Ecological Restoration Report/Environmental Assessment

Technical Appendices

Smelt Hill Dam Environmental Restoration Study - Falmouth, Maine

January 2001

US Army Corps
of Engineers

New England District

TECHNICAL APPENDICES

APPENDIX B –

HYDROLOGIC AND HYDRAULIC ANALYSIS

SMELT HILL DAM REMOVAL FEASIBILITY STUDY FALMOUTH, MAINE

APPENDIX B
HYDROLOGIC AND HYDRAULIC ANALYSIS

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CONCORD, MASSACHUSETTS 01742

JANUARY 2000

SMELT HILL DAM REMOVAL
FEASIBILITY STUDY
FALMOUTH, MAINE

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1. PURPOSE AND SCOPE

The purpose of this study is to determine the environmental and economic benefits and costs of removing all or portion of the Smelt Hill Dam on the Presumscot River in Falmouth, Maine in order to enhance local and anardromous fisheries. The scope of the study consists of the identification of alternatives which would enhance local and anadromous fisheries in the lower Presumpscot River within identified planning constraints. An incremental analysis of project costs and benefits was performed to identify the recommended alternative.

This appendix presents, hydrologic information, hydraulic analyses of with and without dam conditions, and discussion of the results of the dam removal alternatives. Sections included in the report are; a description of study area, study procedures including dam removal alternatives and results, and a summary.

2. AUTHORITY

This study was conducted by the Corps of Engineers under Section 206 of the Water Resources Development Act of 1996 (PL 104-303) enititled "Aquatic Ecosystem Restoration". The study was completed at the request of the Maine Department of Environmental Protection, and was performed by the New England District.

3. DESCRIPTION OF STUDY AREA

a. General. The study area (shown on plate 1) is located on the Presumpscot River in the town of Falmouth, Maine, at approximately latitude $43^0 43'$ N., and longitude $70^0 16'$ W. in Cumberland County. The Presumpscot River begins at Sebago Lake, in the Town of Standish, and flows for approximately 23 miles to the town of Falmouth, where it enters Casco Bay. The drainage area of the Presumpscot River at the outlet of Sebago Lake is 441 square miles and the drainage area of the entire watershed is 648 square miles (199 net square miles below Sebago Lake). The Smelt Hill Dam is located approximately 3 miles from the mouth of the river and one mile west (upstream) of Route I-295 at a naturally occurring bedrock outcrop. This outcrop approximately divides the head of tide, and historically has been known as Presumpscot Falls. The drainage area of Smelt Hill dam is 640 square miles.

The watershed is sparsely developed woodland, and contains some hilly terrain. The total fall in the river from Sebago Lake to the ocean is approximately 270 feet or an overall average of 10.8 feet per mile, however, most of the drop is accounted for at dams, therefore, most reaches between dams have relatively mild slopes. The Presumscot has three major tributaries below Sebago Lake – the Pleasant, Little, and Piscataqua Rivers. The Pleasant River begins northeast of Little Sebago Lake and has a drainage area of 50 square miles. The Little River starts southwest of Gorham and includes 49 square miles below Sebago Lake. The Piscataqua River consists of two branches with a total drainage area of 46 square miles.

b. Smelt Hill Dam. The dam is approximately 151 feet long, 31 feet wide, and 15 feet high and is constructed of stone-filled timber cribs. A plan of the dam is shown on plate 2 and a section and elevation are shown on plate 3. The crest elevation is approximately 15 feet NGVD. There is spillway sluice gate and a gatehouse building located to the right (looking downstream) of the spillway section. There are five 5'X8' hydraulic gates located in a gatehouse building. A powerhouse building, with its damaged power-generating equipment, is also located near the right abutment. A now-damaged hydraulically-operated fish lift that raised the fish 20 feet to the headpond (for upstream passage) is located between the powerhouse and the gatehouse. There is also an existing fish passage facility, installed in the 1800's, at the left (northern) end of the dam that was never successful.

The history of this dam can be found in Section 1 of the main report, however, in the late 1980's, the dam was repaired and raised, and a new powerhouse was constructed by Cumberland Power Company, along with a fish lift. The dam and hydropower plant were bought by Central Maine Power in 1994. On October 21, 1996, a significant flood event severely damaged the hydroelectric generating facility, including the fish lift, rendering it inoperable. This is the condition of the dam today.

c. Climatology. The area has a variable climate, and frequently experiences periods of heavy precipitation produced by local thunderstorms, and larger weather systems of tropical and extratropical origin. The area lies in the path of the prevailing "westerlies" which generally travel across the country in an easterly or northeasterly direction, producing frequent weather changes. The climate is characterized as moderate, and the mean annual temperature is 45 degrees Fahrenheit (^{0}F). Temperatures range from an average 22 ^{0}F in January to an average of 68 ^{0}F in July. The average yearly rainfall is about 44 inches and the average yearly snowfall is approximately 75 inches.

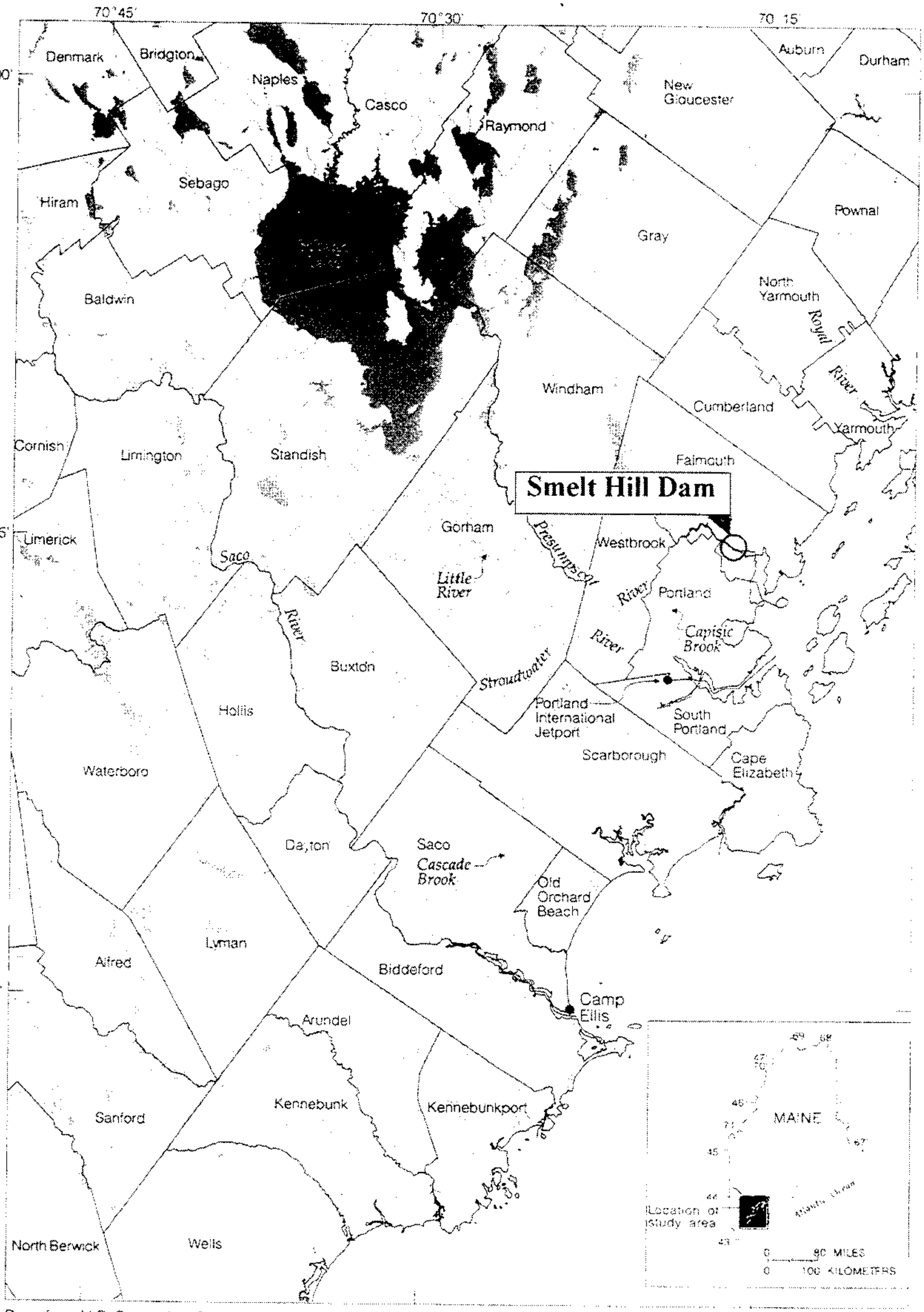
d. Streamflow. The U.S. Geological Survey (USGS) has recorded flows on the Presumpscot River at a gage (gage #01064118) at Westbrook, Maine, from October 1975 to Septemer 1995. The drainage area at the Westbrook gage is 577 square miles. The USGS has also recorded outflows from Sebago Lake since 1887. The long-term record Presumpscot River at Outlet of Sebago Lake gage (#01064000) has a drainage area of 441 square miles. It should be noted that flows on the lower Presumpscot River are regulated by Sebago Lake and many small powerplants upstream. Also used for reference in the hydrologic analysis, was the USGS gaged record on the nearby Royal River at Yarmouth, Maine. This nearby Royal River gage (gage #01060000) has a drainage area of 141 square miles, and a period of record of 48 years.

4. STUDY PROCEDURES

a. General. This section discusses the methods and assumptions used in the study of the removal of all or part of Smelt Hill Dam. The existing dam and river were hydraulically modeled using multiple flows to determine peak water surface elevations and velocities for a range of events. Two removal alternatives were then modeled to determine corresponding water elevations and velocities. The results of each of the removal alternatives were compared to the results of the existing dam conditions to determine the effects that dam removals will have on the peak water surfaces and velocities along the river.

b. Dam Removal Alternatives. Two dam removals were modeled for the hydraulic analysis. A partial dam removal which represented the smallest flow area (most restrictive channel without dam) to expect on the river and a complete removal which represents the largest flow area (similar to pre-dam conditions). It was found that there were minor differences in water surface elevations and velocities between these two options and therefore, no need to run incremental removal options between these two. The two removal alternatives are described below.

(1) Partial Dam Removal. This alternative involves the removal of the approximately 150-foot in length, 14-foot high timber crib dam and the adjacent 1-story concrete block gatehouse only. The powerhouse is to be left standing untouched in this alternative. Disposal of the inert material from the demolition will be either off-site, or in the intake canal area, with steps taken to protect the powerhouse.

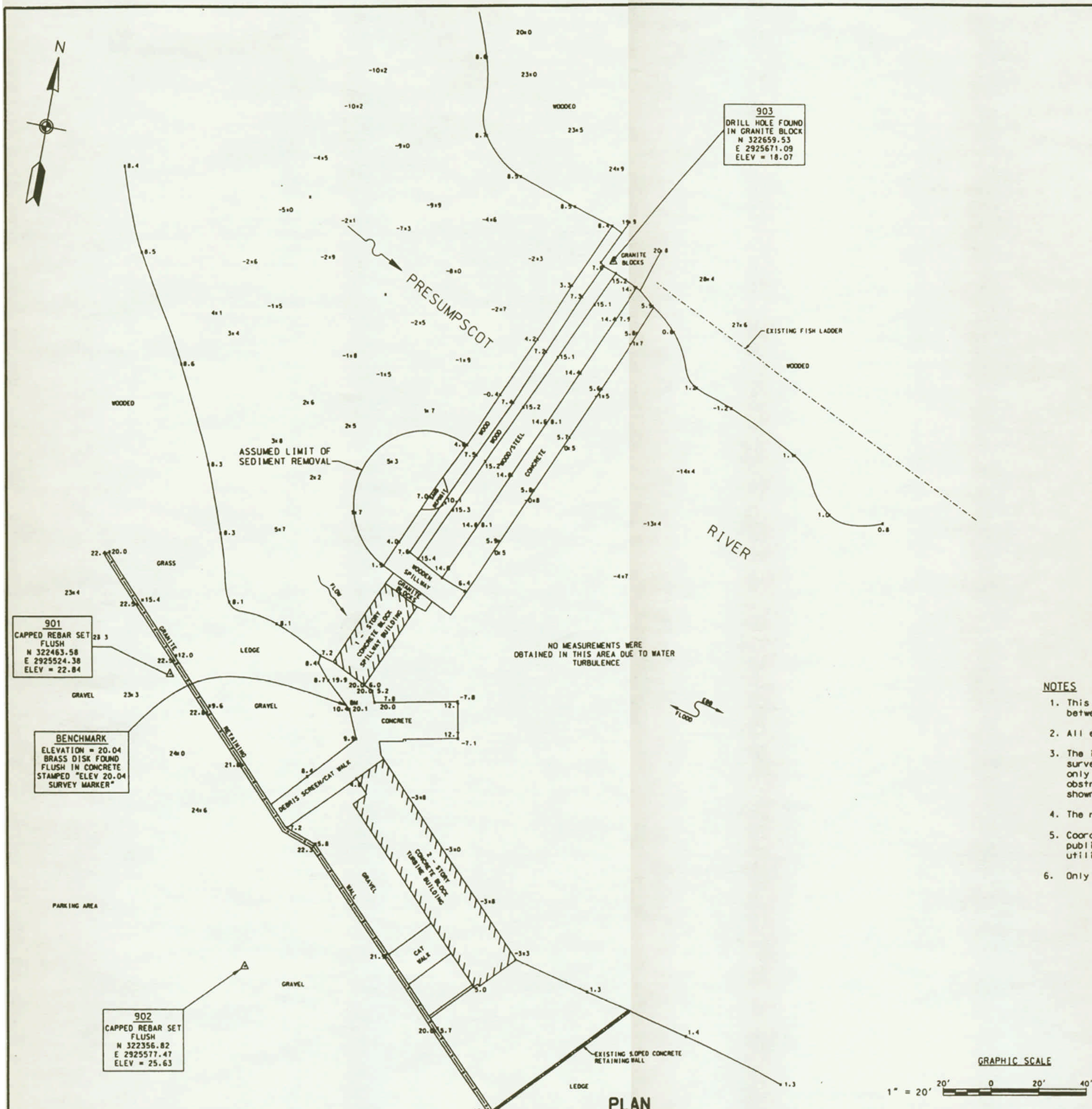


Base from U.S. Geological Survey Portland, and Kittery quadrangles 1:100,000, 1985

SCALE
0 5 MILES
0 5 KILOMETERS

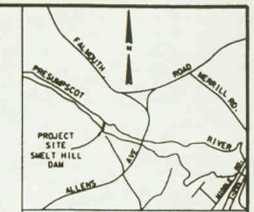
Study Area

Plate 1



PLAN

SCALE: 1" = 20'



LOCATION MAP

SCALE: 1" = 2000

NOTES

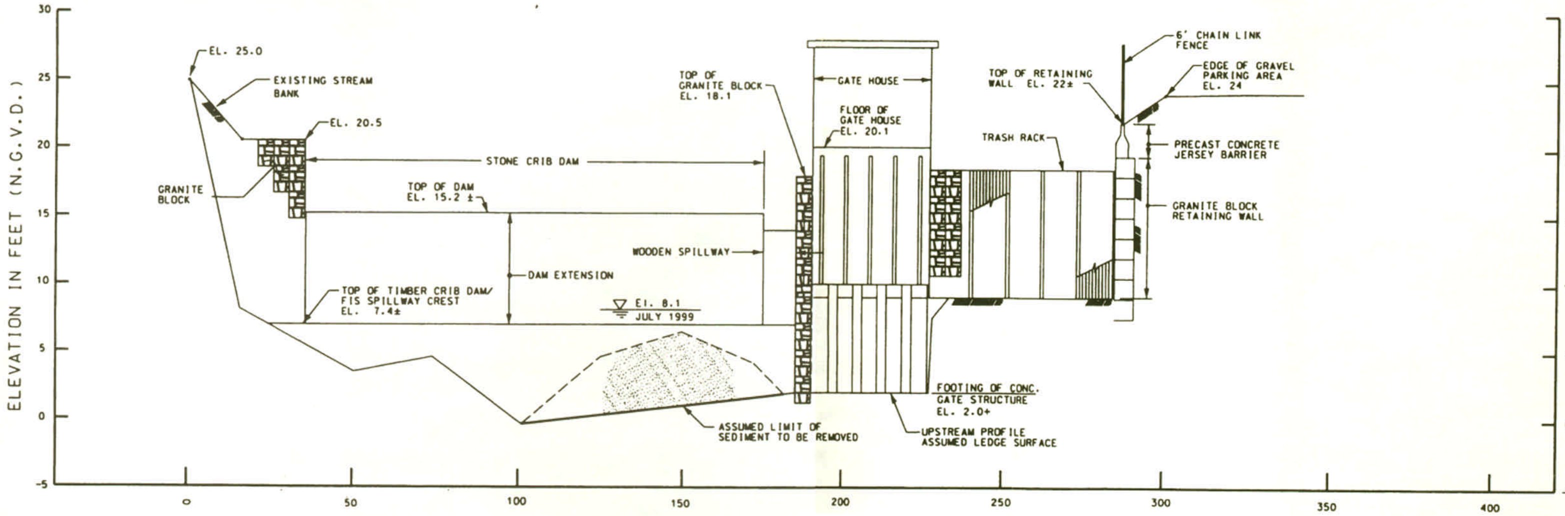
1. This survey was conducted on the ground using a Topcon GTS-300 Total Station between 9 July and 14 July 1999 by James W. Seawall Co., Old Town, ME.
2. All elevations refer to NGVD 1929 and are expressed in US Survey Feet.
3. The information depicted on this worksheet represents the results of a survey performed during the time period indicated above. This survey can only be considered as showing conditions at that time. Shoals, holes, obstructions or outcroppings may exist between the sounding elevations shown.
4. The river downstream from the dam is tidal.
5. Coordinates and elevations for control points shown were derived from published control points MDOT "A170", NGS "Auburn", "J5", and "H163" utilizing three Trimble 4000ssi Geodetic GPS receivers.
6. Only select detail is shown.

DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASS.

SMELT HILL DAM ENVIRONMENTAL RESTORATION STUDY
PRESUMPSCOT RIVER
FALMOUTH, MAINE

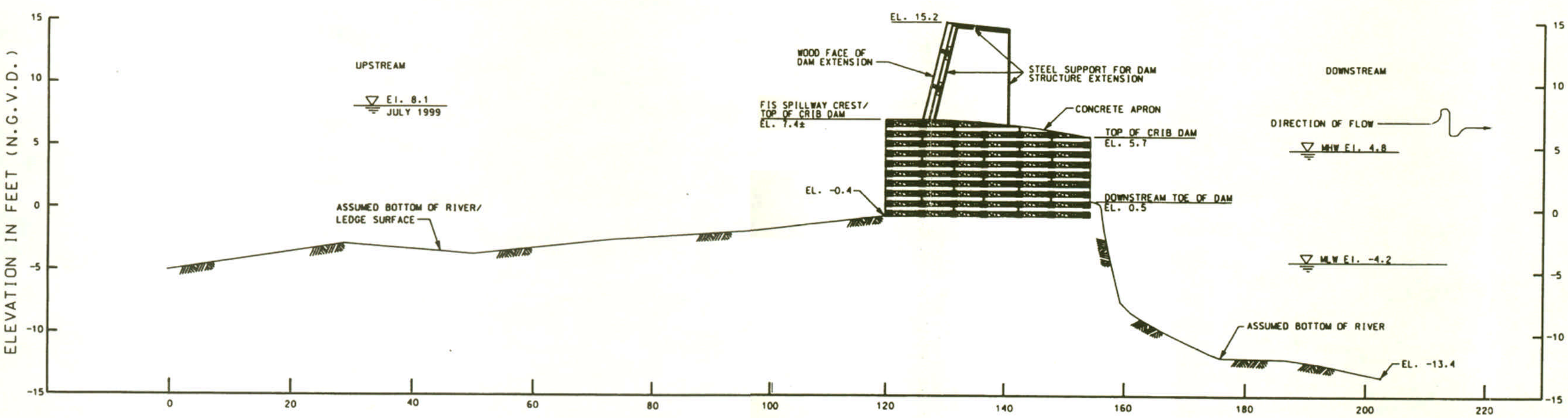
EXISTING SITE PLAN

CADD NO: N:/CIV/ME/SMELTED/EPDC/CSHD01X.DGN	SCALE: 1" = 20'	DATE: MAY 2000



UPSTREAM ELEVATION: EXISTING DAM - LOOKING DOWNSTREAM

SCALE: HORIZ. 1" = 20'
VERT. 1" = 5'



SECTION THROUGH APPROXIMATE MIDDLE OF CRIB DAM

SCALE: HORIZ. 1" = 10'
VERT. 1" = 5'

GRAPHIC SCALES

1"= 5' 5 0 5 10FT

1"= 10' 10 0 10 20FT

1"= 20' 20 0 20 40FT

DEPARTMENT OF THE ARMY
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SMELT HILL DAM ENVIRONMENTAL RESTORATION STUDY
PRESUMPSCOT RIVER
FALMOUTH, MAINE

EXISTING DAM SECTION AND ELEVATION

CADD NO: N:/CIV/ME/SMELTED/EPDC/CSHD02X.DGN	SCALE: 1" = 10'	DATE: MAY 2000

(2) Complete Dam Removal. This alternative involves the removal of the approximately 150-foot in length, 14-foot high timber crib dam, the adjacent 1-story concrete block gatehouse, the fish lift and catwalk, and the powerhouse including all associated appurtenances. The site under this alternative will be left in nearly a natural (pre-dam and powerhouse) state. This alternative will primarily restore a natural river ecosystem.

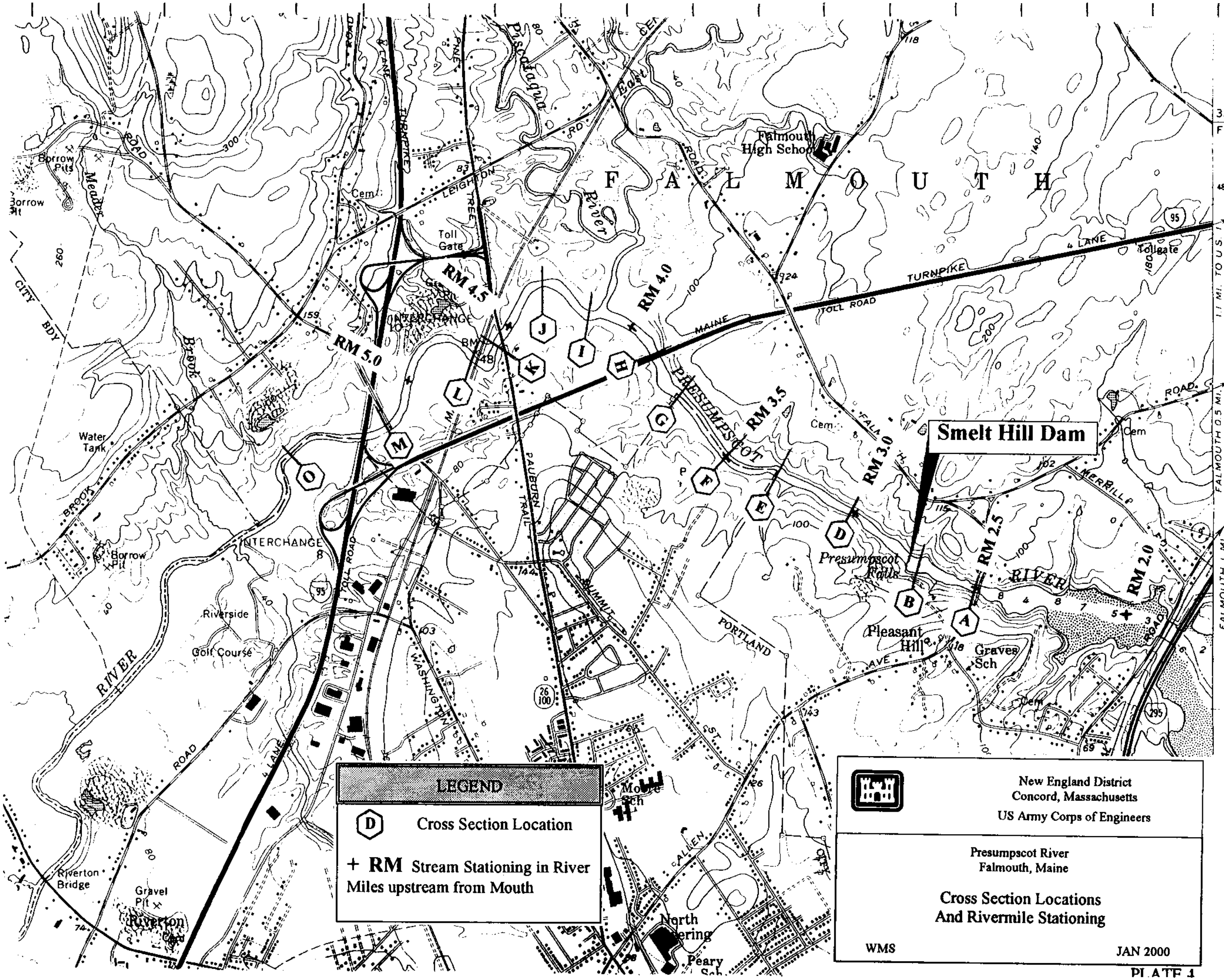
c. Discharge Frequencies. Hydrologic analyses were carried out to establish the peak discharge-frequency relationships. Discharge records at the Presumpscot River at Westbrook gage have only been recorded from 1975 to 1995. Since this is a relatively short period of record, the computed discharge frequencies at this gage have considerable uncertainty associated with them. There is a long-term record (1887-present) of discharges at the outlet to Sebago Lake, however, extensive regulation of the lake has greatly attenuated peak flows from the upper 440 square miles of the Presumpscot River watershed and is not indicative of runoff conditions of the lower watershed. Runoff from the lower 200 square mile drainage is the primary contributor to flood flows in Falmouth. In a 1997 report from the USGS titled "Flood of October 1996 in Southern Maine" discharge frequency analysis for the Presumpscot River was presented. Their frequency analysis considered many of these factors and incorporated historical peak flow information. The calculated peak flow from the October 1996 flood (highest of record) was also included.

The USGS discharge frequencies were checked against COE frequencies at the Westbrook gage, and the hydrologically similar Royal River at Yarmouth gage, along with a comparison of Town of Falmouth, Maine Flood Insurance Study (FIS) frequencies. The Royal River has a drainage area of 141 square miles, and a period of record of 48 years. It is located adjacent to the Presumpscot and is considered hydrologically similar to the lower Presumpscot River. All discharge frequencies compared well to one another, therefore, the USGS discharge frequencies for the Presumpscot River at Westport were used. These values were transferred to the site by ratio of drainage area and were adopted for use in this study. The adopted peak discharge frequencies and mean flow values are listed in Table 4-1.

Table 4-1
Smelt Hill Dam
Presumpscot River
Adopted Discharge-Frequencies

Location	Drainage Area (sq.mi.)	Adopted Peak Discharges (CFS)							
		Jul-Sep Mean	Annual Mean	1-Year	2-Year	10-Year	50-Year	100-Yr	500-Yr
Smelt Hill Dam	640	650	1,000	3,000	6,640	12,360	19,625	23,625	35,000
Near Corp. Limit	598	590	925	2,665	5,895	10,980	17,430	20,980	31,080

d. HEC-2 Backwater Analyses. The Corps of Engineers HEC-2 computer model was used to conduct backwater analyses. It is a standard step method for calculating water surface elevations for steady gradually varied flows, based on river geometry and structures crossing the channel. Input for the model consisted of flow regime, starting elevations, discharge, loss coefficients, cross section geometry, and reach lengths. Outputs from the model include computed water surface elevations and channel velocities.



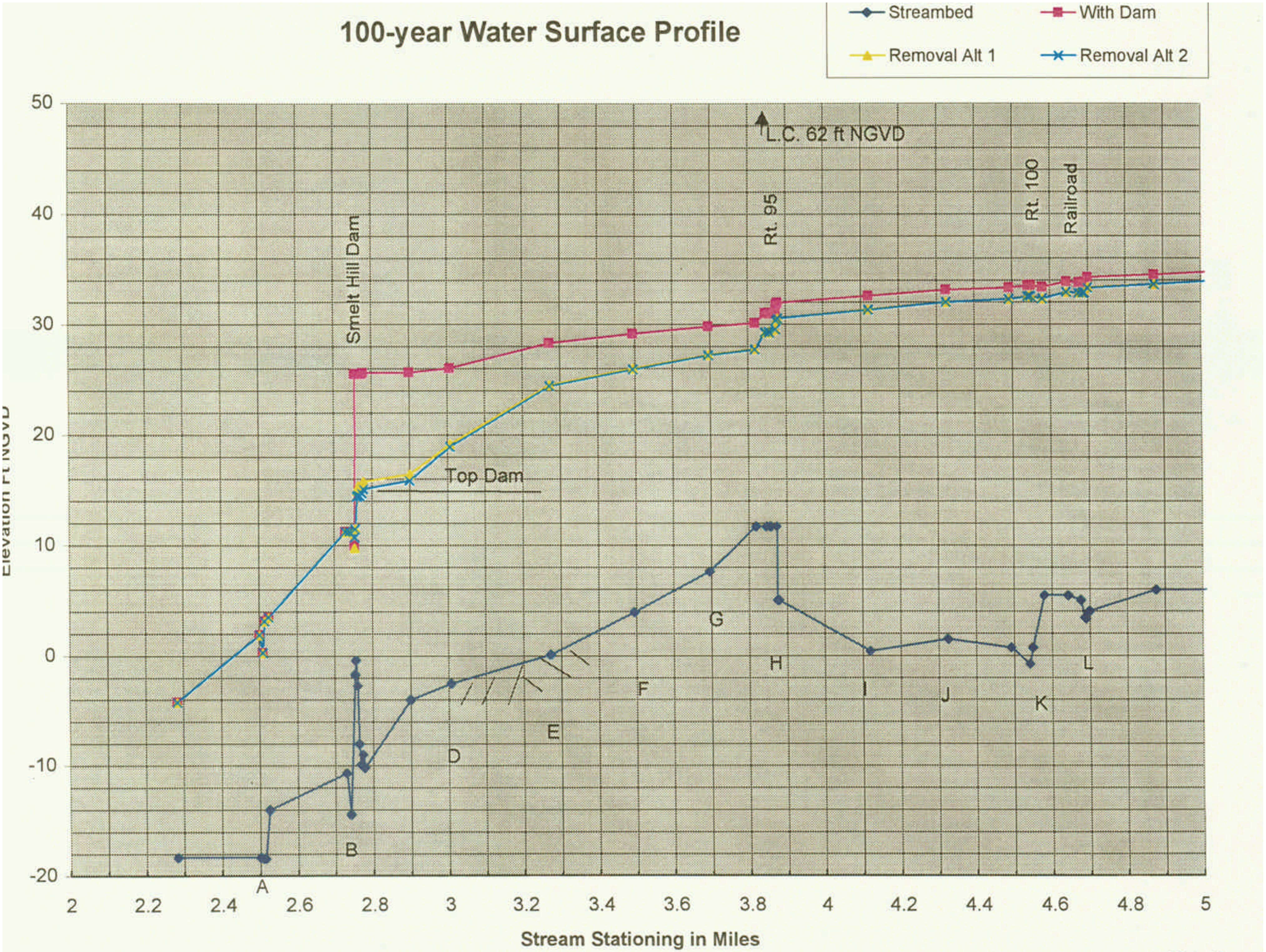
New England District
Concord, Massachusetts
US Army Corps of Engineers
Presumpscot River
Falmouth, Maine
Cross Section Locations
And Rivermile Stationing
WMS
JAN 2000
PLATE 1
LEGEND
Cross Section Location
+ RM Stream Stationing in River Miles upstream from Mouth
Smelt Hill Dam
RM 2.0
RM 2.5
RM 3.0
RM 3.5
RM 4.0
RM 4.5
RM 5.0
A
B
D
E
F
G
H
I
J
K
L
M
O
F A L M O U T H
Falmouth High School
Presumpscot Falls
Pleasant Hill
Graves Sch
PRESUMPSCOT
RIVER
Piscataqua
River
TURNPIKE
TOLL ROAD
MAINE
4 LANE
Tollgate
Toll Gate
INTERCHANGE
PAUBURN TRAIL
SUMMIT
PORTLAND
WASHINGTON
ALLEN
Moore Sch
North Deering
Peary Sch
Riverside
Golf Course
Riverton Bridge
Riverton
Gravel Pit
Water Tank
Borrow Pits
Borrow Pit
Meader
Brook
CITY BDY
LEIGHTON
PINE TREE
Cem
330 000 FEET
1.1 MI. TO U.S. 1
FALMOUTH 0.5 MI.
FALMOUTH 1 MI.
DURHAM (JUNC. ME. 136) 21 MI.

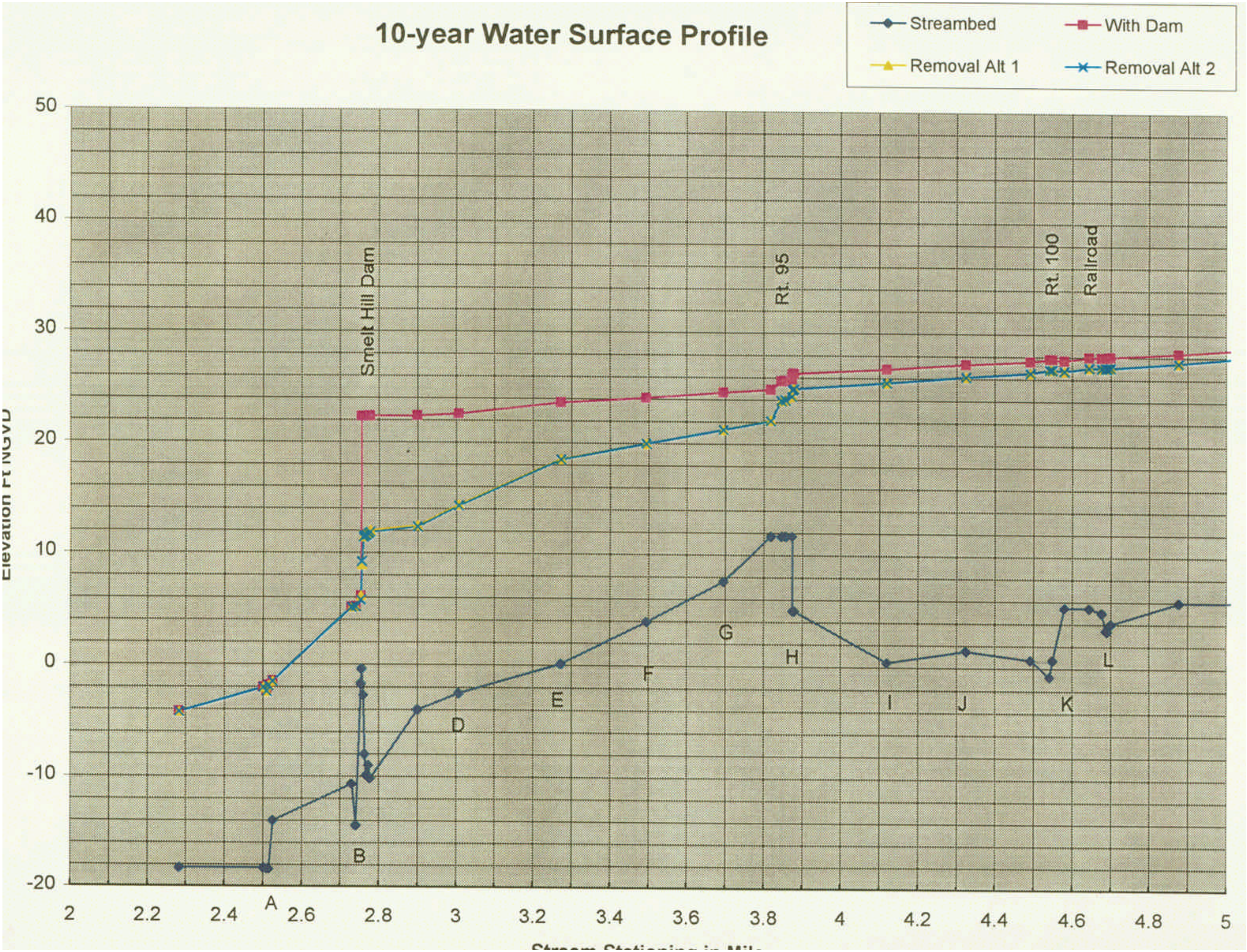
Table 4-2

SMELT HILL DAM

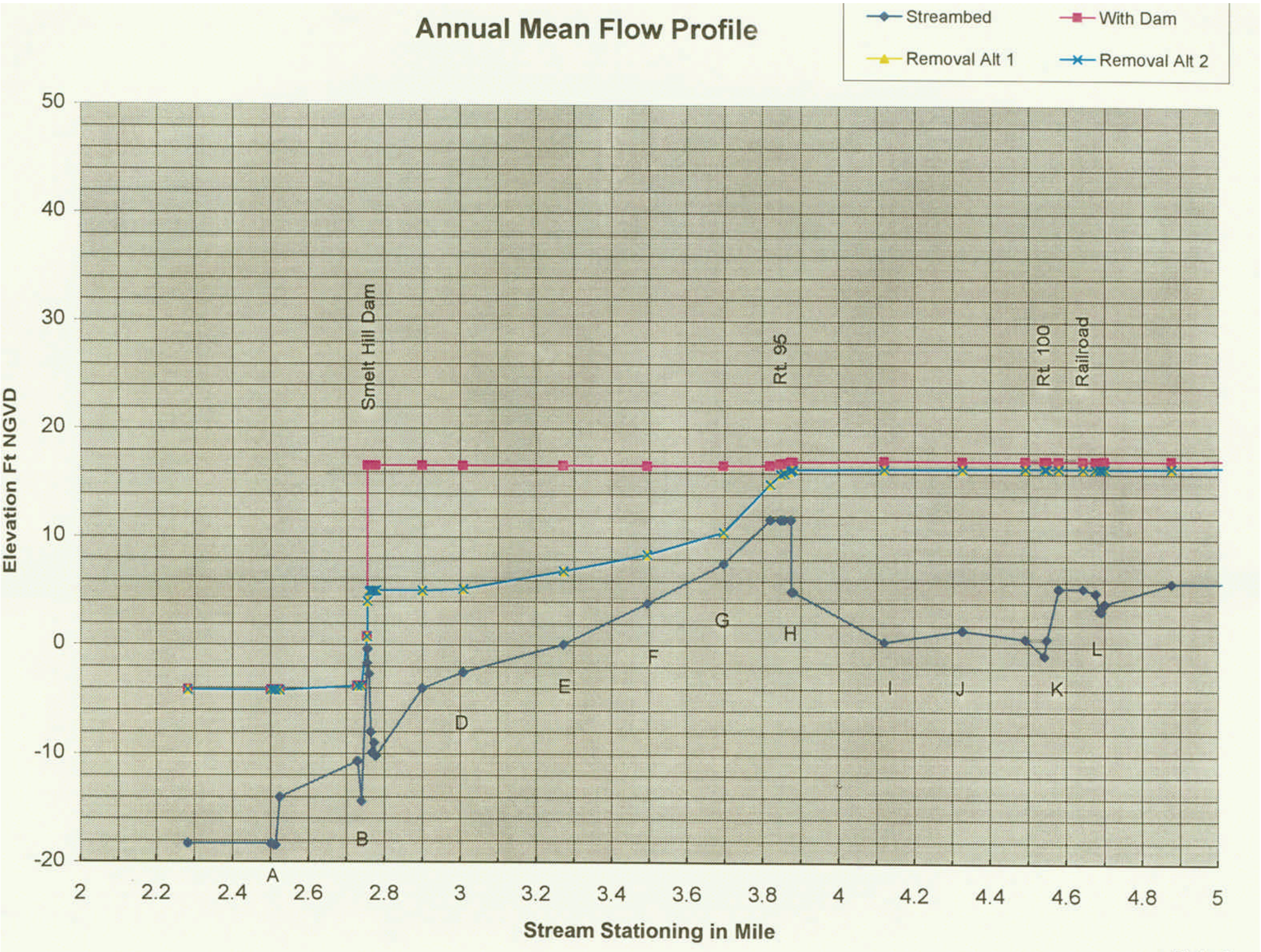
Velocity and Elevation Table (With and Without Dam Conditions)

			With Dam Condition		Alternative 1- Partial Removal				Alternative 2 - Complete Removal			
SEC DES	SECNO	FLOW *	CWSEL	VCH	CWSEL	VCH	Change In Elev.	Change In Vel.	CWSEL	VCH	Change In Elev.	Change In Vel.
	2.74	Mean	-3.79	1.37	-3.79	1.37	0.0	0.0	-3.79	1.37	0.0	0.0
45' d/s Dam	2.74	10-Year	5.14	4.77	5.14	4.77	0.0	0.0	5.16	4.46	0.0	-0.3
	2.74	100-Year	11.2	6.1	11.20	6.1	0.0	0.0	11.24	5.48	0.0	-0.6
	2.756	Mean	16.6	0.34	4.01	6.91	-12.6	6.6	4.01	6.91	-12.6	6.6
At Dam	2.756	10-Year	22.3	2.77	8.92	12.61	-13.4	9.8	9.17	11.84	-13.1	9.1
	2.756	100-Year	25.5	4.45	11.51	15.55	-14.0	11.1	11.44	14.5	-14.1	10.1
	2.764	Mean	16.6	0.3	4.98	1.01	-11.6	0.7	4.98	1.01	-11.6	0.7
50' u/s Dam	2.764	10-Year	22.32	2.7	11.69	5.42	-10.6	2.7	11.55	5.47	-10.8	2.8
(Sew 3)	2.764	100-Year	25.54	4.46	15.35	7.79	-10.2	3.3	14.55	8.16	-11.0	3.7
	2.778	Mean	16.6	0.3	5.00	0.75	-11.6	0.5	5.00	0.75	-11.6	0.5
110' u/s	2.778	10-Year	22.35	2.75	11.98	4.89	-10.4	2.1	11.85	4.94	-10.5	2.2
(Sew 6)	2.778	100-Year	25.61	4.61	15.78	7.32	-9.8	2.7	15.08	7.63	-10.5	3.0
	3.007	Mean	16.61	0.67	5.18	2.69	-11.4	2.0	5.18	2.69	-11.4	2.0
X-SEC D	3.007	10-Year	22.59	5.82	14.34	9.87	-8.3	4.1	14.28	9.92	-8.3	4.1
	3.007	100-Year	26.05	9.44	19.14	13.46	-6.9	4.0	18.91	13.64	-7.1	4.2
	3.495	Mean	16.65	0.61	8.43	2.2	-8.2	1.6	8.43	2.2	-8.2	1.6
X-SEC F	3.495	10-Year	24.14	4.27	19.98	5.69	-4.2	1.4	19.97	5.7	-4.2	1.4
	3.495	100-Year	29.17	5.86	26.00	7.19	-3.2	1.3	25.95	7.22	-3.2	1.4
	3.857	Mean	16.91	2.09	15.97	2.89	-0.9	0.8	15.97	2.89	-0.9	0.8
Rt. 95	3.857	10-Year	25.71	6.03	23.96	7.17	-1.8	1.1	23.96	7.17	-1.8	1.1
	3.857	100-Year	30.97	7.79	29.26	8.71	-1.7	0.9	29.24	8.72	-1.7	0.9


100-year Water Surface Profile
Streambed
With Dam
Removal Alt 1
Removal Alt 2
L.C. 62 ft NGVD
Smelt Hill Dam
Rt. 95
Rt. 100
Railroad
Top Dam
A
B
D
E
F
G
H
I
J
K
L
50
40
30
20
10
0
-10
-20
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5
Stream Stationing in Miles
Elevation Ft NGVD



10-year Water Surface Profile
Streambed
With Dam
Removal Alt 1
Removal Alt 2
Smelt Hill Dam
Rt. 95
Rt. 100
Railroad
A
B
D
E
F
G
H
I
J
K
L
50
40
30
20
10
0
-10
-20
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5


Annual Mean Flow Profile
Streambed
With Dam
Removal Alt 1
Removal Alt 2
Elevation Ft NGVD
50
40
30
20
10
0
-10
-20
2
2.2
2.4
2.6
2.8
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5
Stream Stationing in Mile
Smelt Hill Dam
Rt 95
Rt 100
Railroad
A
B
D
E
F
G
H
I
J
K
L

(2) Velocities

Plates 8, 9, and 10 present channel velocities along the river reach for the 100-year, 10-year and annual mean flow conditions, respectively. Each plot shows velocities for the with dam condition and removal alternative 1 condition. Velocities for the removal alternative 2 were very similar to removal alternative 1, therefore, only removal alternative 1 velocities were shown for clarity. For the 100-year flow condition, the mean channel velocity at the dam increases about 11 feet per second (fps) due to the dam removal. The increase in velocity is greatly reduced upstream of the dam. The velocity increase attributed to the removal of the dam at Route 95 is less than 1 fps. Velocity increases upstream of Route 95 are negligible.

For the annual mean flow and 10-year flood runs, it can be seen that there is still about a 7-10 fps velocity increase right at the dam due to the dam removals. 50 feet upstream of the dam, velocities due to the dam removal are about 1 to 3 fps higher than with the dam condition. At the Route 95 bridge, velocity increases due to dam removal are only about 1 fps. As with the 100-year, velocity increases upstream of Route 95 are negligible.

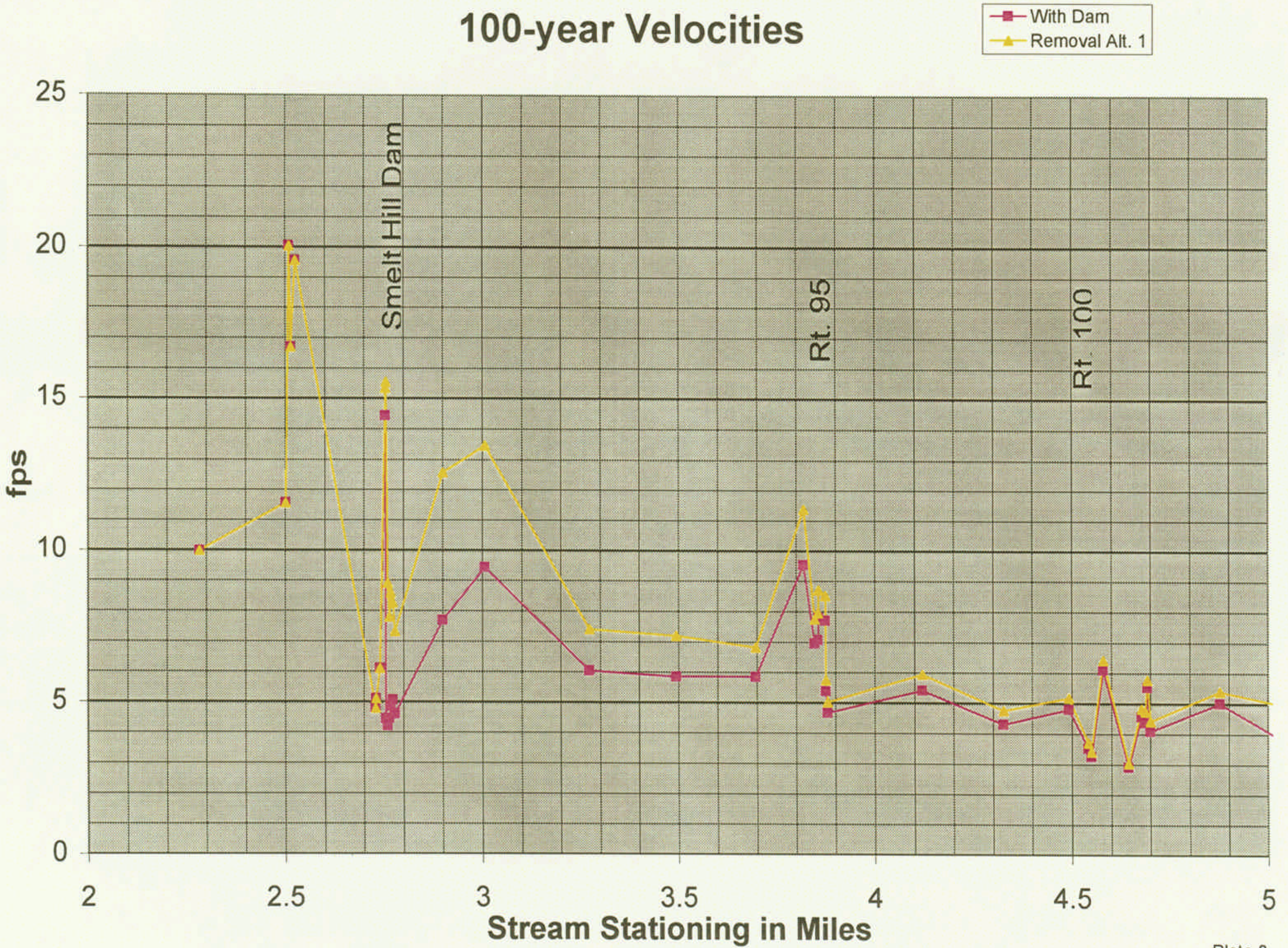
As expected, the 100-year flood event produced the greatest elevation differences and velocity increases at the dam, due to the dam removal. A sensitivity analysis of manning's loss coefficients used in the analysis resulted in relatively minor changes in elevations and velocities. A sensitivity analysis of the starting water surface elevation resulted in less of a difference in water surface and velocities from the with dam to without dam conditions.

5. SUMMARY

The hydraulic analysis for the removal of Smelt Hill Dam considered the effects of the dam removal on water surface elevations and channel velocities. The hydraulic model was used to analyze the existing (with dam) condition along with two removal alternative conditions. The effects of a dam removal (partial or total) are primarily limited to the reach from the dam, upstream, to approximately Route 95 (1.1 miles upstream of the dam). Areas upstream of Route 95 bridge are minimally effected by any dam removal options.

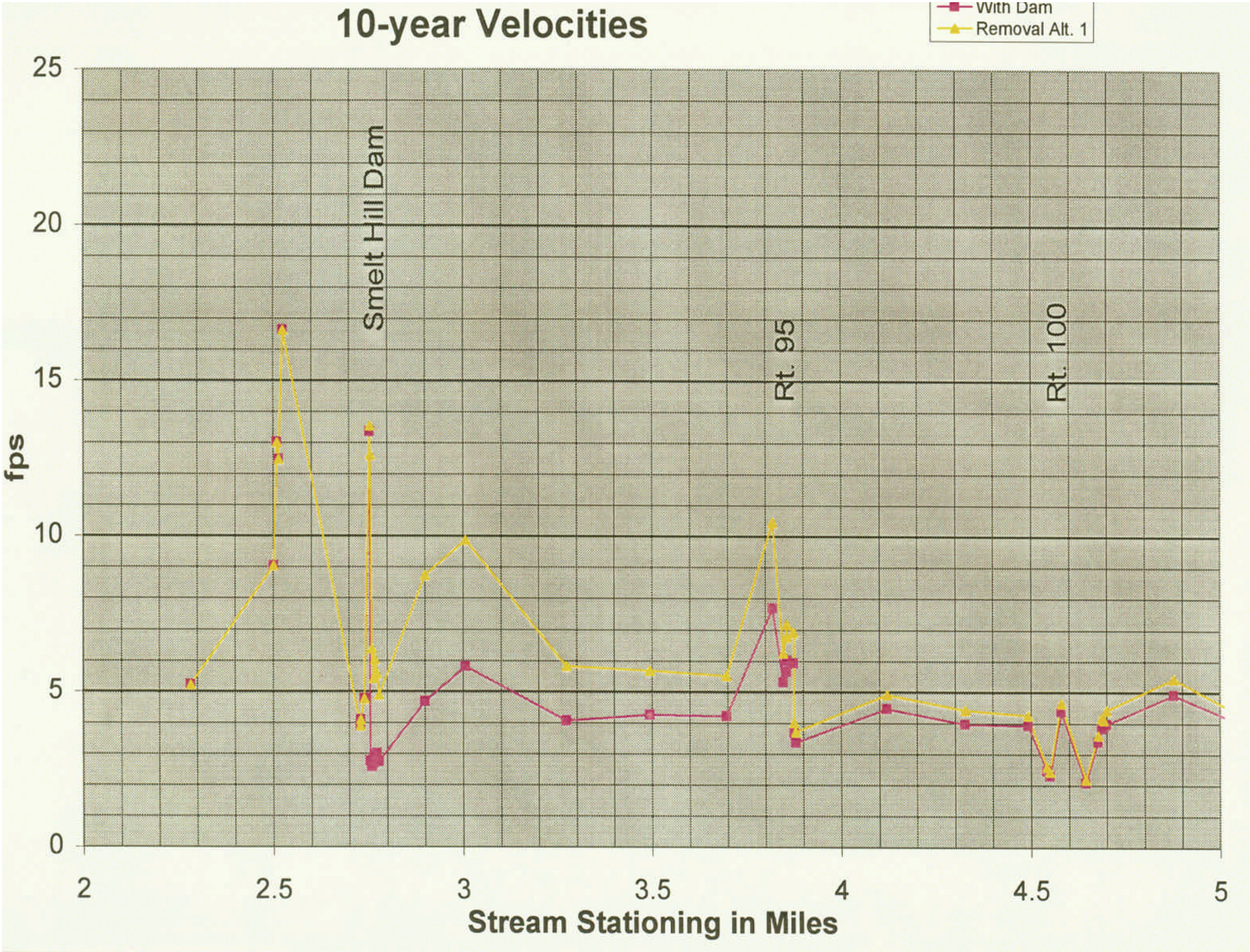
With either dam removal alternative, significant increases in velocity are expected right at the dam due to the new cross sectional geometry and steep slope of the natural falls in this area. No protection will be needed on the north side of the river at the dam removal area, as this is rock ledge. However, slope protection will be needed on the south side from approximately 100 feet upstream of the dam to approximately 150 feet downstream of the dam. D30 stone sizes were determined based on average channel velocities and provide for the Geotechnical Analysis of the design of the stone protection. Stone protection sizes and top elevations were based on the 100-year flow conditions (worst case). Even though an 100-year event is somewhat of a rare event (1 percent chance of occurrence) it is indicative of flow conditions that could occur, and has been adopted by FEMA as the base flood for purposes of flood plain management measures.

Based on the hydraulic analyses and natural conditions upstream of the dam, it was determined (in coordination with Geotechnical Engineering) that bank protection/stabilization was not needed at areas upstream of the dam. The reach between the dam and Route 95 primarily has rock banks and none of the area is developed. The change in water levels and increases in velocities due to the dam removals at the Route 95 bridge are relatively minor and it was determined (in coordination with Geotechnical Engineering) that additional protection at the bridge was not needed.

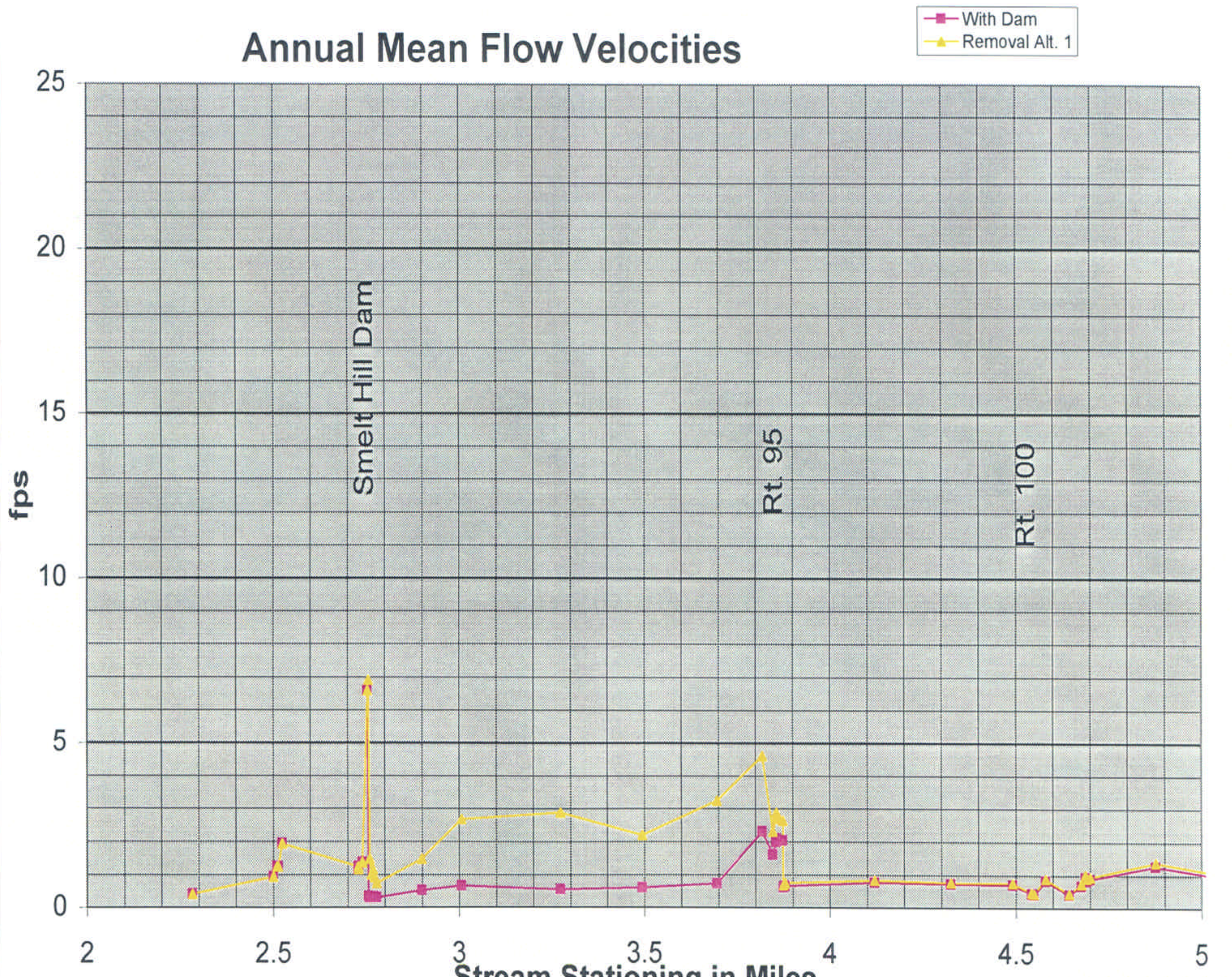


100-year Velocities
With Dam
Removal Alt. 1
fps
25
20
15
10
5
0
2
2.5
3
3.5
4
4.5
5
Stream Stationing in Miles
Smelt Hill Dam
Rt. 95
Rt. 100

Plate 8



10-year Velocities
With Dam
Removal Alt. 1
fps
Stream Stationing in Miles
Smelt Hill Dam
Rt. 95
Rt. 100
0
5
10
15
20
25
2
2.5
3
3.5
4
4.5
5



Annual Mean Flow Velocities
With Dam
Removal Alt. 1
fps
25
20
15
10
5
0
2
2.5
3
3.5
4
4.5
5
Smelt Hill Dam
Rt. 95
Rt. 100