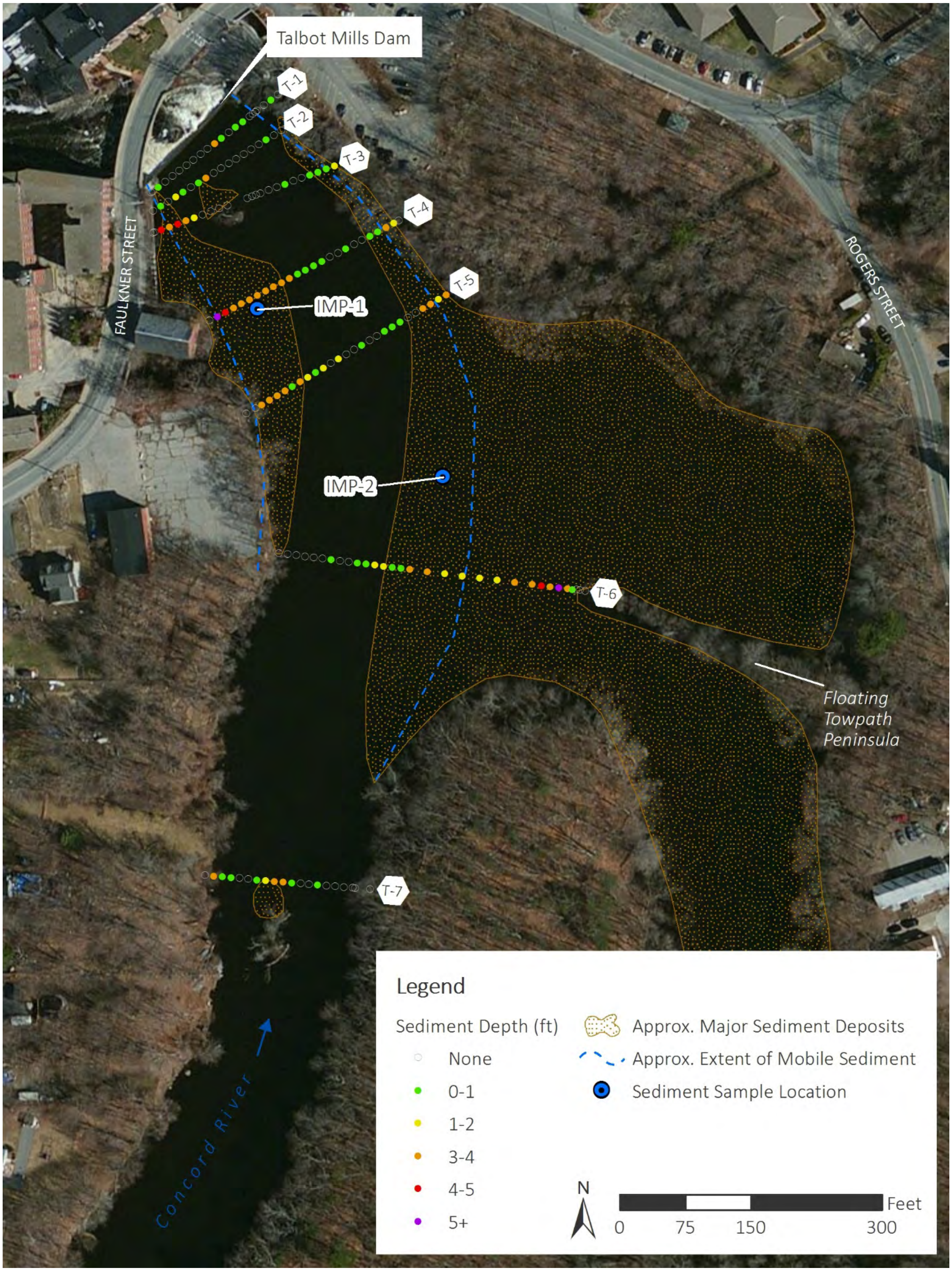


Figure 3.2.1-2: Map of Talbot Mills Dam Impoundment Sediment Transects & Samples *(with aquatic veg)*

Figure 3.2.1-3: Talbot Mills Dam Impoundment Sediment Depth Transect T-1 *(upstream of dam)*

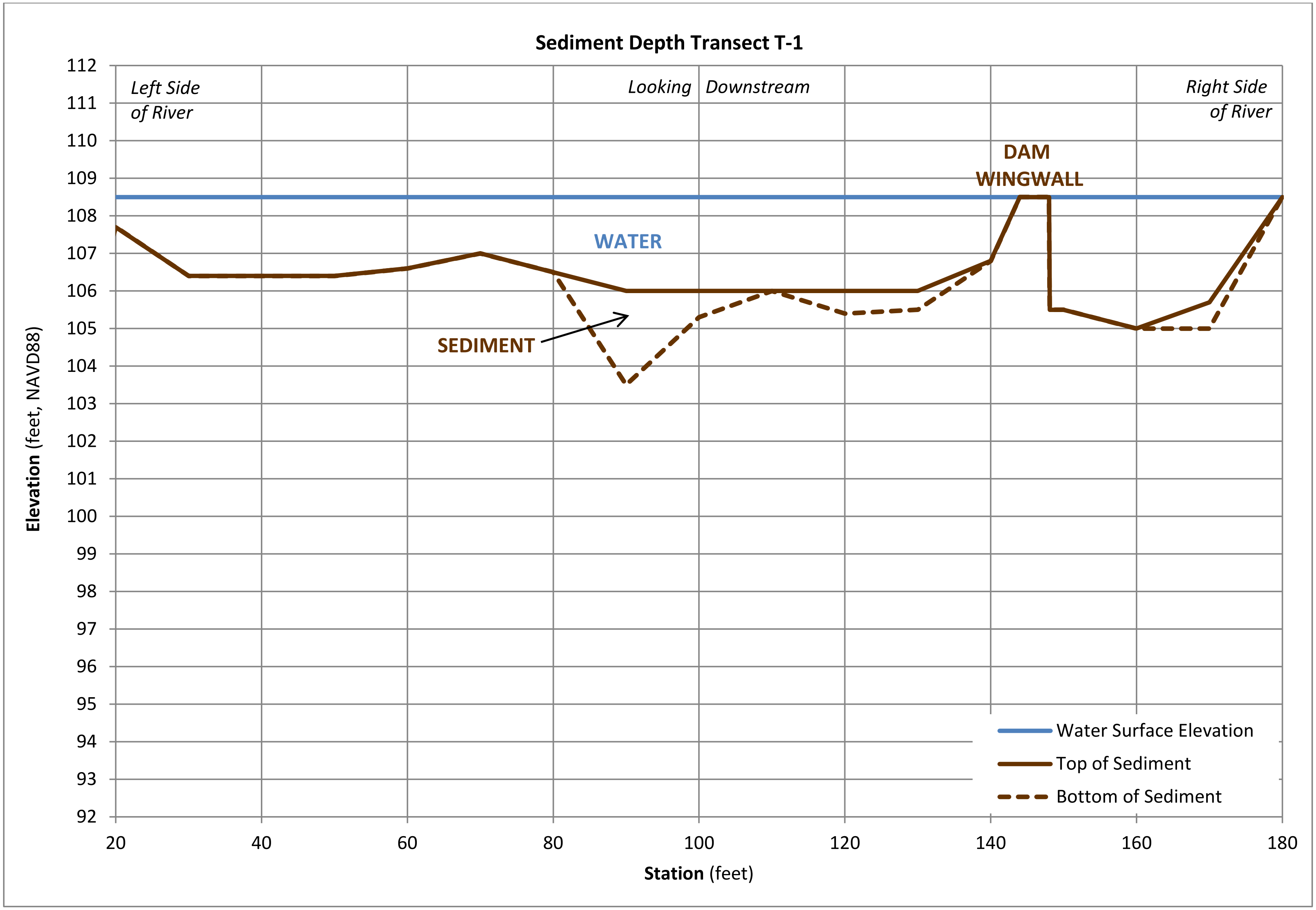


Figure 3.2.1-4: Talbot Mills Dam Impoundment Sediment Depth Transect T-2

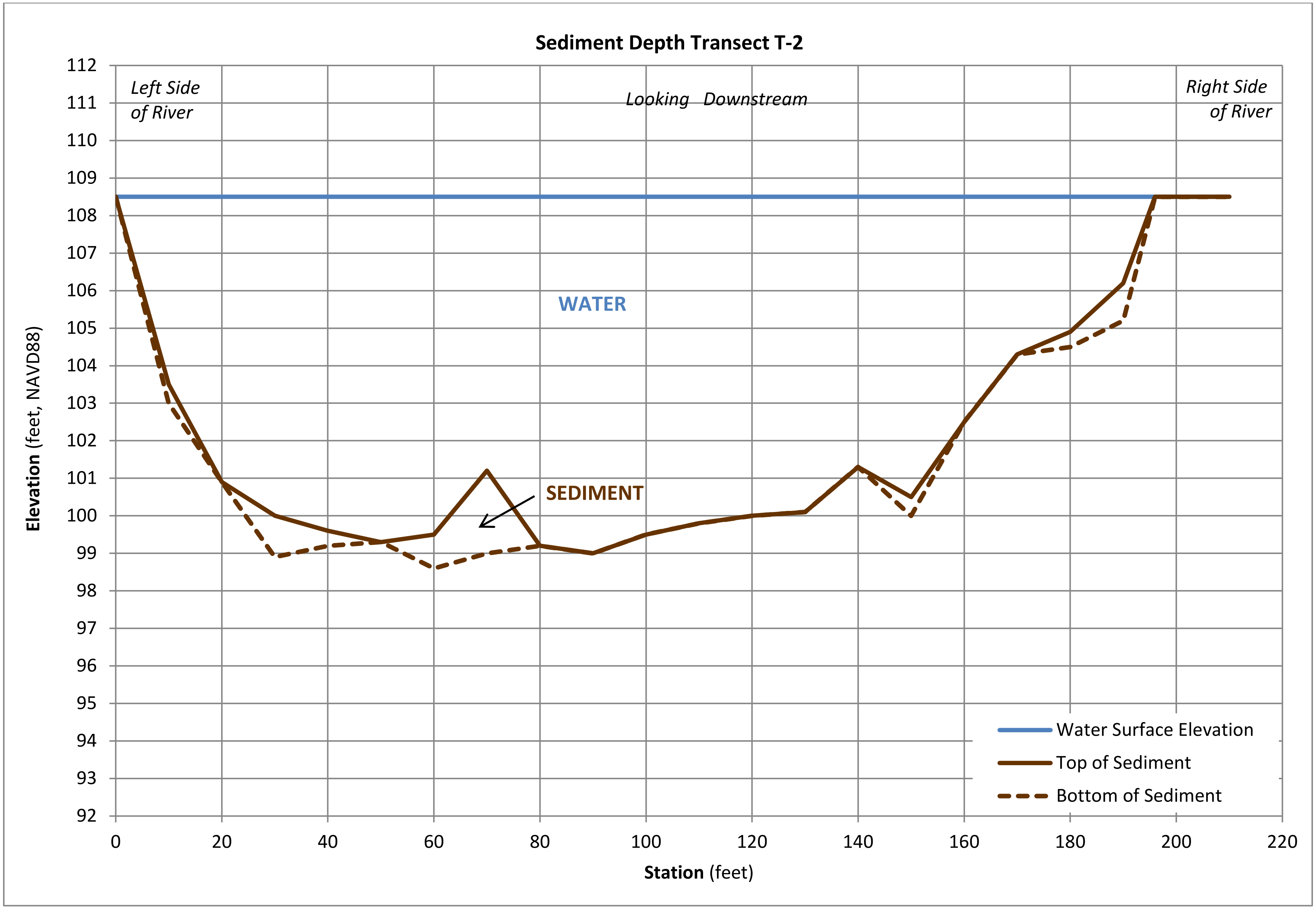


Figure 3.2.1-5: Talbot Mills Dam Impoundment Sediment Depth Transect T-3

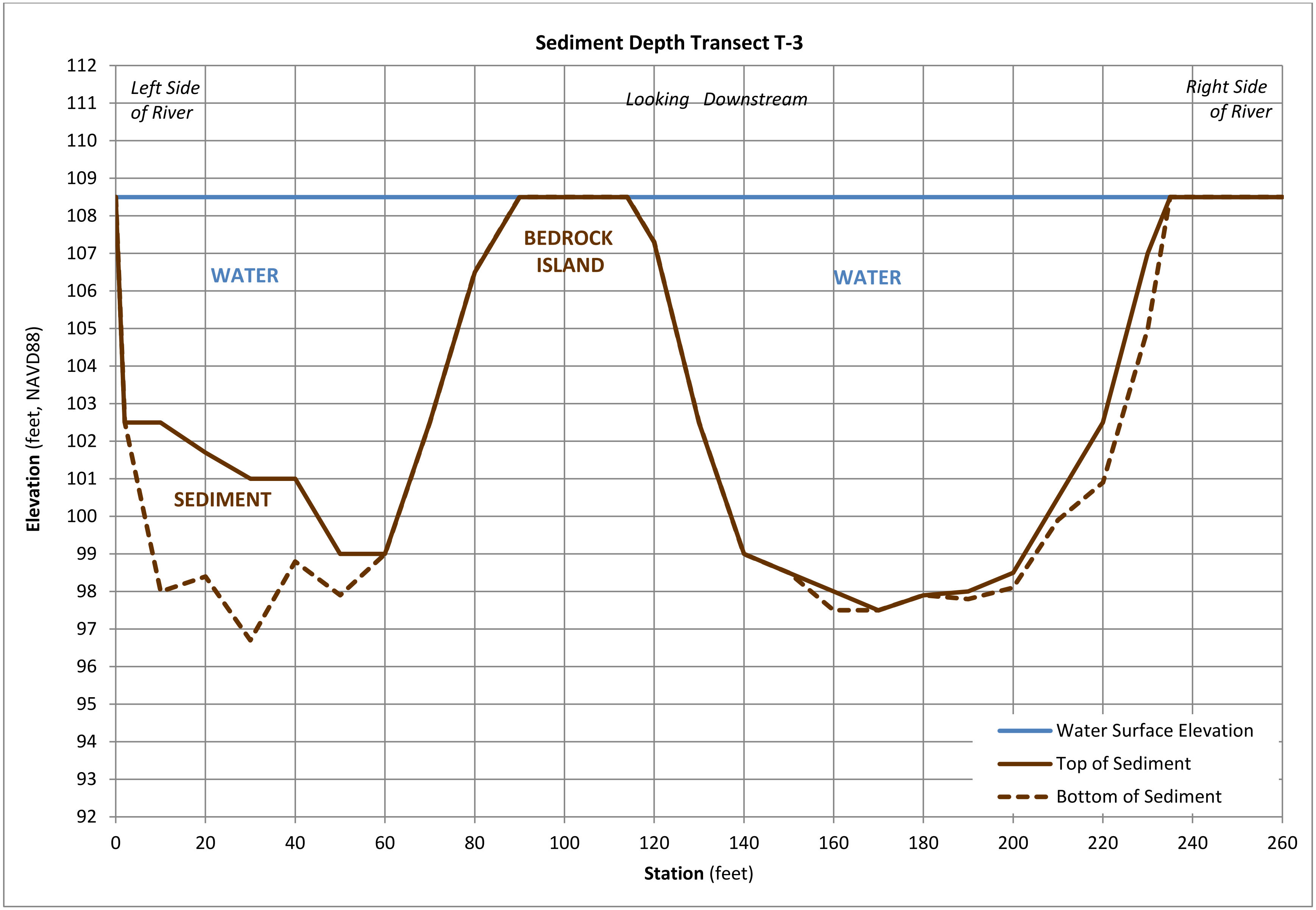


Figure 3.2.1-6: Talbot Mills Dam Impoundment Sediment Depth Transect T-4

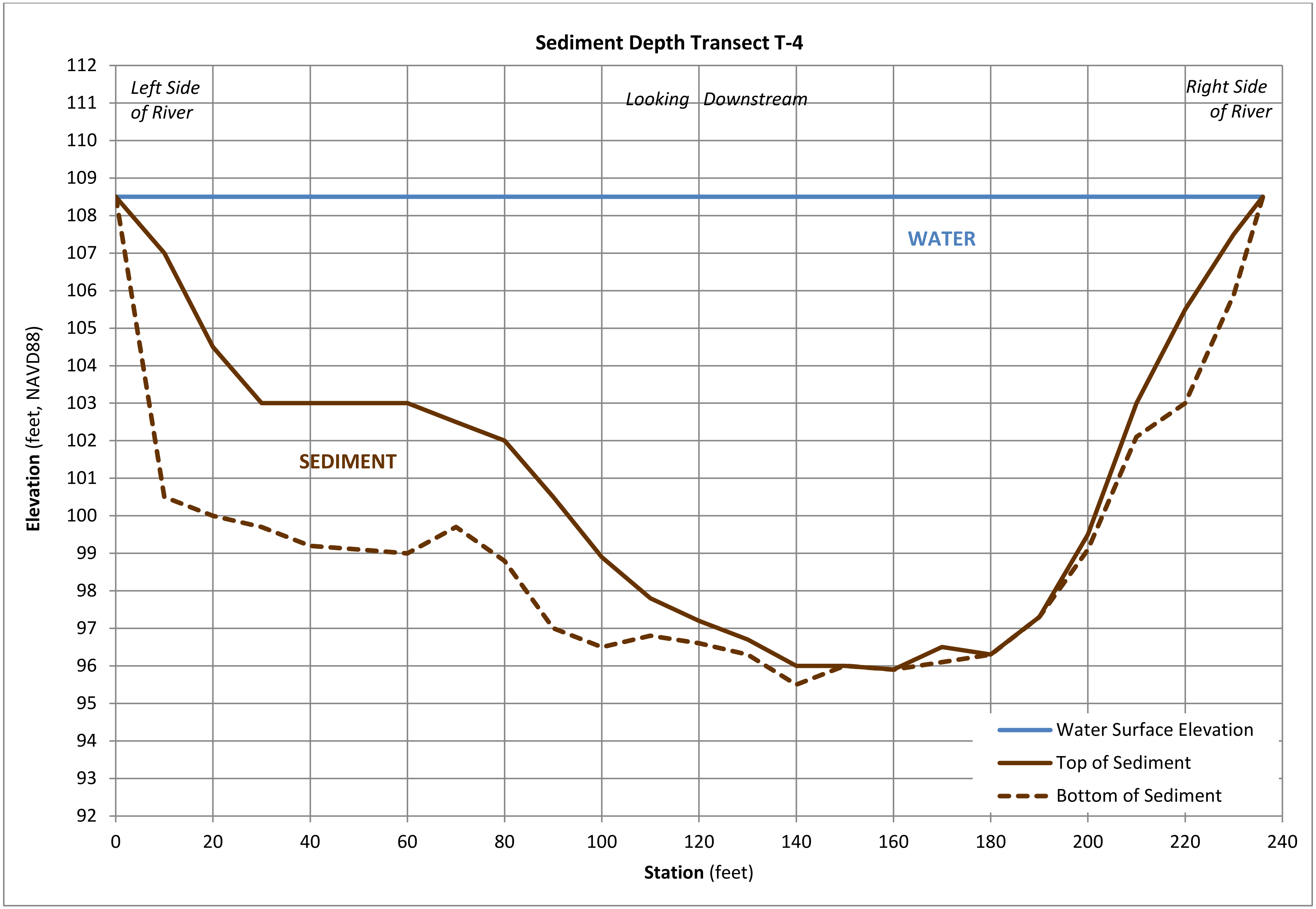


Figure 3.2.1-7: Talbot Mills Dam Impoundment Sediment Depth Transect T-5

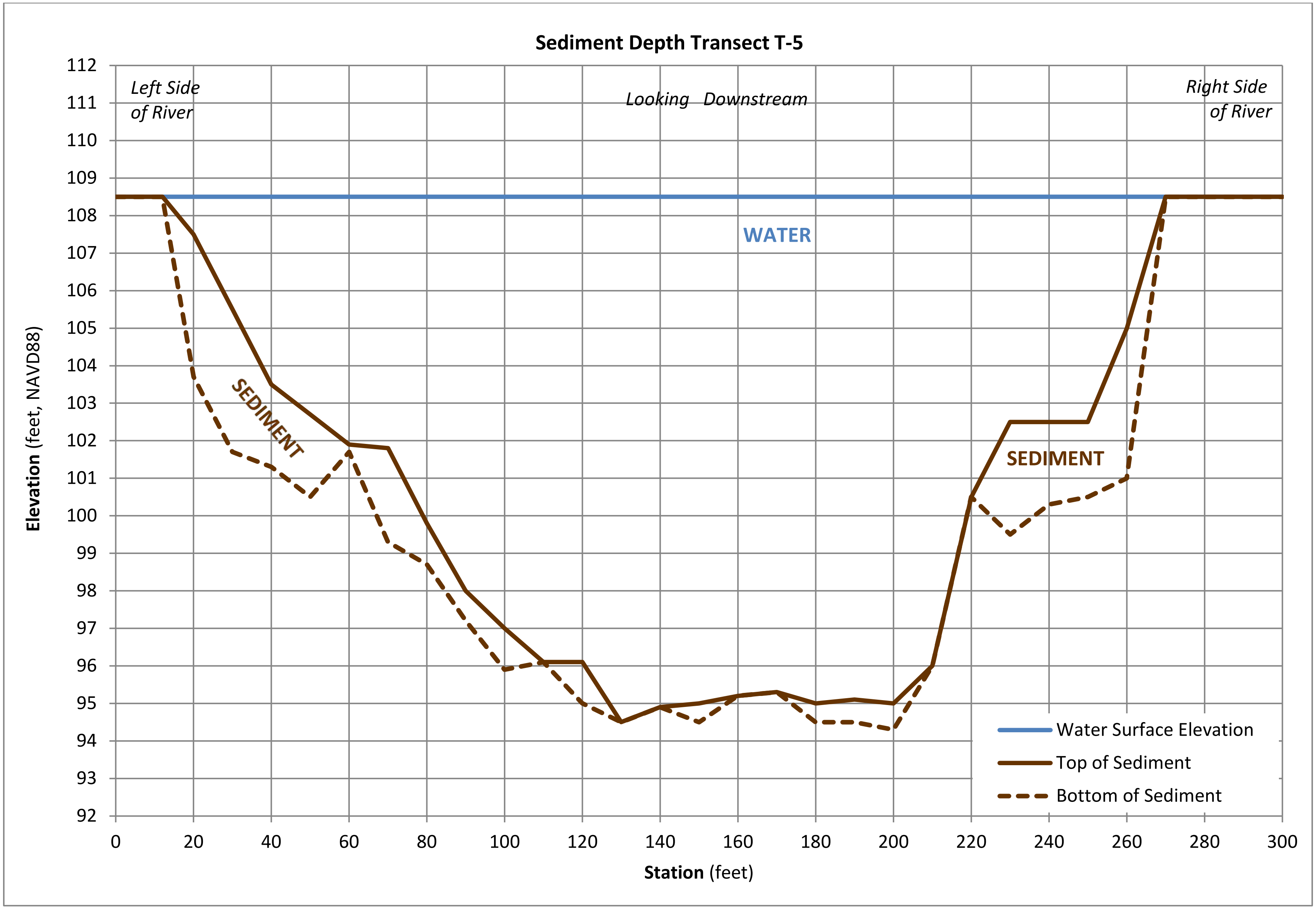


Figure 3.2.1-8: Talbot Mills Dam Impoundment Sediment Depth Transect T-6

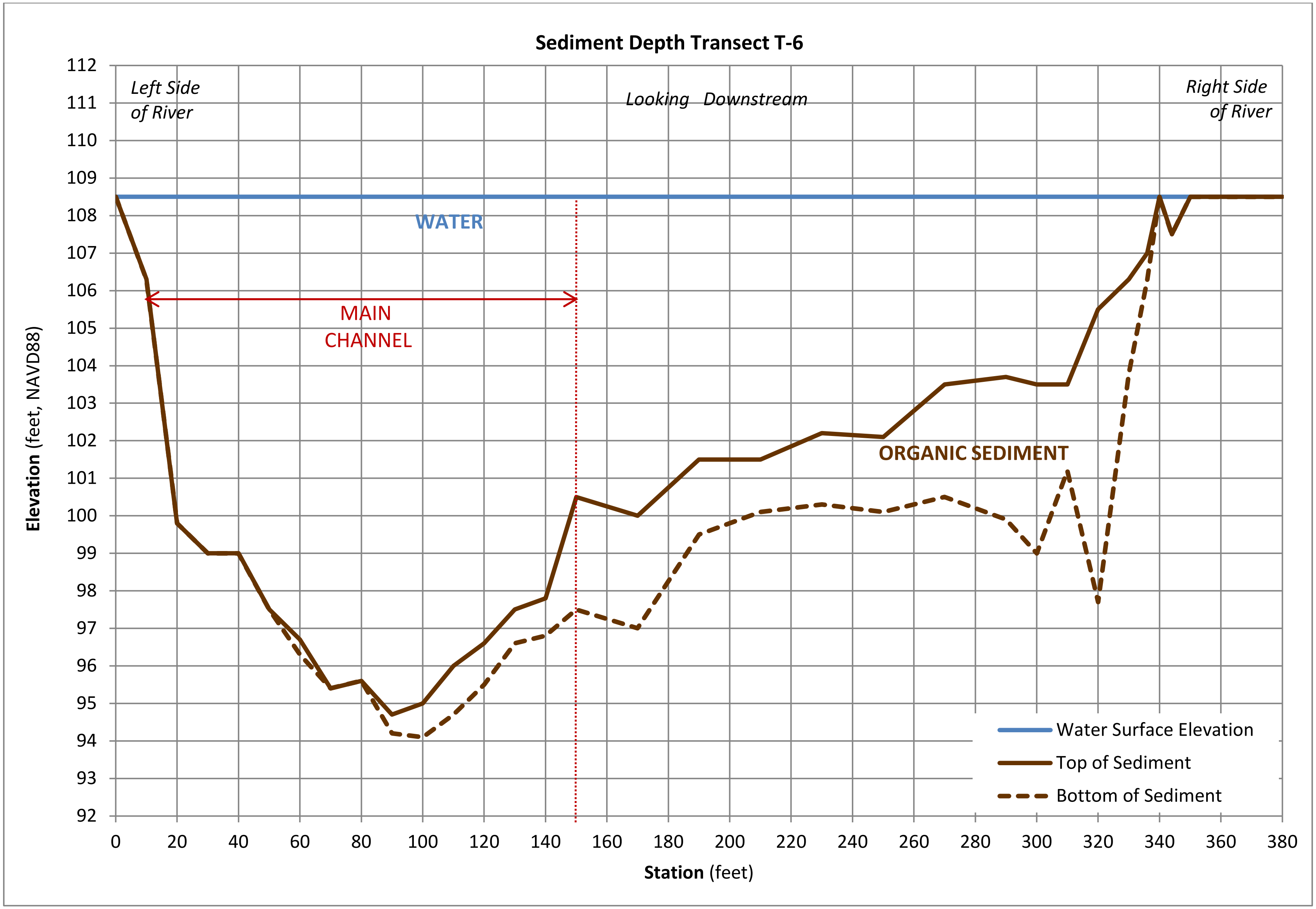


Figure 3.2.1-9: Talbot Mills Dam Impoundment Sediment Depth Transect T-7

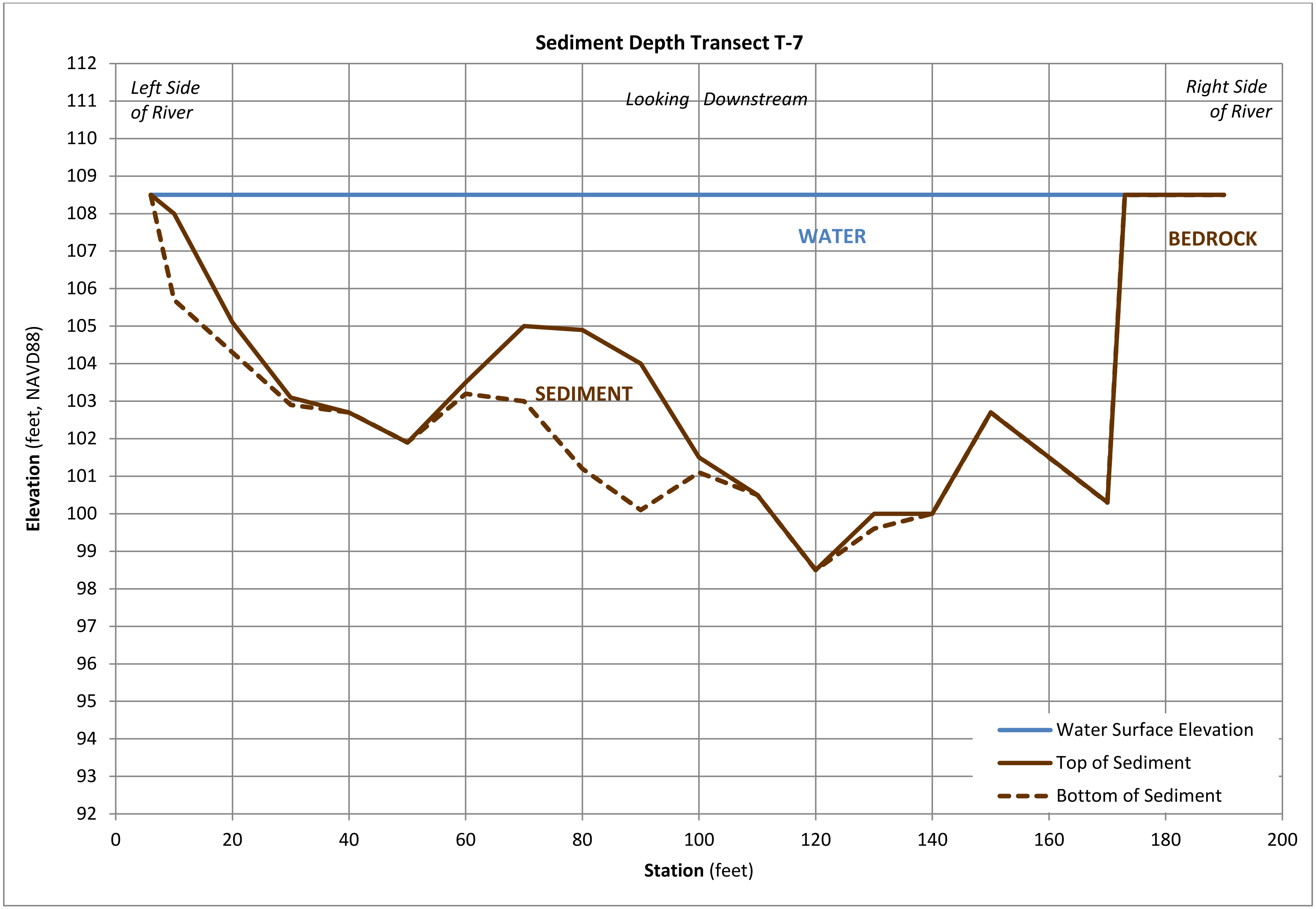


Figure 3.2.1-10: Talbot Mills Dam Impoundment Sediment Depth Transect T-8 *(Fordway Bar)*

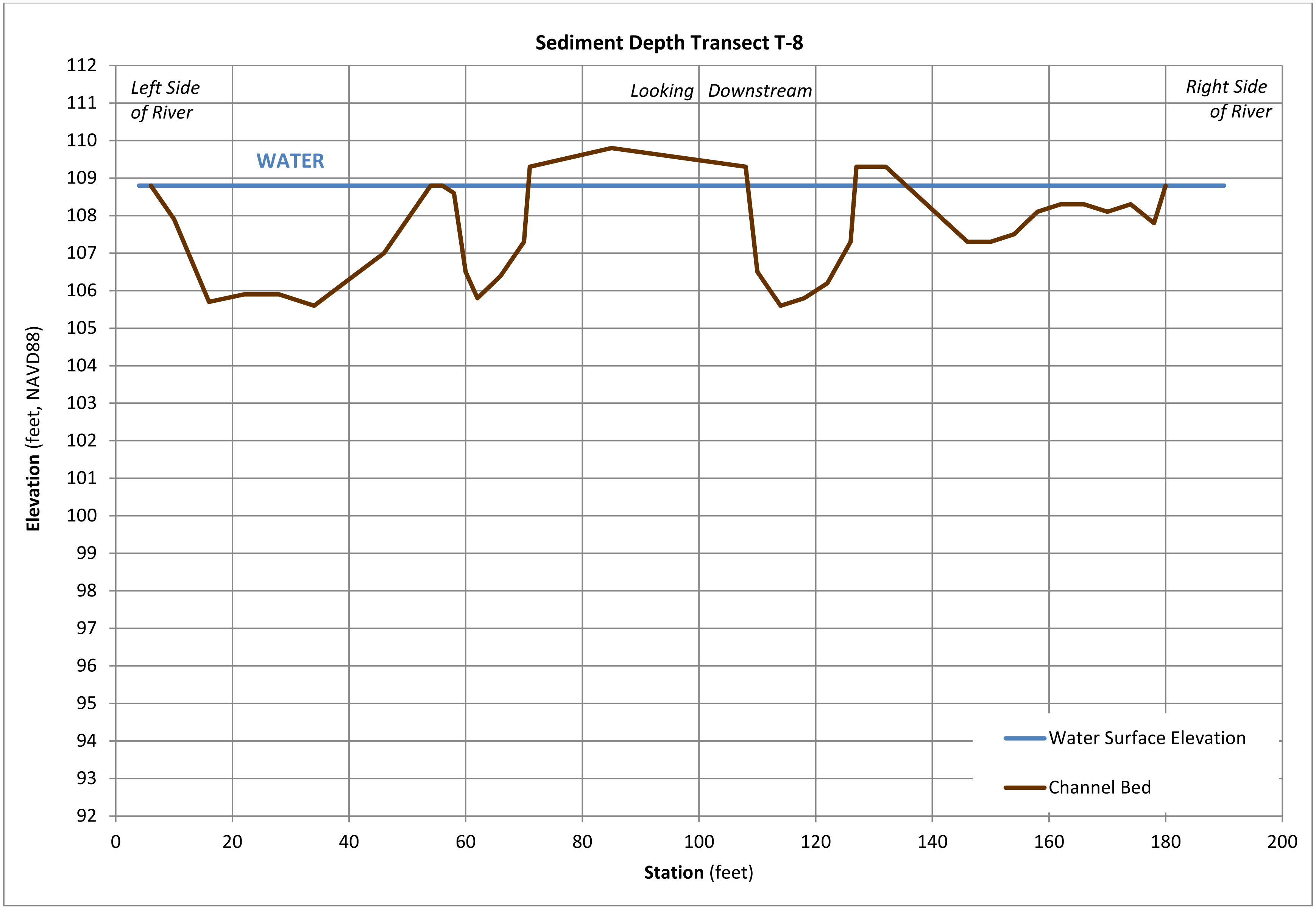


Figure 3.2.2-1: Map of Sediment Sampling Locations

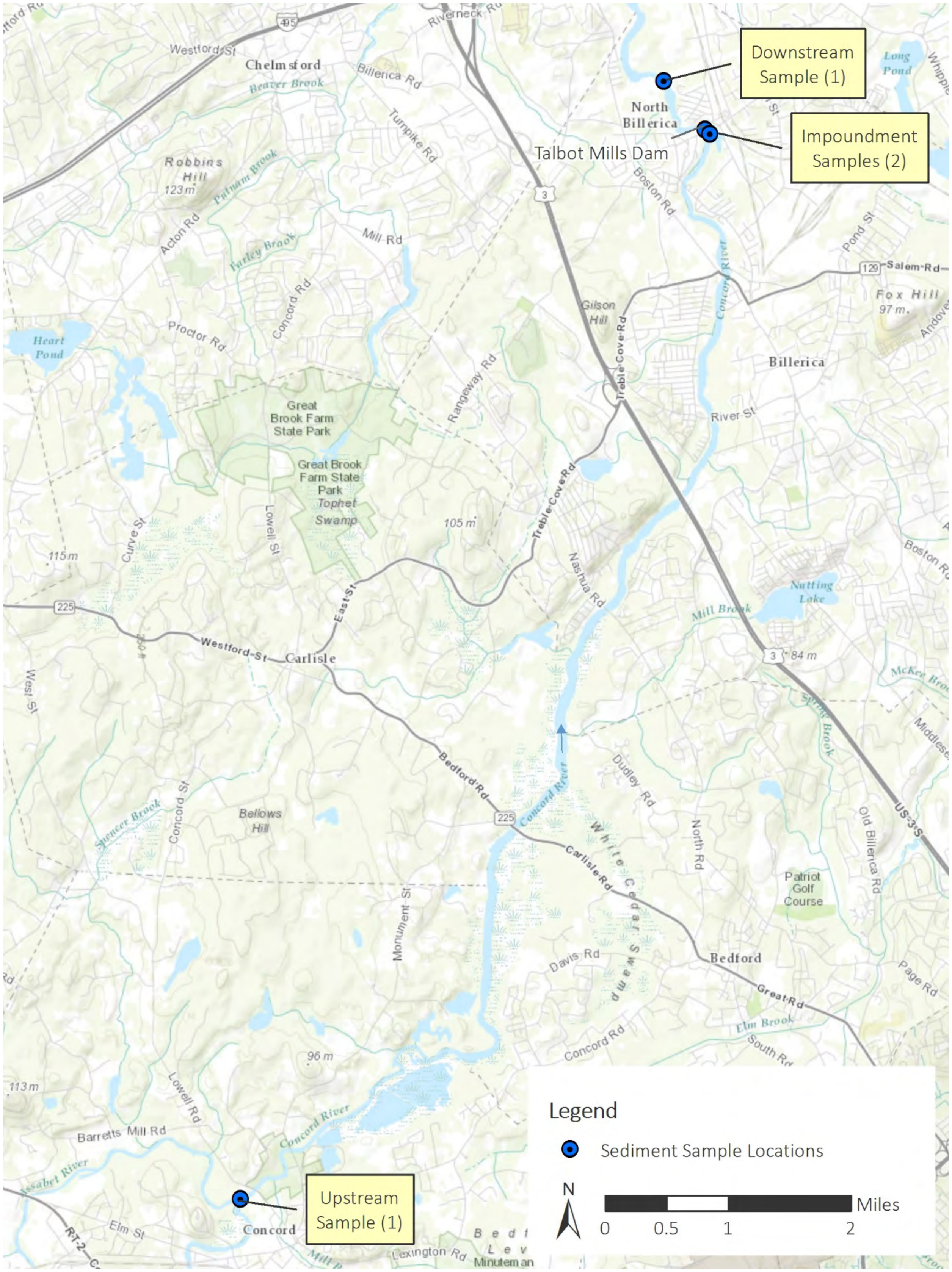


Table 3.2.2-1: Sediment Sample Info

Sample ID	Location	Date	Time	Notes
IMP-1	Dam impoundment, river left. On sediment probing transect T-4, about 60 ft from left bank tie-off	11/6/2014	7:50 AM	Composited 2 full cores. Approx. 5 ft sediment depths / 4 ft water depths. Mostly silty/organic, bottom foot sand, some detritus, slight oil sheen, odor.
IMP-2	Dam impoundment, river right. Near sediment probing transect T-6 (slightly downstream), about 65 yds from left bank	11/6/2014	8:45 AM	Composited about 4 full cores. Approx. 1-3 ft sediment depths / 6-7 ft water depths. Mostly silty/organic, bottom half-foot sand, some detritus, slightly oily sheen, odor.
DS-1	Downstream of dam at powerline crossing, about 20-25 ft off left bank	11/6/2014	1:35 PM	Composited 3 cores. Approx. 1.5 ft core depths (sediment deeper) / 4 ft water depths. Organic/silty material. Impounded by downstream dam.
US-1	Just below confluence of Assabet & Sudbury Rivers	11/6/2014	12:15 PM	Composited 3 full cores. Approx. 1-2.5 ft sediment depths / 2.5 ft water depths. Sandy substrate, some cobble. Detectable velocity.

Table 3.2.2-1: Sediment Sampling Results

Parameter	Screening Benchmarks			Dam Impoundment Samples			Downstream Sample	Upstream Sample
(Important: units by category below)	**MCP S1/GW1** *Human Health*	**TEC** *Freshwater*	**PEC** *Freshwater*	IMP-1	IMP-2	Mean	DS-1	US-1
Metals [mg/kg]								
Arsenic	20.0	9.79	33.0	15	12	13.5	5.1	4.7
Cadmium	70.0	0.99	4.98	0.7	1.1	0.9	0.95	0.43
Chromium (Total)	100.0	43.4	111.0	**140**	97	**118.5**	21	44
Chromium (VI)	100.0			2.35	3.6	3.0	3.3	0.75
Copper		31.6	149.0	46	420	233.0	24	9.9
Lead	200.0	35.8	128.0	67	130	98.5	18	15
Mercury	20.0	0.18	1.06	1.3	1.7	1.5	0.56	0.089
Nickel	600.0	22.7	48.6	11	14	12.5	9.6	6.9
Zinc	1,000.0	121.0	459.0	120	230	175.0	40	56
SVOCs (PAHs)[ug/kg]								
Acenaphthene	4,000.0			15	23.5	19.3	21	9.5
Acenaphthylene	1,000.0			58	23.5	40.8	21	9.5
Anthracene	1,000,000.0	57.2	845.0	82	16.5	49.3	14.5	15
Benzo[a]anthracene	700.0	108.0	1,050.0	290	28	159.0	48	73
Benzo(a)pyrene	2,000.0	150.0	1,450.0	270	29	149.5	39	76
Benzo[b]fluoranthene	7,000.0	27.3	13,400.0	350	42	196.0	49	100
Benzo[g,h,i]perylene	1,000,000.0			170	39.5	104.8	35.5	55
Benzo[k]fluoranthene	70,000.0			120	16.5	68.3	14.5	36
Chrysene	70,000.0	166.0	1,290.0	320	38	179.0	57	98
Dibenz[a,h]anthracene	700.0	33.0	260.0	45	16.5	30.8	14.5	14
Fluoranthene	1,000,000.0	423.0	2,230.0	600	39.5	319.8	100	94
Fluorene	1,000,000.0	77.4	536.0	45	70	57.5	65	29
Indeno[1,2,3-cd]pyrene	7,000.0			190	16.5	103.3	14.5	57
2-Methylnaphthalene	700.0			45	70	57.5	65	29
Naphthalene	4,000.0	176.0	561.0	45	390	217.5	65	29
Phenanthrene	10,000.0	204.0	1,170.0	300	4.65	152.3	85	33
Pyrene	1,000,000.0	195.0	1,520.0	490	70	280.0	65	130
Total PAHs (calculated)		1,610.0	22,800.0	3435	933.65	2184.3	773.5	887
PCBs (ug/kg)								
Aroclor 1016				15	23	19.0	20.5	9.5
Aroclor 1221				15	23	19.0	20.5	9.5
Aroclor 1232				15	23	19.0	20.5	9.5
Aroclor 1242				15	23	19.0	20.5	9.5
Aroclor 1248				15	23	19.0	20.5	9.5
Aroclor 1254				34	100	67.0	20.5	9.5
Aroclor 1260				15	23	19.0	20.5	9.5
Aroclor 1262				15	23	19.0	20.5	9.5
Aroclor 1268				15	23	19.0	20.5	9.5
Total PCBs (calculated)	1,000.0	59.8	676.0	154	284	219.0	184.5	85.5

Parameter	Screening Benchmarks			Dam Impoundment Samples			Downstream Sample	Upstream Sample
(Important: units by category below)	**MCP S1/GW1** *Human Health*	**TEC** *Freshwater*	**PEC** *Freshwater*	IMP-1	IMP-2	Mean	DS-1	US-1
Pesticides (ug/kg)								
Aldrin	80.0			1.45	2.3	1.9	2.05	0.95
alpha-BHC				1.45	2.3	1.9	2.05	0.95
beta-BHC				1.45	2.3	1.9	2.05	0.95
delta-BHC				1.45	2.3	1.9	2.05	0.95
gamma-BHC (Lindane)		2.4	5.0	0.6	0.9	0.8	0.8	0.38
Chlordane	5,000.0	3.2	17.6	6	9	7.5	8	3.8
4,4'-DDD	4,000.0	4.88	28.0	1.15	1.8	1.5	1.6	0.75
4,4'-DDE	3,000.0	3.16	31.3	1.15	1.8	1.5	1.6	0.75
4,4'-DDT	3,000.0	4.16	62.9	1.15	1.8	1.5	1.6	0.75
Total DDTs (calc'd)		5.28	572.0					
Dieldrin	80.0	1.9	61.8	1.15	1.8	1.5	1.6	0.75
Endosulfan I				1.45	2.3	1.9	2.05	0.95
Endosulfan II				2.35	3.65	3.0	3.25	1.55
Endosulfan Sulfate				2.35	3.65	3.0	3.25	1.55
Endrin	10,000.0	2.2	207.0	2.35	3.65	3.0	3.25	1.55
Endrin Ketone				2.35	3.65	3.0	3.25	1.55
Heptachlor	300			1.45	2.3	1.9	2.05	0.95
Heptachlor Epoxide	100.0	2.5	16.0	1.45	2.3	1.9	2.05	0.95
Hexachlorobenzene	700.0			1.75	2.75	2.3	2.45	1.15
Methoxychlor				14.5	23	18.8	20.5	9.5
Physical Characteristics								
TOC (mg/kg)				176900	176900		132700	8280
Percent Solids (%)				33.4	21.5		23.9	51.3
Percent Water (%)				66.6	78.5		76.1	48.7
pH				5.8	5.8		5.9	5.8
Grain Size Dist. (%)								
Sieve No. 4				97	90		97	97
Sieve No. 10				93	79		95	80
Sieve No. 40				31	21		74	25
Sieve No. 60				16	10		65	11
Sieve No. 200				3.3	2.9		24	1.1

Key

- X Exceeds freshwater Threshold Effects Concentration (TEC)
- X Exceeds freshwater Probable Effects Concentration (PEC)
- **X** Exceeds Massachusetts Contingency Plan (MCP) Soil 1 / Groundwater 1 (S1/GW1) standards
- X Below the laboratory detection limit (BDL); a value of 1/2 the detection limit is provided

Notes: No TEC or PEC values exist for 4'4 DDD, DDE, or DDT. This sheet used the TEC and PEC values for the SUM of DDE, DDD, and DDT, respectively, to provide a conservative value for comparison. Total PCBs are calculated as the sum of aroclors; total PAHs are similarly calculated by summing values. Percent water is inferred from percent solids. TEC values are expected to be exceeded in a developed watershed such as the Concord River, but are provided in this table for reference.

Table 3.3.1-1: Average Daily Flow Statistics for the Concord River

Flow Statistic	Flow (cfs) for Time Period														
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN	Upstream Migration *(Apr 15-Jul 15)*	Downstream Migration *(Jul 1-Dec 31)*
USGS Gage No. 01099500 (Concord River at Lowell, MA)														**Drainage Area (mi^2):**	**400**
Minimum	50	90	182	211	67	32	16	9	4	6	23	22	4	19	4
95% exceeds	192	243	470	487	297	112	60	39	38	50	96	167	70	114	51
Median	750	853	1287	1345	827	566	290	244	242	347	536	746	670	498	401
Mean	627	736	1130	1180	757	430	186	153	136	208	424	625	498	594	242
5% exceeds	1550	1900	2600	2716	1600	1390	899	705	806	1110	1326	1660	1840	1760	1270
Maximum	5340	4270	5590	5540	3740	4340	3710	4490	3270	3240	2310	2840	5590	4340	4490
Talbot Mills Dam														**Drainage Area (mi^2):**	**370**
Minimum	46	83	168	195	62	30	15	8	4	6	21	20	4	18	4
95% exceeds	177	224	435	451	275	104	56	36	35	46	89	155	65	105	47
Median	694	789	1190	1245	765	524	268	226	224	321	496	690	619	460	371
Mean	580	680	1045	1092	700	398	172	142	126	192	392	578	461	549	224
5% exceeds	1434	1758	2405	2512	1480	1286	832	652	745	1027	1226	1536	1702	1628	1175
Maximum	4940	3950	5171	5125	3460	4015	3432	4153	3025	2997	2137	2627	5171	4015	4153

Note: Period of record = October 1936 through December 2015. Highlighted flows were selected for use in the hydraulic model for this study.

Figure 3.3.1-1: Annual Flow Duration Curve for Concord River at Talbot Mills Dam

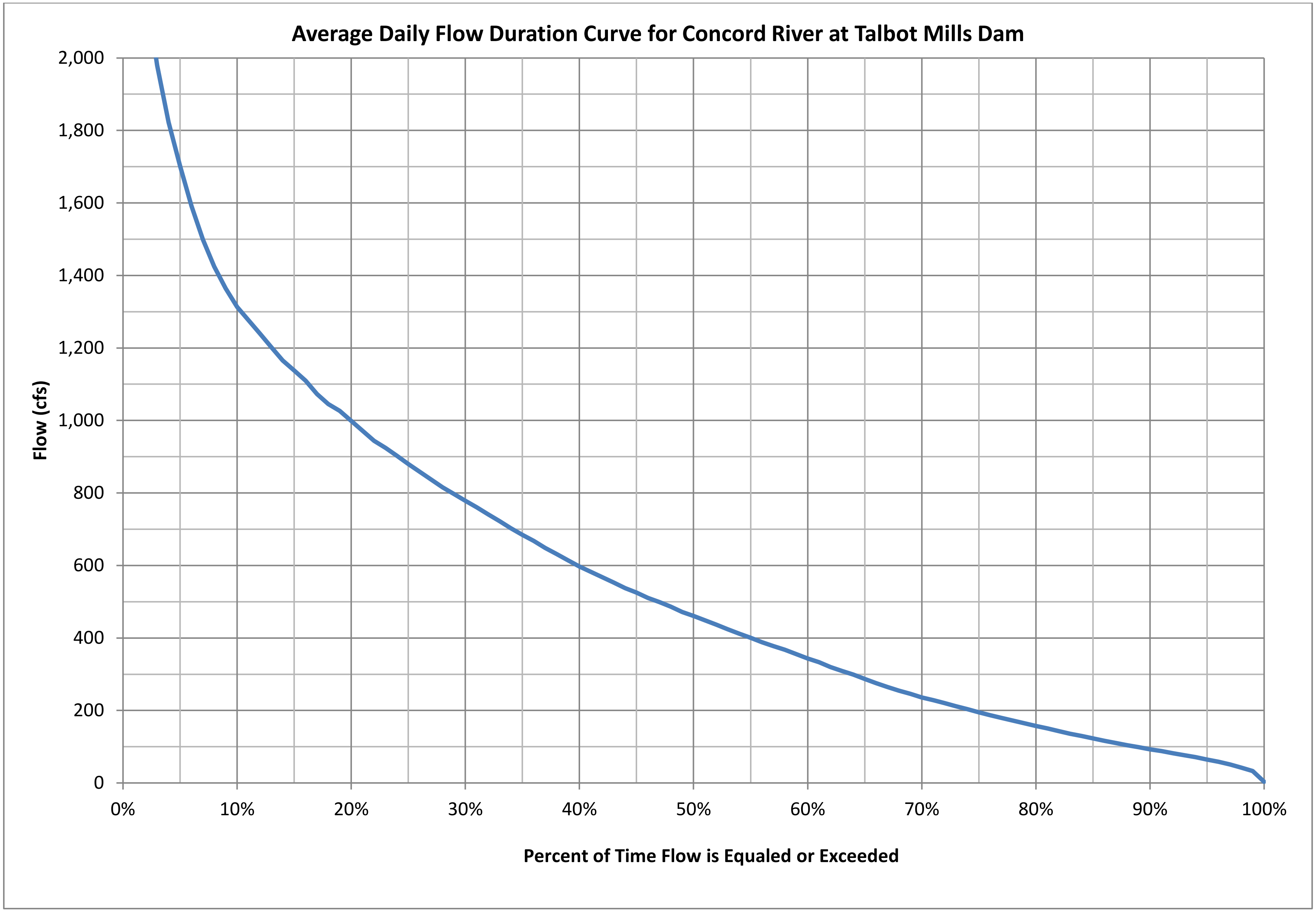


Figure 3.3.1-2: Jan-Mar Flow Duration Curves for Concord River at Talbot Mills Dam

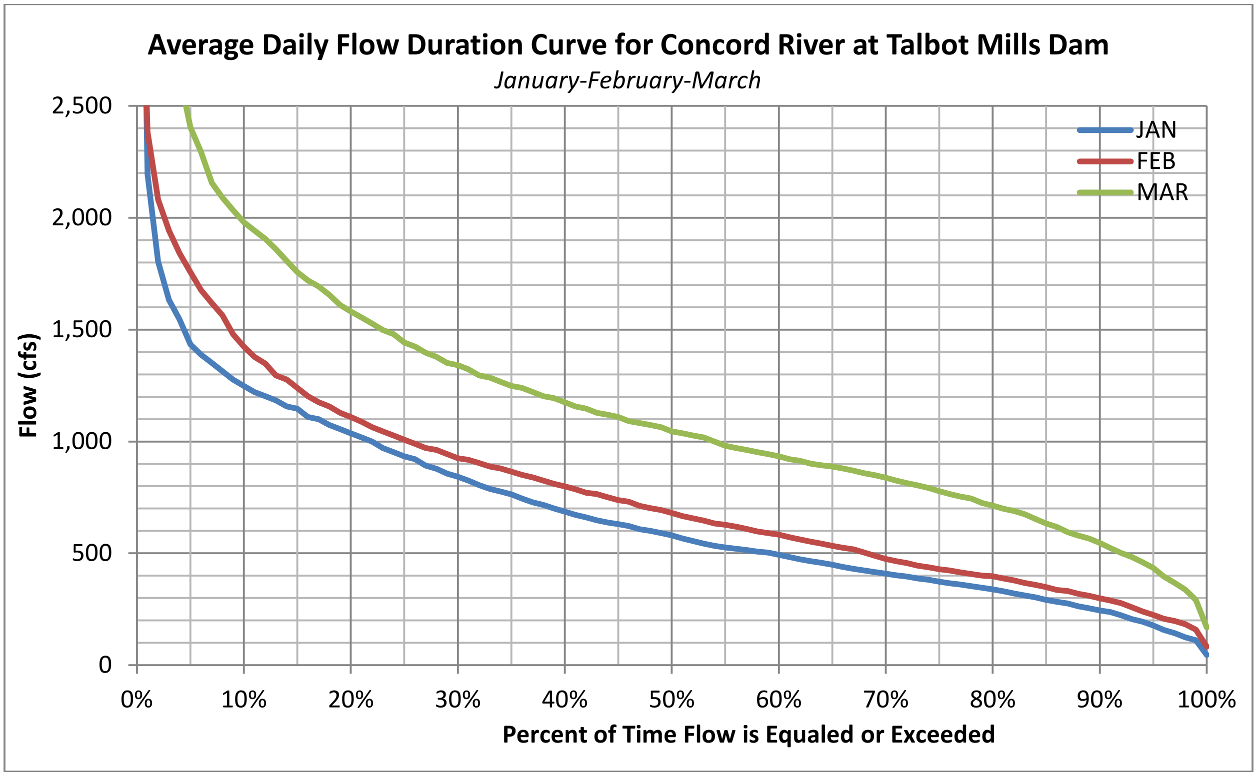


Figure 3.3.1-3: Apr-Jun Flow Duration Curves for Concord River at Talbot Mills Dam

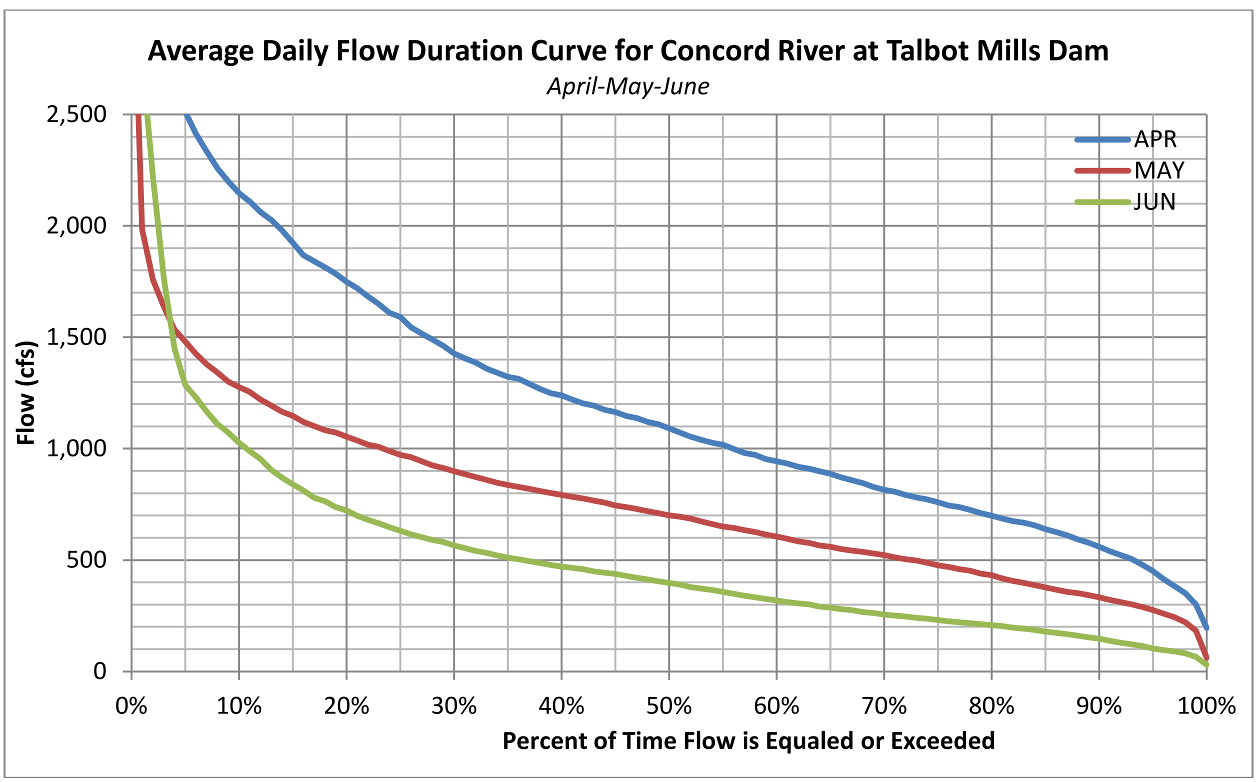


Figure 3.3.1-4: Jul-Sep Flow Duration Curves for Concord River at Talbot Mills Dam

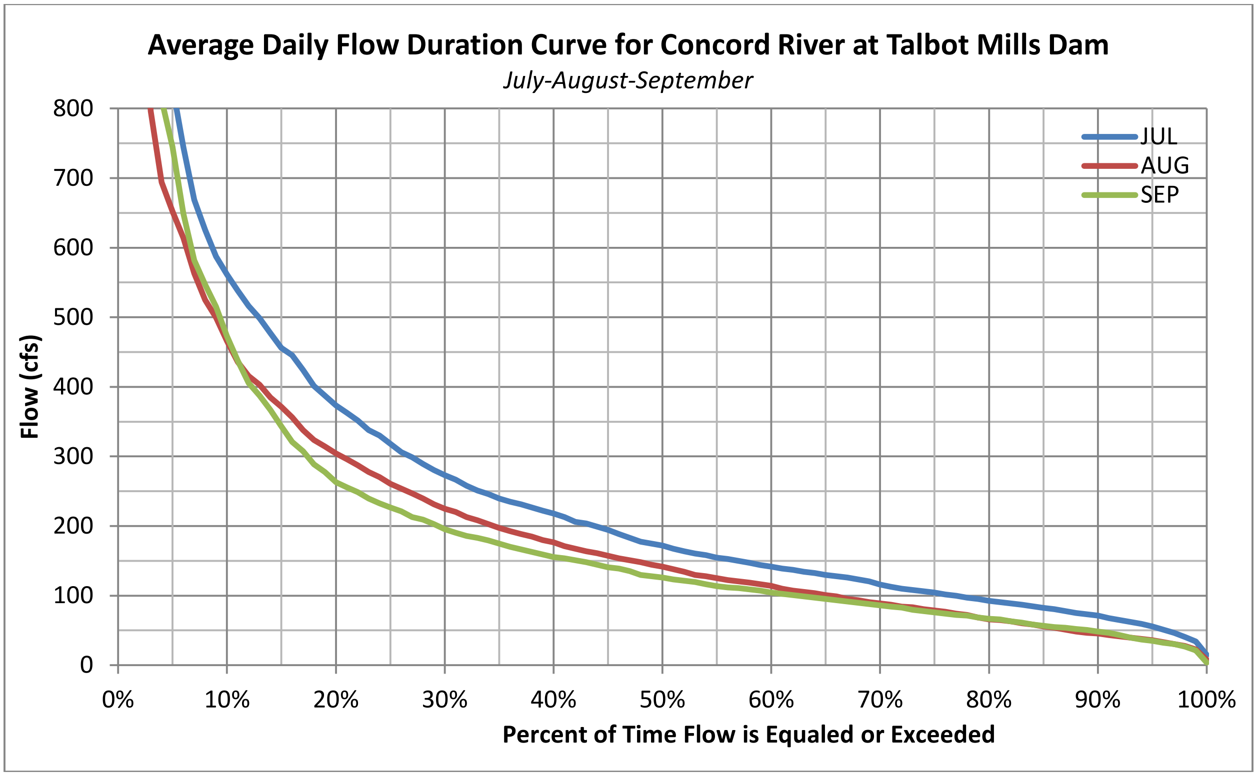


Figure 3.3.1-5: Oct-Dec Flow Duration Curves for Concord River at Talbot Mills Dam

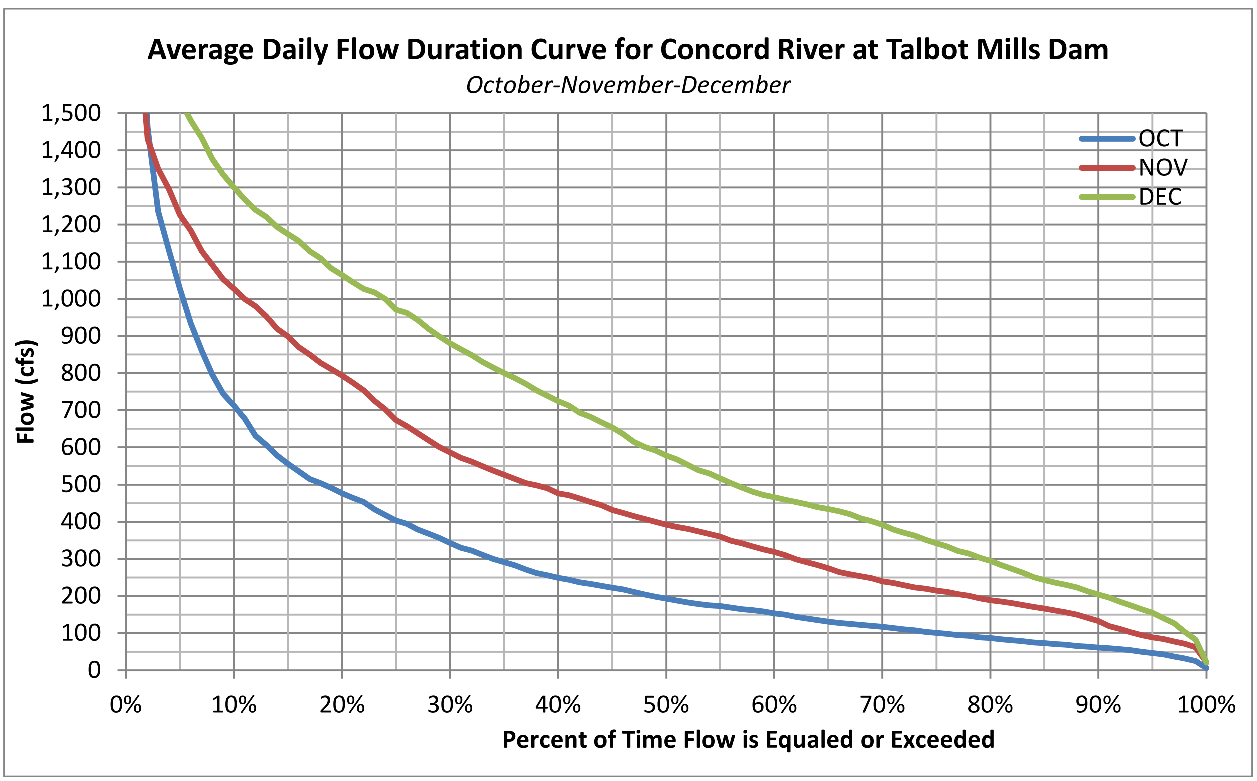


Figure 3.3.1-6: Upstream Migration Flow Duration Curve for Concord River at Talbot Mills Dam

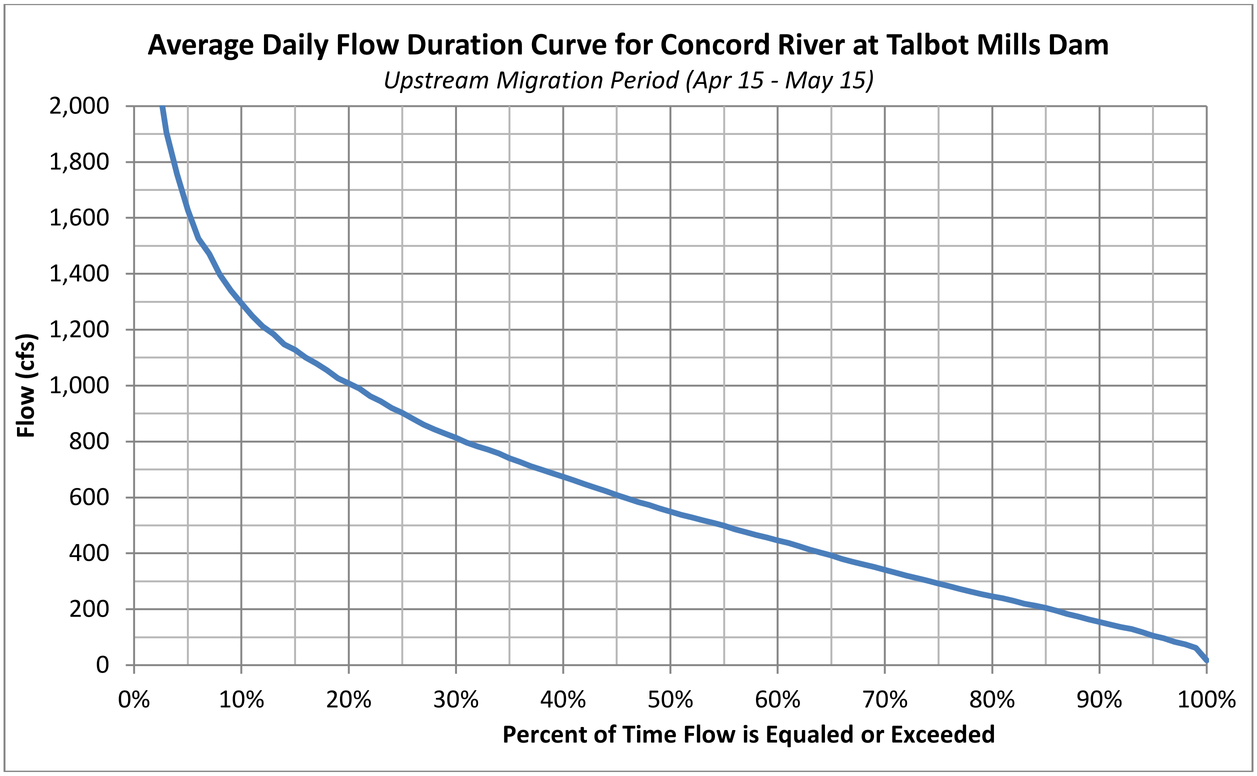


Figure 3.3.1-7: Downstream Migration Flow Duration Curves for Concord River at Talbot Mills Dam

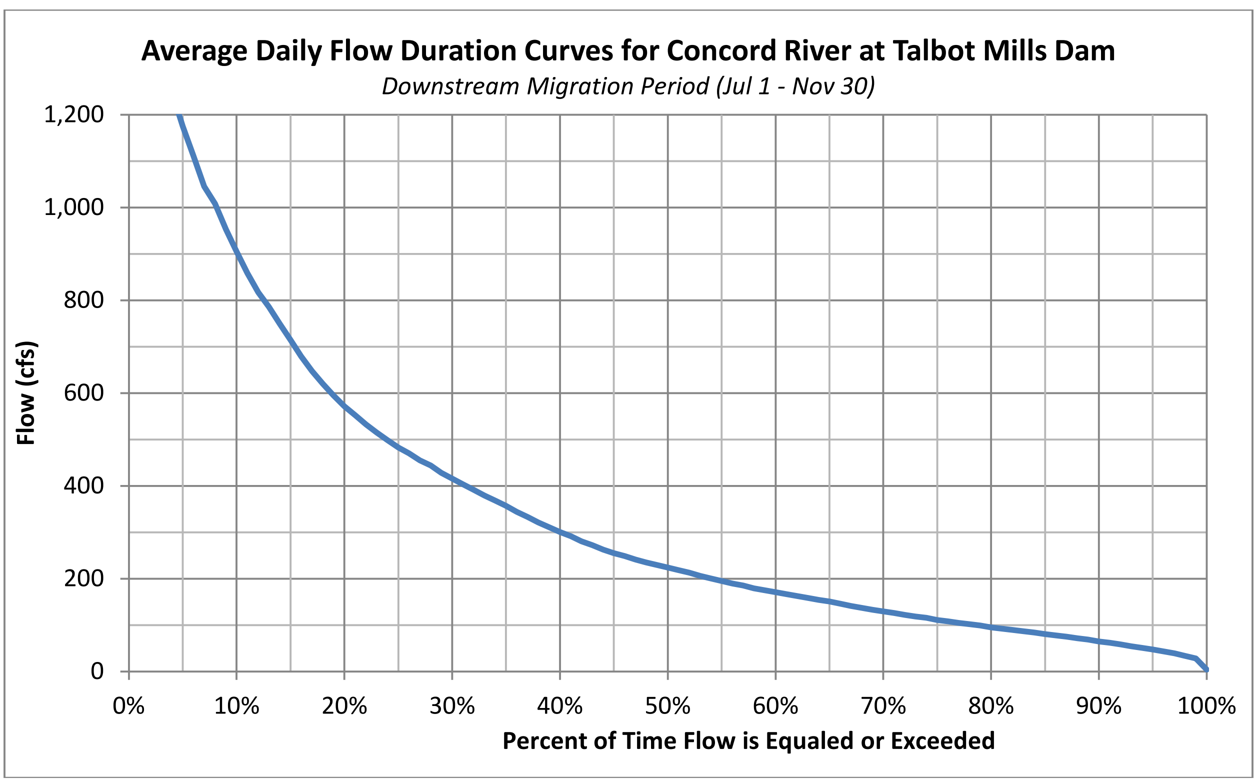
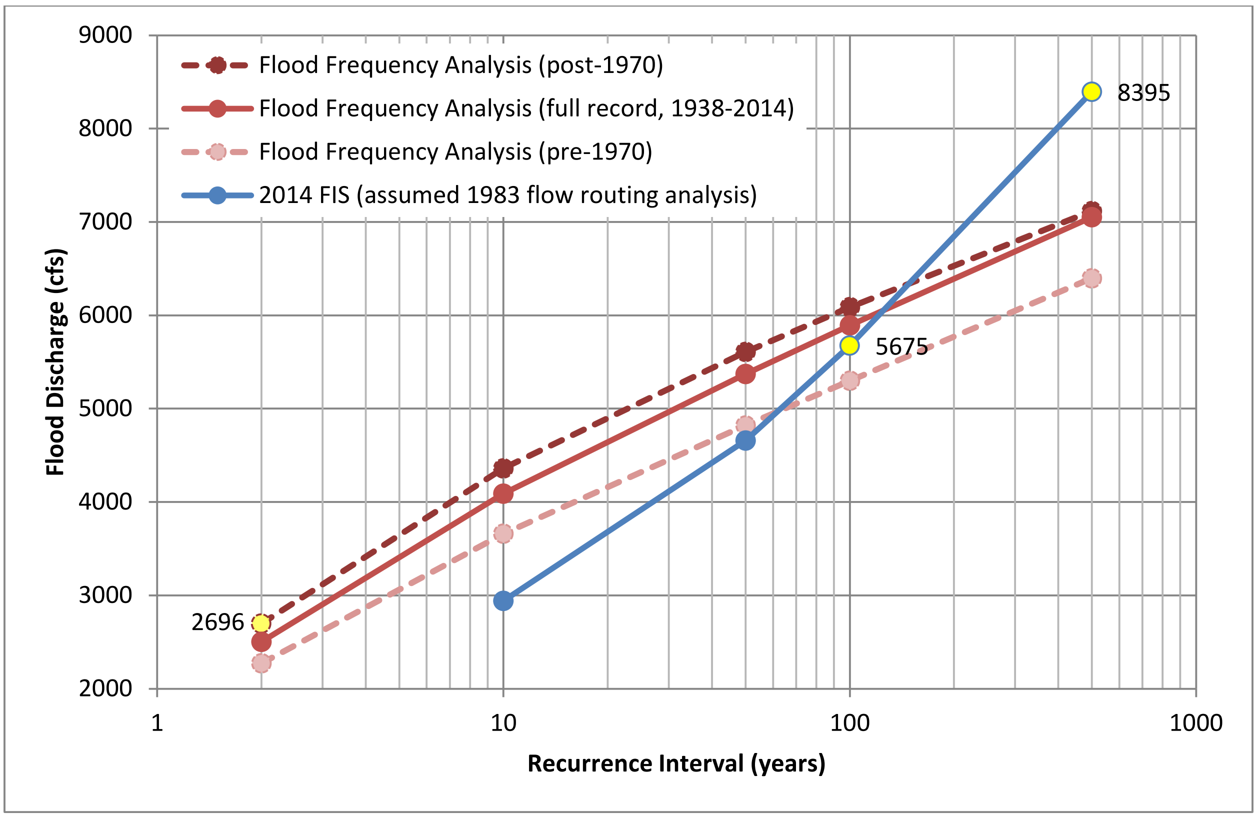


Table 3.3.2-1: Summary of Flood Frequency Estimates for the Concord River at Talbot Mills Dam

Annual Exceedence Probability	**Recurrence Interval** (yrs)	**Peak Discharge** (cfs)			
		Updated Flood Frequency Analysis			**2014 FIS** (assumed 1983 flow routing analysis)
		Full Record 1938-2014	Pre-1970 (1938-1969)	Post-1970 (1970-2014)	
50%	2	2503	2271	2696	-
10%	10	4091	3661	4361	2940
2%	50	5373	4820	5608	4660
1%	100	5891	5299	6088	5675
0.2%	500	7052	6398	7117	8395

Note: Updated flood frequency analysis conducted USGS Bulletin 17B methodology (USGS, 1981) within PeakFQ program. FIS estimates assumed to be based on gage data and a flow routing analysis. Values highlighted in yellow were selected for use in the hydraulic model.

Figure 3.3.2-1: Comparison of Flood Frequency Estimates for the Concord River at Talbot Mills Dam



Note: Points highlighted in yellow were selected for use in the hydraulic model. Note that the published FIS 500-year flood flow does not appear to follow the trend of the available data for lower flood flows. This may be due in part to differences in calculation methods (i.e., a flow routing analysis for the FIS vs. a statistical analysis of stream gage data for the updated flows). Also note that there is a discrepancy between modeled and published flows for the 2014 FIS, as discussed in ***Section 3.3.2****. The modeled 500-year flood flow is approximately 6,950 cfs at the Talbot Mills Dam, which would put it more in line with the trend of the other flows. For this study, the published FIS value was used as it is more conservative; however, this discrepancy could be further investigated in future phases of the project.*

Table 3.3.3-1: Summary of Flows for the Hydraulic Model

Category	Flow Name	Flow (cfs)	Description/Rationale	Description	Source
Calibration Flows	Calibration Low Flow	120	For calibration of normal flows	Average daily flow on October 6, 2014 during the field survey	Average daily flows for Concord River gage (No. 01099500) adjusted to Talbot Mills Dam by drainage area ratio (370/400 = 0.925) for the period of record of October 1936 through December 2015
Low Flows	Low Flow	35	To determine impoundment extent and evaluate impacts of alternatives during low flows	95% exceedence flow for September	
	Normal Flow	461	To determine impoundment extent and evaluate impacts of alternatives during normal flows	Mean annual flow	
Fish Passage Flows	Upstream Migration High Flow	1628	For evaluation of fish passage throughout the study area (USFWS fish passage design criteria)	5% exceedence flow for upstream migration period (April 15-July 15)	
	Upstream Migration Low Flow	105		95% exceedence flow for upstream migration period (April 15-July 15)	
	Downstream Migration High Flow	1175		5% exceedence flow for downstream migration period (July 1-December 31)	
	Downstream Migration Low Flow	47		95% exceedence flow for downstream migration period (July 1-December 31)	
High Flows	2-year Flood	2696	For evaluation of dam breach alternative (bankfull width check & scour potential check)	50% annual chance exceedence flow	A log-Pearson Type III statistical analysis of Concord River gage annual peaks for 1970-2014, adjusted by drainage area ratio
	100-year Flood	5675	For spillway capacity check (for existing conditions & fishway alternative)	1% annual chance exceedence flow	Effective FIS (based on 1983 analysis with 2012 review)
	500-year Flood	8395	For evaluation of dam breach alternative (to size breach width to not impound water during 500-year flood)	0.2% annual chance exceedence flow	

Figure 3.4.3-1: Selected Water Surface Profiles for Existing Conditions

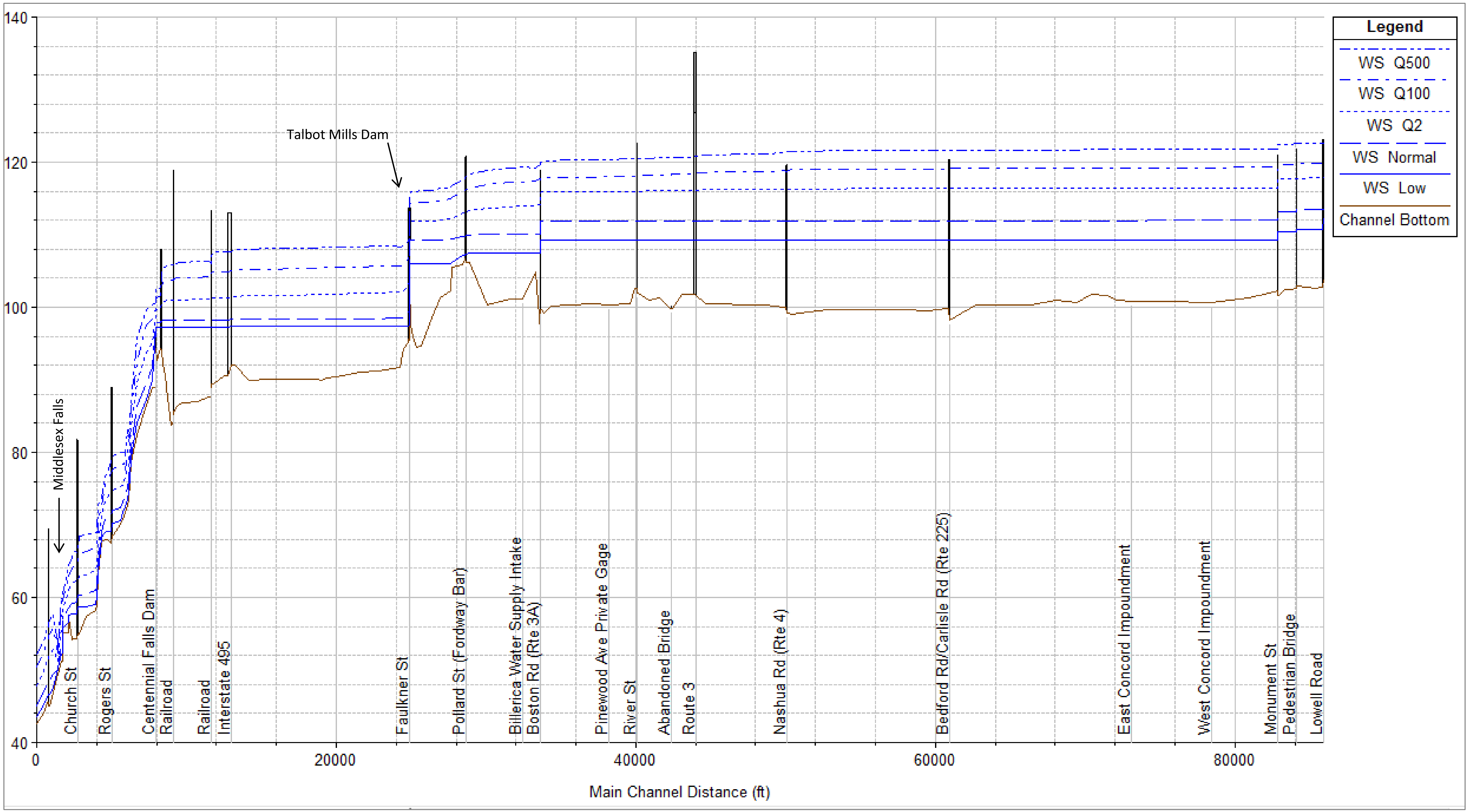


Figure 3.4.3-2: Comparison of Concord River Water Surface Profiles for Impoundment Extent Check

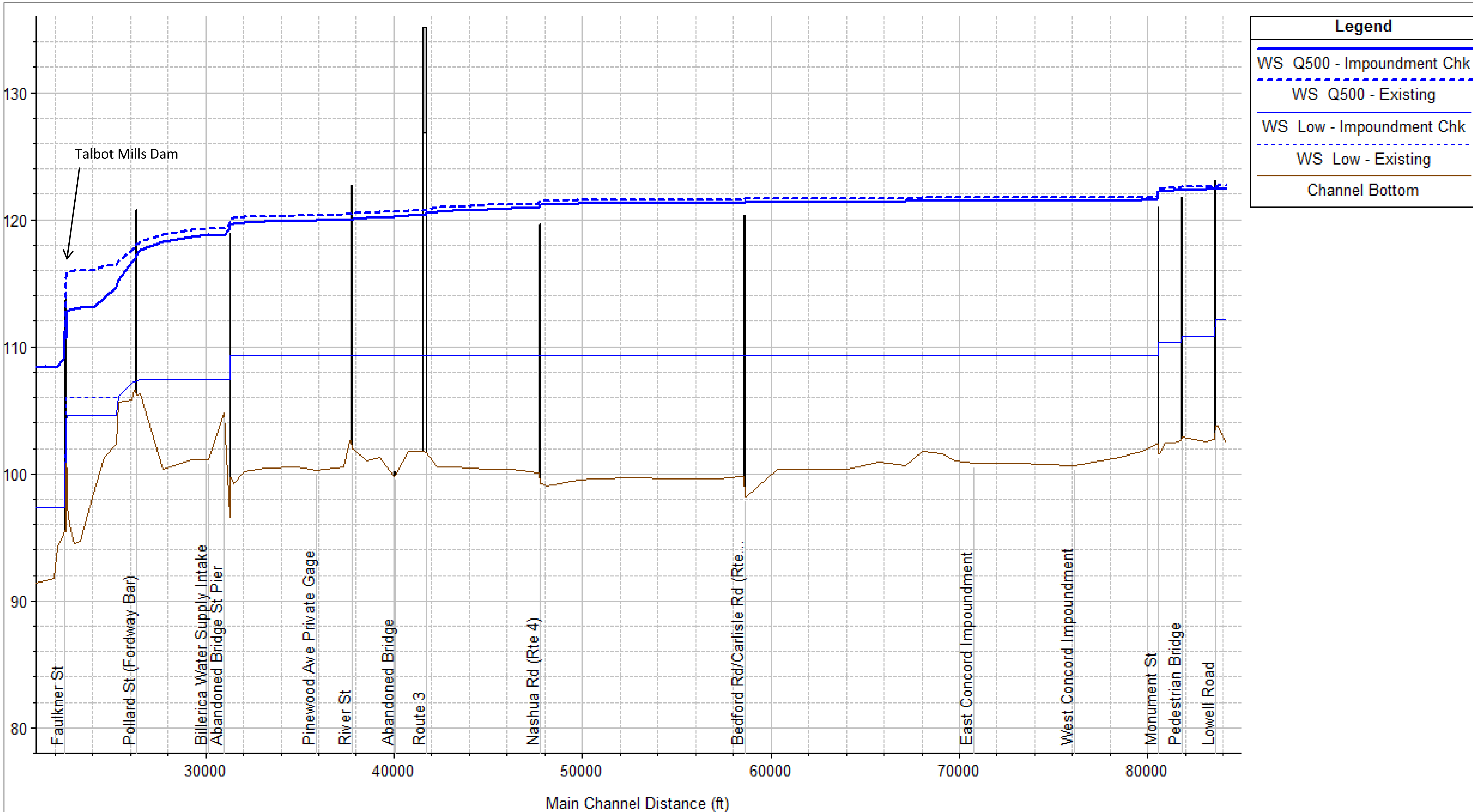


Figure 3.4.3-4: 100-year Flood Elevation at Talbot Mills Dam

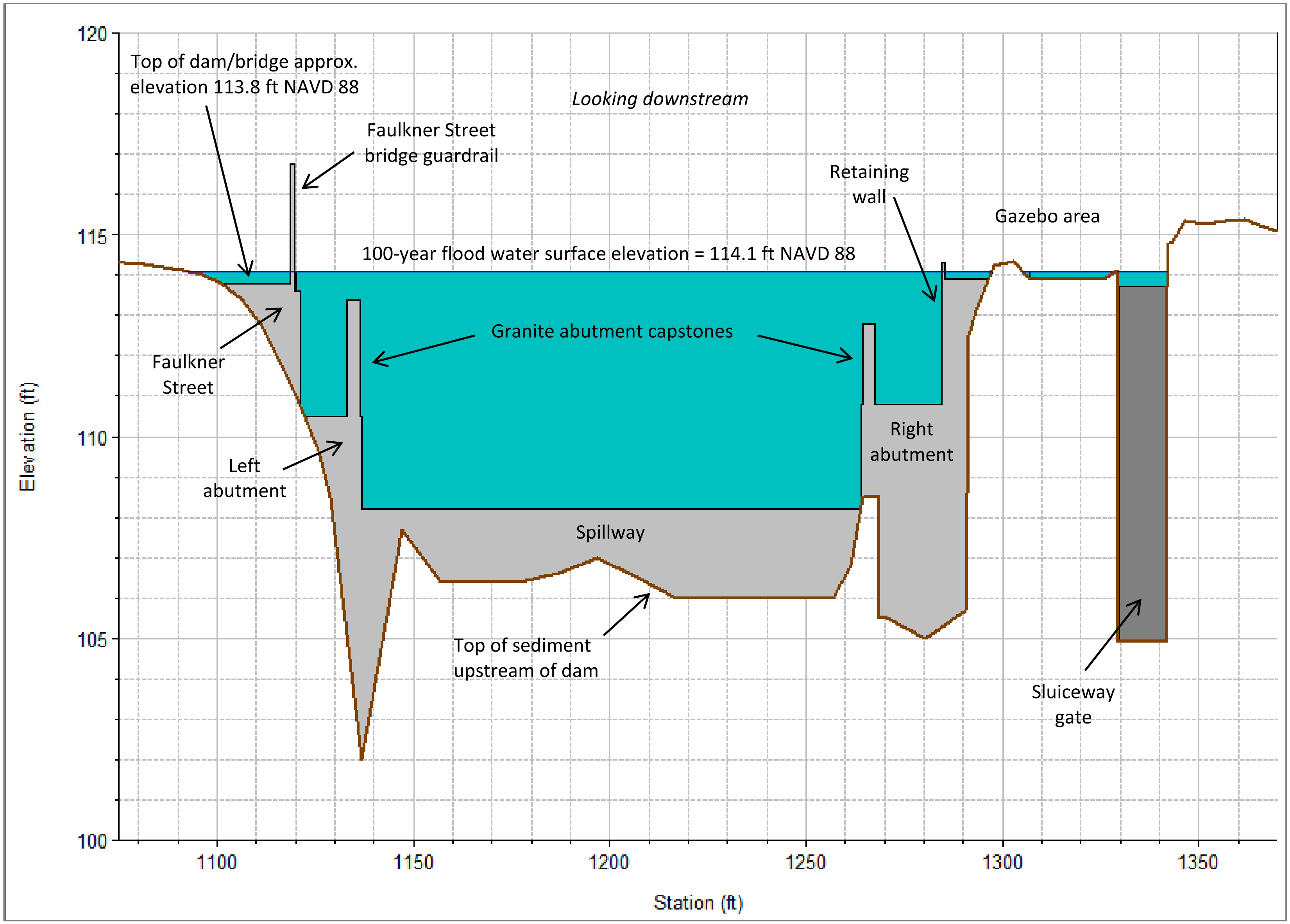


Figure 4.1.1-1: Map of Model Cross-Sections at Middlesex Falls

Table 4.1.1-1: Existing Channel Parameters at Middlesex Falls

Location	River Station (ft)	Average Channel Velocity (ft/s)		Max Channel Water Depth (ft)		Wetted Channel Top Width (ft)	
		Low Flow (105 cfs)	High Flow (1628 cfs)	Low Flow (105 cfs)	High Flow (1628 cfs)	Low Flow (105 cfs)	High Flow (1628 cfs)
U/S End of Middlesex Falls	2423	3.9	5.5	0.6	3.1	58	111
	2366	1.0	3.8	2.1	5.1	88	123
	2343	3.3	7.0	1.2	2.6	101	153
Middlesex Dam (breached)	2308	1.2	4.7	1.7	4.1	84	92
D/S End of Middlesex Falls	2293	3.0	5.4	1.4	3.9	93	142
	MIN	0.0	0.2	0.6	2.6	27	45
	MAX	4.8	12.7	13.7	16.6	510	510
	AVG	0.8	2.1	6.5	10.2	190	210

Key

Exceeds low target fish passage thresholds (5 ft/s velocity or 0.67 ft depth)
Exceeds high target fish passage thresholds (7 ft/s velocity or 0.5 ft depth)

Table 4.1.2-1: Existing vs. Proposed Channel Parameters for Middlesex Falls Channel Improvements (Alt 1A)

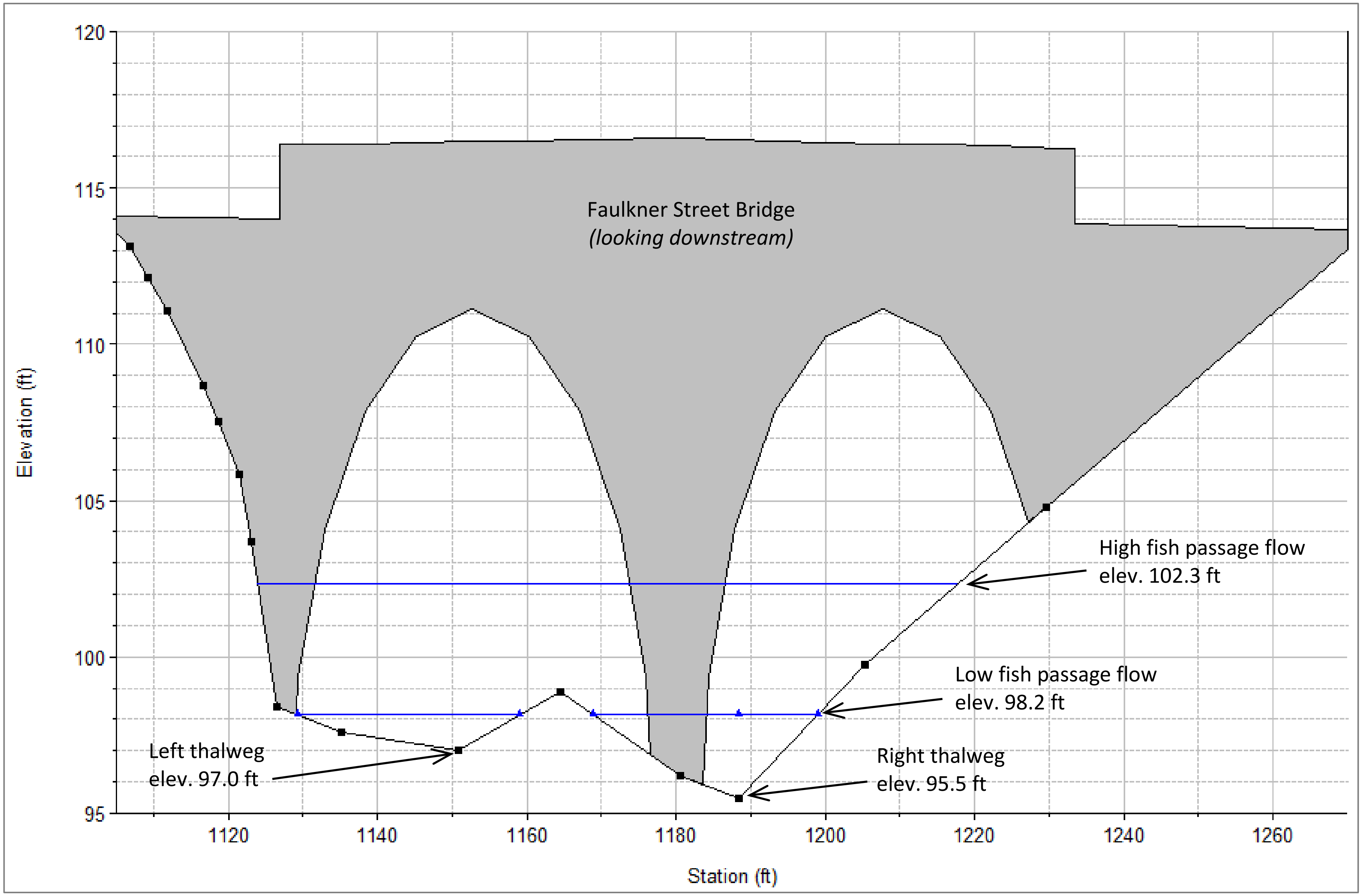
Alternative	Location	River Station (ft)	Average Channel Velocity (ft/s)		Max Channel Water Depth (ft)		Wetted Channel Top Width (ft)	
			Low Flow (105 cfs)	High Flow (1628 cfs)	Low Flow (105 cfs)	High Flow (1628 cfs)	Low Flow (105 cfs)	High Flow (1628 cfs)
Existing	U/S End of Middlesex Falls	2423	3.9	5.5	0.6	3.1	58	111
		2366	1.0	3.8	2.1	5.1	88	123
		2343	3.3	7.0	1.2	2.6	101	153
	Middlesex Dam (breached)	2308	1.2	4.7	1.7	4.1	84	92
	D/S End of Middlesex Falls	2293	3.0	5.4	1.4	3.9	93	142
Proposed	U/S End of Middlesex Falls	2423	3.9	5.7	0.6	3.0	57	111
		2366	1.3	3.9	1.8	5.0	79	123
		2343	5.7	7.0	1.5	4.1	19	149
	Middlesex Dam (breached)	2308	1.9	4.8	1.2	4.1	57	92
	D/S End of Middlesex Falls	2293	3.5	5.5	2.3	5.2	21	140
Difference	U/S End of Middlesex Falls	2423	0.0	0.2	0.0	-0.1	0	0
		2366	0.3	0.1	-0.3	-0.1	-9	0
		2343	2.4	0.0	0.3	1.5	-82	-4
	Middlesex Dam (breached)	2308	0.7	0.1	-0.5	-0.1	-26	0
	D/S End of Middlesex Falls	2293	0.5	0.1	0.9	1.3	-72	-1

Key

Exceeds low target fish passage thresholds (5 ft/s velocity or 0.67 ft depth)

Exceeds high target fish passage thresholds (7 ft/s velocity or 0.5 ft depth)

Figure 4.3.2-1: Channel Elevation under the Faulkner Street Bridge



Note: Channel cross-section surveyed for the 2014 FIS.

Table 4.3.2-1: Budgetary Opinion of Cost for Technical Fishway at Talbot Mills Dam (Alt 3A)

Description	Est. Cost
ADDITIONAL STUDIES	**$8,000**
Additional topographic survey	$4,000
Wetlands, wildlife, & botanical resources survey	$2,000
Additional hydraulic modeling	$2,000
ENGINEERING & PERMITTING	**$112,000**
Engineering design, drawings, cost estimates, memo, & technical specifications	$30,000
Regulatory reviews and permitting (incl. cultural resources consultation)	$42,000
Meetings (including public meetings)	$10,000
Bid phase services (bid package, solicitation, meetings, bid review, contracting)	$10,000
Construction phase services (observation, inspections, documentation, invoices, etc.)	$20,000
CONSTRUCTION	**$470,000**
Mobilization & demobilization (10% of construction subtotal, rounded up)	$35,000
Cultural resources mitigation	$26,000
Erosion & sediment control (oil boom, silt fencing)	$3,000
Care & diversion of water (cofferdam, sandbags, dewatering pump)	$33,000
Temporary construction access (gravel subbase, crane to lift materials into channel)	$7,000
Ledge removal (beneath fishway, thalweg to entrance channel, plunge pool)	$20,000
Concrete/masonry demolition (for abutment & spillway notches)	$5,000
Concrete (for fish ladder)	$130,000
Fish ladder appurtenances (baffles, gates, stoplogs, flashboards, trash racks, etc.)	$10,000
Eel ramp	$2,000
Dam repairs (minimum requirements)	$105,000
Construction contingency (25% of construction subtotal, rounded up)	$94,000
TOTAL *(rounded up to nearest $1000)*	**$590,000**

Figure 4.3.3-1: Cross-Section of Proposed Talbot Mills Dam Breach (Alt 3B)

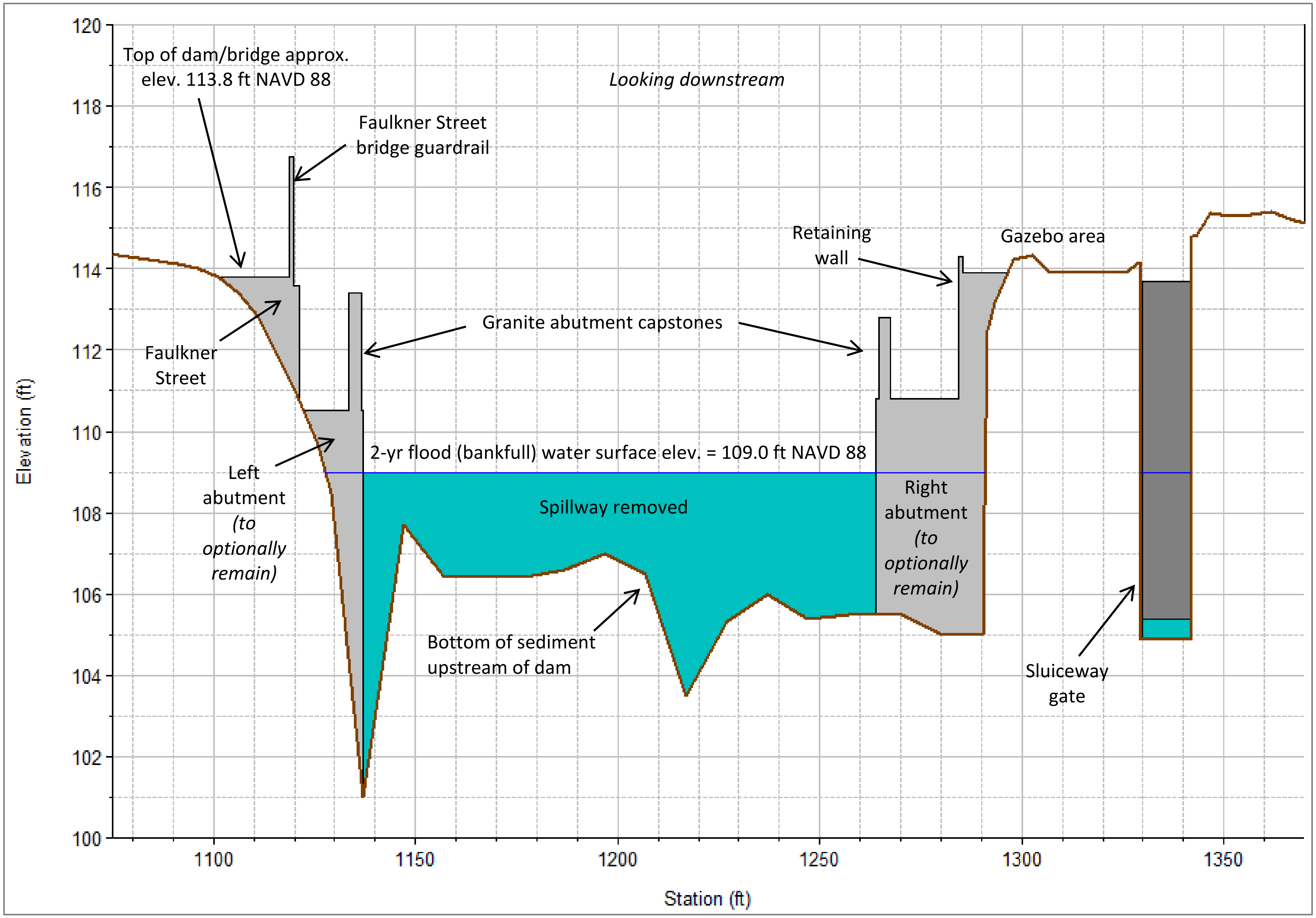


Figure 4.3.3-2: Comparison of Concord River Water Surface Profiles for Existing vs. Partial Dam Removal Conditions (Alt 3B)

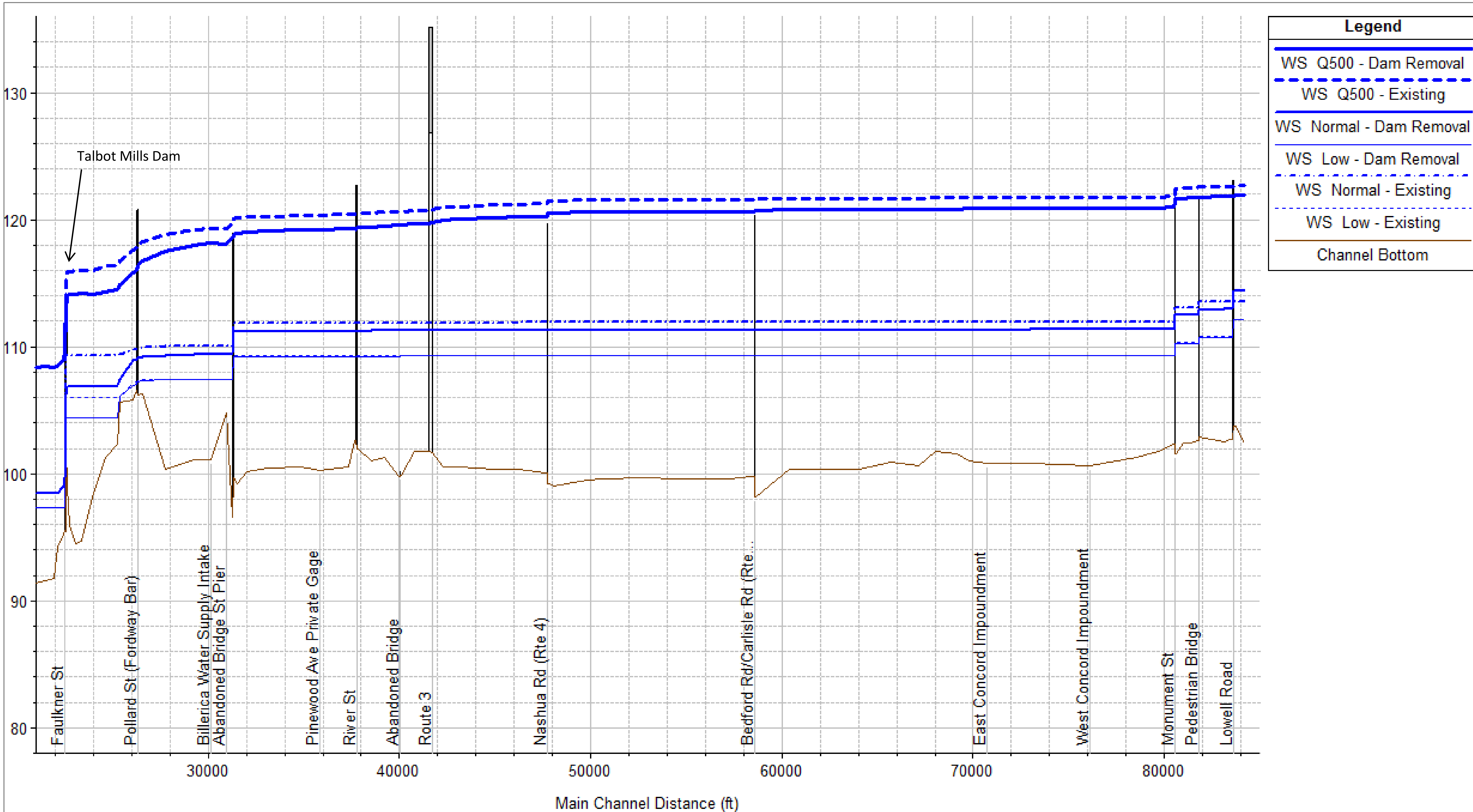


Figure 4.3.3-3: Comparison of Concord River Water Surface Profiles for Existing vs. Partial Dam Removal Conditions (Alt 3B) *(lower impoundment detail)*

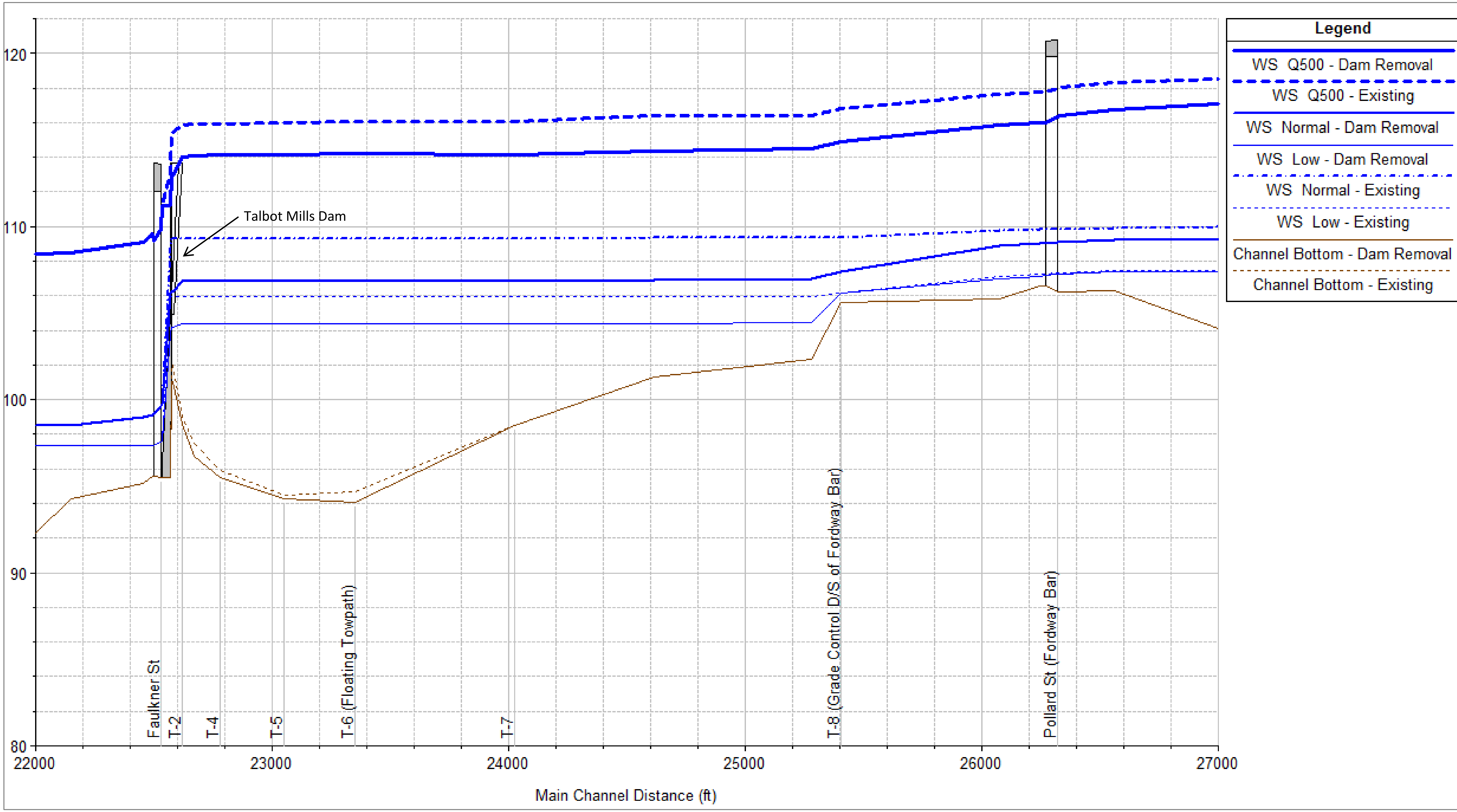


Figure 4.3.3-4: Comparison of 500-year Flood Elevation for Talbot Mills Dam Breach Alternatives (Alt 3B)

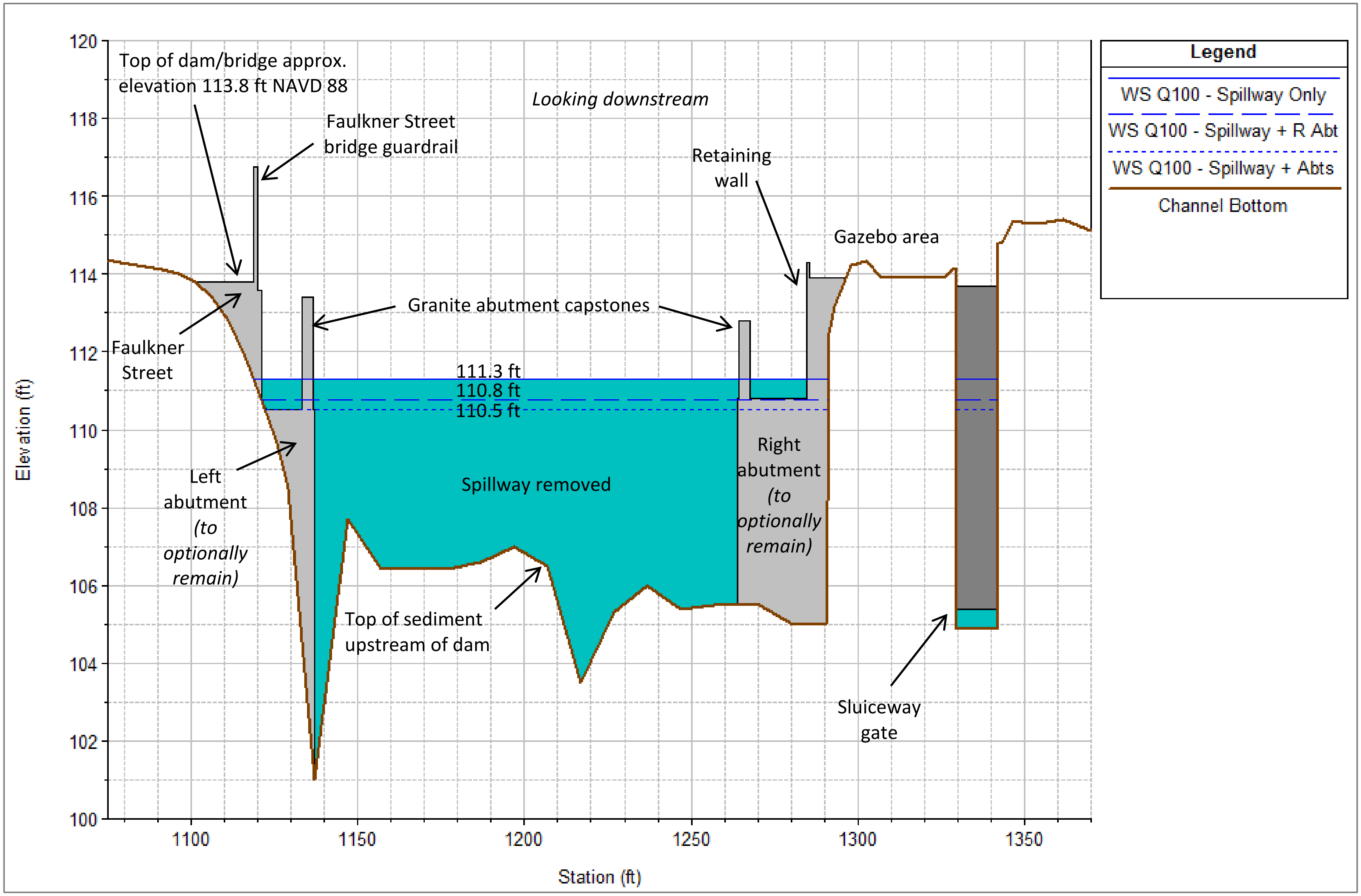
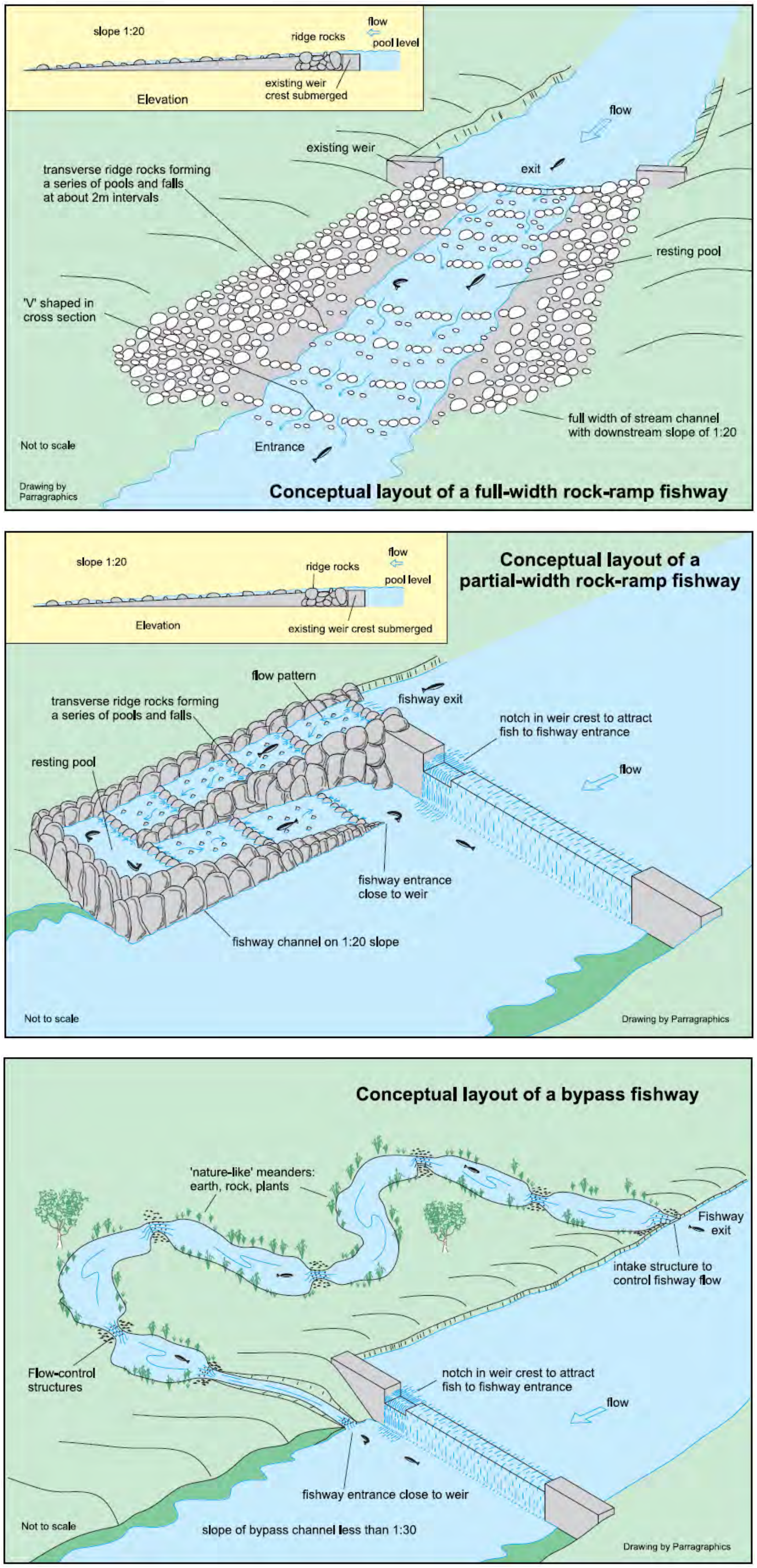


Table 4.3.3-1: Budgetary Opinion of Cost for Partial Removal of Talbot Mills Dam (Alt 3B)

Description	Est. Cost
ADDITIONAL STUDIES	**$41,000**
Additional topographic survey	$4,000
Bathymetric survey	$5,000
Sediment depth probing (at Fordway Bar)	$2,000
Additional sediment sampling (10 samples) & sediment management plan	$10,000
Wetlands, wildlife, & botanical resources survey	$4,000
Ground-penetrating radar	$10,000
Additional hydraulic modeling	$2,000
Bridge assessment	$2,000
Recreation/aesthetic study	$2,000
ENGINEERING & PERMITTING	**$120,000**
Engineering design, drawings, cost estimates, memo, & technical specifications	$30,000
Regulatory reviews and permitting (incl. cultural resources consultation)	$45,000
Meetings (including public meetings)	$15,000
Bid phase services (bid package, solicitation, meetings, bid review, contracting)	$10,000
Construction phase services (observation, inspections, documentation, invoices, etc.)	$20,000
CONSTRUCTION	**$309,000**
Mobilization & demobilization (10% of construction subtotal, rounded up)	$23,000
Cultural resources mitigation	$72,000
Erosion & sediment control (oil boom, silt fencing)	$5,000
Care & diversion of water (full width cofferdam, sandbags, dewatering pump)	$53,000
Temporary construction access (crane to lift equipment into channel, swamp mats)	$17,000
Masonry demolition (removal of primary spillway)	$54,000
Rock fill excavation (removal of legacy dam and fill)	$23,000
Construction contingency (25% of construction subtotal, rounded up)	$62,000
TOTAL *(rounded up to nearest $1000)*	**$470,000**

Figure 4.3.4-1: Conceptual Layout of Nature-Like Fishway Alternatives



Source: Thorncraft & Harris, 2000.

Table 5.0-1: Potential Permitting Requirements for Talbot Mills Dam Restoration Alternatives

Permit	Agency	Applicable Regulations	Categories	Applicability	Potential Requirements	
					Fish Ladder (3A)	*Dam Removal (3B)*
Wetlands Protection Act Notice of Intent (NOI) & Order of Conditions	MA Dept. of Environmental Protection (DEP) / Conservation Commission	310 CMR 10.00; MGL. c.131 s.40	Order of Conditions Restoration Order of Conditions (general permit or limited project)	Any construction in or near a wetland resource. Ecological restoration projects may qualify for a Restoration Order of Conditions (either general permit or as a limited project). If the project is located within Estimated Habitat of Rare Wildlife, the NOI must also be submitted to the NHESP and DFW where it is subject to the Massachusetts Endangered Species Act (MESA) review.	X *Restoration General Permit (fish passage improvement)*	X *Restoration General Permit (dam removal)*
Environmental Notification Form (ENF)	MA Environmental Policy Act (MEPA) Office	301 CMR 11.00	ENF Expanded ENF (EENF) Environmental Impact Report (EIR)	Thresholds include alteration of 5,000+ SF of bordering or isolated vegetated wetlands, alteration of one-half acre of other wetlands, alteration of 1000+ SF of outstanding resource waters, new/expanded fill or structure in a regulatory floodway, or structural alteration of a dam that causes an expansion of 20% or any decrease in impoundment capacity (triggers EIR). Restoration projects that require an EIR may request a waiver by filing an EENF.	X *EENF*	X *EENF* *Possible EIR*
Project Notification Form (PNF)	MA Historical Commission (MHC)	950 CMR 70-71; MGL c.9 s.26-27C	N/A	Projects that require state funding, licenses, or permitting.	*Submitted*	
Section 106 Historical Review		36 CFR 800	N/A	Projects that require federal funding, licenses, or permitting.	X	X
Rare Species Information Request Form	Natural Heritage and Endangered Species Program (NHESP)	321 CMR 10:00; M.G.L. c.131A	N/A	Projects proposed in estimated rare or endangered species habitat, as delineated on the NHESP database.	X	X
401 Water Quality Certificate (WQC)	DEP	314 CMR 9.00	Minor Project Cert. for Dredging & Disposal (> 100 CY; < 5,000 CY) Major Project Cert. for Dredging & Disposal (> 5,000 CY) Minor Project Cert. for Fill & Excavation (< 5,000 SF) Major Project Cert. for Fill & Excavation (> 5,000 SF or any ORW or special case)	Any activity that would result in a discharge of dredged material (e.g., sediment release) greater than 100 CY that is also subject to federal regulation (e.g., USACE Section 404 General Permit). Application can be combined with Ch. 91.	X *Minor Dredge* *Minor Fill*	X *Major Dredge*
Chapter 91 Waterways License	DEP	310 CMR 9.00	Water Dependent - General	Removal of a licensed structure or dredging of a navigable waterway (most rivers & streams in MA). Application can be combined with 401 WQC.	X	X
Chapter 253 Dam Permit	DCR Office of Dam Safety	302 CMR 10.09-10 M.G.L c.253;	N/A	Any project to construct, repair, materially alter, breach, or remove a dam.	X	X
Fishway Permit	MA Div. of Marine Fisheries (DMF)	322 CMR 7.01 (4(f)) and (14(m))	N/A	Any activity to construct, reconstruct, rebuild, repair, or alter any anadromous fish passageway, or to construct or build any new anadromous fish passageway	X	--
Clean Water Act Section 404 Programmatic General Permit	US Army Corps of Engineers (USACE)	40 CFR 230-232 33 CFR 320-332	Category I GP Category II GP Individual Permit	Discharge of dredged or fill material in a water of the United States, or instream construction activities. Requires Category II review for greater than 25,000 CY dredging, any fill, or other special circumstances.	X *Category II GP*	X *Category II GP*
National Pollutant Discharge Elimination System (NPDES) Permit	Environmental Protection Agency (EPA)	40 CFR 122-125	Dewatering General Permit (DGP) Construction General Permit (CGP) Remediation General Permit (RGP)	Discharges from certain construction sites, including clearing, grading, and excavation activities. If disturbance is < 1 acre and discharge is not contaminated, a DGP may be required, or the project may potentially be covered as allowable non-stormwater discharge under the host community's Small MS4 Permit. If > 1 acre, a CGP would be required. If discharge is contaminated, an RGP or Individual Permit would be required. See flowchart for details.	*Possibly not required if disturbance is < 1 acre and discharge is not contaminated*	
Conditional Letter of Map Revision (CLOMR)	Federal Emergency Management Agency (FEMA)	44 CFR 60, 65, 72	MT-2 Application: Based on Bridge, Culvert, Channel or Combination Based on Levee, Berm or Other Structural Measures Based Solely on Submission of More Detailed Data	Required to officially revise the current Flood Insurance Rate Map (FIRM) to show changes to floodplains, floodways, or flood elevations.	X	*Optional (free)*

Table 5.0-2: Decision Matrix for Talbot Mills Dam Restoration Alternatives

	TALBOT MILLS DAM		
	-	3A	3B
	No Action	Technical Fishway	Dam Removal
POTENTIAL BENEFITS			
Upstream passage of target fish species	Low	Moderate	High
Downstream passage of target species	Moderate	High	High
Passage of other species (connectivity)	Low	Moderate	High
Improved water quality & aquatic habitat	None	None	High
Reduction of invasive species	None	None	High
Restoration of natural wetland habitat	None	None	High
Restoration of ecological functions (e.g., sediment transport)	None	None	High
Reduced upstream flooding	None	None	High
Improved recreation	None	Subjective	Subjective
Improved aesthetics	None	Subjective	Subjective
Decommissioning of aging infrastructure	None	None	High
Environmental justice for Nyanza	None	Low	High
POTENTIAL IMPACTS			
Blockage of fish passage	High	Low	None
Impairment of water quality	High	High	None
Fragmentation of aquatic habitat	High	High	None
Rare/threatened/endangered species	None	Low	Low
Loss of upstream wetlands	None	None	High
Impoundment of sediment	High	High	None
Sediment management impacts	None	Low	Moderate
Artificial upstream flooding	High	High	None
Reduction of spillway capacity	None	Low	N/A
Water supply impacts	None	None	None
Infrastructure impacts (e.g., bridges)	None	None	Low
Cultural resources impacts	None	Moderate	High
Recreation impacts	None	None	Subjective
Aesthetic impacts	None	Subjective	Subjective
OTHER FACTORS			
Permitting effort	Moderate	High	High
Operation & maintenance	High	High	None
Estimated cost (engineering, permitting, construction)	$200k+	$665k	$410k