COOPERS MILLS DAM, WHITEFIELD, MAINE
CONCEPTUAL REPAIR DESIGN

Prepared for:

ATLANTIC SALMON FEDERATION
BRUNSWICK, MAINE

Prepared by:

MBP CONSULTING
PORTLAND, MAINE

December 2015

COOPERS MILLS DAM, WHITEFIELD, MAINE
CONCEPTUAL REPAIR DESIGN

Table of Contents

1. General 1
2. Dam Description 2
3. Dam Inspection 4
4. Site Hydrology and Hydraulics 8
5 Conceptual Repair Design 13
6 Preliminary Construction Cost Estimate 16
7 Conclusions 19
8 Recommendations 22

Attachments

A Existing Conditions: Project Drawings 24
B Inspection Photographs 25
C Conceptual Remedial Design 26

MBP Consulting
PLANNING AND ENGINEERING

10 Woodfield Road, Portland, ME 04102 ▪ 207-773-5425 tel/fax ▪ 207-809-9242 cell ▪ myronp@maine.rr.com

December 14, 2015

Mr. Andrew T. Goode
Vice President, U.S. Operations
Atlantic Salmon Federation
Fort Andross, Suite 406
14 Main Street
Brunswick, ME 04011-2030

Subject: Conceptual Repair Design for Coopers Mills Dam, Whitefield, Maine

Dear Mr. Goode,

In accordance with the agreement for professional engineering services between the Atlantic Salmon Federation (ASF) and MBP Consulting (MBP) dated August 28, 2015, MBP performed a review of the project documentation, dam condition inspection, hydrologic and hydraulic analyses, conceptual design, and preliminary construction cost estimate for repair of the Coopers Mills Dam (CMD) owned by the Town of Whitefield, Maine (Town). The activities associated with the dam are overseen by the Town's Coopers Mills Dam Committee (Committee). Preliminary results of the study were discussed with the ASF and Committee in Whitefield on October 29, 2015. This letter report presents our findings, results, conclusions, and recommendations.

1. GENERAL

The Coopers Mills Dam (State ID 04201, National ID ME00336) is located on the Sheepscot River, in the Coopers Mills Village of the Town of Whitefield, Lincoln County, Maine. According to the National Inventory of Dams and the State of Maine records, the Coopers Mills Dam supports an impoundment with a 523-acre surface area and 4,045-acre-foot storage and has low hazard potential classification (Class 3). The dam impoundment is used for recreation, fire protection, and fisheries, and has a historic significance to the local community. Over the years the dam has experienced significant deterioration and development of excessive leakage. During low-flow periods the pond drops below a critical level causing both a dry hydrant used for fire control and fishway installed for the upstream passage of migratory fish inoperable for about one month on average each given year. The Sheepscot River watershed provides habitat for nine species of migratory fish including two federally-protected endangered species, Atlantic salmon and Shortnose sturgeon. The purpose of this study to assess the current condition of the dam and develop a reasonable and cost-effective approach to improve durability, watertightness, functionality, and reliability of the dam, extend its life expectancy, and provide reliable source of water for fire protection and fish passage year round.

2. DAM DESCRIPTION[1]

The 20-foot high, 185-foot long Coopers Mills Dam consists of a central spillway and left[2] and right nonoverflow gravity structures. The dam is of stone/rubble construction covered with a thin layer of concrete or shotcrete. The structure was built circa 1824 to provide mechanical waterpower for a downstream mill. Since construction, the dam had likely experienced several alternations with the last recorded repair made in 1973 when the dam was resurfaced with concrete. The dam is presumably founded on bedrock which is visible in the downstream river channel at the spillway and at the toe of the right nonoverflow structure.

Spillway. The spillway is a broad-crested weir, 43.5 feet long (across flow) and 13.2 feet wide (along flow). The spillway crest is flat for a width of 6.6 feet and then sloping downstream for the remaining 6.6 feet. The flat portion of the crest is at elevation 165.8 feet which is considered the normal pond level. The downstream edge of the sloping crest portion is at elevation 164.9 feet. The spillway side piers are part of the adjacent nonoverflow structures.

[1] Description of the dam is based on a report *"Coopers Mills Dam, Alternative Analysis"* prepared by Kleinschmidt Associates (KA), November 2006 and findings from dam inspection performed by MBP in September 2015.
[2] The terms "left" and "right" refers to an orientation of dam structures looking in the downstream direction (toward the flow).

Left Nonoverflow Structure. The 46-foot long left nonoverflow structure consists of two parts: a 30-foot long riverside section with the top elevation 169.25 feet and a 16-foot long landside section with the top elevation 171.5 feet. The riverside section contains a 14-foot long portion with a 2.5-foot wide top and inclined downstream face backfilled to about elevation 164 feet. The landside section is 1.5 feet wide at the top and partially embedded in soil fill.

Right Nonoverflow Structure. The right nonoverflow is an angled structure with a total length of about 61 feet and top elevation 169.6 feet or 0.35 foot above the top of the left nonoverflow. The structure is 7 feet wide at the top and has a vertical upstream face and inclined downstream face. The structure accommodates two, left and right low level outlets each containing 36-inch diameter corrugated metal pipe (CMP) culverts spaced 13 feet apart. The downstream invert elevations of left and right outlets are 161.4 feet and 160.9 feet, respectively. Each outlet is equipped with a timber gate and manual operator.

Fishway. The left nonoverflow structure contains a concrete Devil fishway with wooden baffles installed in 1958 by the Maine Department of Inland Fisheries and Wildlife and currently operated by the Maine Department of Marine Resources. The upstream fishway entrance opening is 24 inches high, 22 inches wide with a sill elevation at 164.4 feet or 1.4 feet below the spillway crest. The opening is equipped with a timber slide gate manually operated. The downstream fishway entrance is 3 feet wide with the sill at elevation 153.9 feet.

The existing dam is shown on the drawings contained in the KA 2006 study. Selected drawings from this study including a site plan, elevation, and spillway section are included in Attachment A to this report. Main features of the dam are summarized in Table 1.

Table1
Summary of Coopers Mills Dam Data

Structure	Crest/Invert Elevation (ft)	Length (ft)	Width at Top (ft)	Remarks
Spillway	165.8	43.5	13.2	
Left Spillway Pier	169.25	8	7	
Right Spillway Pier	169.6	11	3	
Left Nonoverflow:		45		
Riverside Section 1	169.25	30	2.5	Inclined downstream face
Landside Section 2	171.5	15	1.5	Partially embedded in soil fill
Right Nonoverflow	169.6	61	7	Angled in plan view; inclined d/s face
Left Low Level Outlet	161.4	9		3-foot diameter CMP culvert
Right Low Level Outlet	160.9	9		3-foot diameter CMP culvert

3. DAM INSPECTION

The inspection of the dam was performed on September 1, 2015 to observe and evaluate its current condition prior to development of a conceptual remedial design. The inspection was conducted by Myron Petrovsky (MBP) assisted by Messrs. Andrew Goode (ASF), Louis Sell and Chuck Vaughn (both representing the Dam Committee), and Steve Patton (Sheepscot Valley Conservation Association). The weather was sunny, about 75 degrees. The pond level was measured at elevation 161.85 feet which was about 4 feet below the spillway crest and about 2.6 feet below the upstream fishway entrance sill. During the inspection, some dimensional survey was performed to check the existing drawings and photographs of the observed features taken. Representative inspection photos are included in Attachment B to this report. Following the inspection, a brief report containing a summary of observations was prepared and submitted to ASF on September 3, 2015.

Spillway

The concreted spillway crest was weathered exposing course aggregate (Photo 1). The upstream edge of the concrete cover, about 4 inches thick, was eroded through at some places. A flat area extending to the left of the spillway crest contained a large cavity, 2 feet by 1.5 feet by 1 foot deep, providing a direct entry of the pond water to the masonry interior (Photo 2). It is possible the cavity was formed by the impact from moving heavy logs observed hanging on the spillway during our site visit in 2007. About 4 feet of the upstream spillway face above the pond level available for observation experienced significant deterioration resulting in a loss of about 50 to 70 percent of the concrete cover, missing stone, and development of voids (Photo 3). A large cavity, about 20 feet long, 1 foot high, and up to 12 inches deep was observed under spillway crest concrete overlay (Photo 3). The cavity reduces a bearing support for the concrete cover and provides a potential seepage entry into the structure. The downstream face of the spillway composed of angled, mostly elongated rocks appeared stable and dry for the most part. Leakage emerging from the spillway downstream face at the level about 1.5 feet above the tailwater was confined between the exposed ledge[3] and left spillway corner and then continued along the masonry placed between the spillway and fishway (Photo 4). A leakage discharge at this area was estimated about 10 cubic feet per second (cfs). Some foam circulation indicating presence of considerable leakage was also observed immediately to the right of the exposed ledge.

Left Spillway Pier

The left spillway pier experienced significant deterioration (Photos 3, 5-7). The pier was eroded and undermined on the upstream side and along the spillway crest creating a continuous void, 4 to 6 inches high and 6 to 12 inches deep, causing exposure of the interior rubble. The void continues further to the downstream pier side increasing in size and extent, up to 3 feet high, 3 feet long, and 1 foot deep (Photo 6). This void, connected to the spillway, could redirect a significant amount of the spillway flow to the unprotected downstream masonry. Several missing large stones were observed at that area. The pier landside contained even a larger void estimated at 3.5 feet high, 3.5 feet long, and 1 to 2 feet deep (Photo 7). The pier was a massive structure (7 feet long, 6-7 feet wide, 4-5 feet high) and appeared stable despite loss of significant amount of masonry. A crack at the corner of the pier with the left nonoverflow was observed and judged to be old.

---

[3] Location of the exposed ledge is shown in the Figure 2 drawing of the report “Coopers Mills Dam, Alternative Analysis”, KA, 2006 included in Attachment A to this report.

Right Spillway Pier

The right spillway pier was in adequate and stable condition (Photo 1). A horizontal crack in the concrete cover located about 2 feet above the spillway crest was slightly eroded but appeared tight. The concrete surface below the crack was moderately weathered exposing concrete aggregate. High watermark imprinted on the pier below the crack indicated that the typical high water level in the pond was about 2 feet above the spillway crest.

Left Nonoverflow Structure

The structure significantly deteriorated over the years but appeared stable. The top of the nonoverflow was in reasonable condition. The upstream face concrete developed a couple of large diagonal cracks (Photo 3). The cracks were moderately eroded and tight. Two large voids and a loss of the concrete cover were observed on the vertical surface of the structure adjacent to the spillway and nonoverflow (Photo 3). The downstream face of the nonoverflow was significantly deteriorated and undermined showing missing masonry, eroded cement grout and significant amount of voids (Photo 8). The downstream fill consisting essentially of cemented gravel, cobbles and rocks was eroded exposing rugged surface likely caused by overtopping. The area was vegetated and contained a large tree growing close to the structure. A massive block adjacent to the fishway and left nonoverflow experienced significant deterioration including missing and displaced masonry and lost concrete cover (Photo 9). The block contained a large cavity, 4 feet high and 2 feet wide, visible on the riverside and downstream faces.

Right Nonoverflow Structure

The right nonoverflow appeared in stable condition with no signs of movement observed. The wall was heavily overgrown with trees and brush obstructing the inspection. The top of the structure was weathered and slightly eroded at the edges and judged to be in fair condition (Photo 10). The upstream face showed significant deterioration and spalling of the concrete cover (Photo 11), penetration of tree roots causing lifting, dislocation and degradation of the masonry (Photo 12), and development of deep voids with exposure of the interior rubble (Photo 13). The downstream face concrete was in adequate condition. No signs of significant seepage through or at the toe of the structure were noticed.

Low Level Outlets

The timber gates installed to regulate the outlet flow were permanently lowered and inoperable (Photo 13). The interior of the outlets was observed using a flashlight. It appears that the original outlets were about 3 feet by 3 feet, 10-foot long masonry conduits later equipped later with 36-inch diameter corrugated metal pipe (CMP) culverts. The culverts extended about 5 feet inside of the masonry conduits from the downstream leaving the upstream portion of the conduit unlined. The exposed outlet masonry appeared dry and intact. The timber gates were leaking extensively between timber boards and around their perimeter (Photos 14, 16). The depth of flow exiting each culvert (Photos 15, 17) was measured and the discharge assessed using the U.S. Bureau of Reclamation's methodology[4]. The flow from the left and right culverts was determined to be 2 cfs[5] and 8 cfs, respectively, with the combining discharge from the conduits about 10 cfs.

Fishway

The concrete fishway with wooden baffles in place and the intake gate open appeared in fair condition after 57 years in service. The fishway walls and floor showed minor weathering and erosion. A vertical crack mentioned in the KA study has not changed significantly in appearance after 10 years. However, the crack was leaking and vegetated at intersection with a horizontal construction joint causing concrete spalling and void development. The wooden gate at the upstream fishway opening was in good repair (Photo 18). The steel frame supporting the gate appeared rusty, corroded in some places but judged to be in serviceable condition.

The inspection findings described above were used in development of the conceptual repair design and calculation of construction quantities. The results of the inspection are summarize in Section 7 "Conclusions" of this report.

[4] USBR, "Water Measurement Manual", 1984.
[5] 1 cfs is approximately equal to 450 gallons per minute (gpm).

4. SITE HYDROLOGY AND DAM HYDRAULICS

The site hydrology and dam hydraulics were assessed to determine the spillway design flood (SDF), check the existing dam hydraulic capacity against the SDF, and develop requirements for the conceptual repair design.

The site hydrology was studied by KA in the 2006 report using water data recorded by the USGS streamgage No. 01038000, "Sheepscot River at North Whitefield" from 1938 through 2004. The streamgage drainage area is 145 square miles while the drainage area of the Coopers Mills Dam located in the same watershed is 81 square miles. The flood flows at the streamgage site were calculated for the specified recurrence intervals and then prorated to the dam site using the ratio of drainage areas (81/145 = 0.56). The calculated floods for the specified recurring intervals are included in Table 2.

Table 2

Peak Flows at the Dam for Different Recurrence Intervals [a]

	Recurrence Intervals (Years)						
	2	5	10	25	50	100	200
Peak Flow (cfs)	1,071	1,615	2,071	2,775	3,404	4,133	4,980

[a] KA, Coopers Mills Dam Alternative Analysis, 2006, page 8.

The selection of the SDF and appropriate flood recurrence interval is based on the downstream hazard classification and size of the dam. The Coopers Mills Dam is a low hazard structure which implies no significant downstream impact to lives and infrastructure occurs if the dam failed. The dam size is governed by a height of the dam and storage of the impoundment. The height of the Coopers Mills Dam is 20 feet which fits in a small size category (less than 25 feet). The maximum dam storage is 4,045 acre-feet exceeding 1,000 acre-feet for a small dam. Therefore, based on height and storage, the dam has an intermediate size category. The U.S. Army Corps of Engineers' guidelines, adopted by the State of Maine, recommend the SDF for a low hazard, intermediate size dam as 100-year to ½ Probable Maximum Flood (PMF). Although the dam storage is relatively large, it is problematic that the entire impoundment storage assigned to the dam which includes Great Sheepscot Lake upstream would be catastrophically released downstream during an extreme flood. At the normal level, the dam pond is only 750 feet long and 12 below the water level in Long Pond, next upstream from the dam. Based on these considerations, the 100-year flood of 4,133 cfs was selected as the project SDF.

The hydraulic analysis was performed to evaluate the capacity of the existing spillway prior to overtopping the nonoverflow structures, determine the maximum pond level for the 100-year flood, and assess several conceptual modification measures for increasing the spillway capacity.

The dam hydraulic capacity was conservatively estimated assuming the outlet gates and fishway gate installed for maintenance and environmental purposes were closed and not accessible, inoperable, or a gate operator is not available during significant flood events. The KA report also demonstrated that operation of the gates has negligible effect on lowering the pond flood level.

The spillway discharge was determined using a standard weir equation where variables include a spillway length, discharge coefficient (a measure of hydraulic efficiency) and hydraulic head. The discharge coefficient for the broad-crested weir was obtained from the King's "Handbook of Hydraulics" (1976). The discharge was calculated for each structure affected by overtopping including nonoverflow structures and abutments. The maximum capacity of the existing spillway was determined when the pond level is at the lowest point of the dam which is the left nonoverflow structure 1 with the crest elevation 169.25 feet. Subsequently, the dam discharge was determined for the pond level at the top of the right nonoverflow (elevation 169.6 feet), left nonoverflow 2 (elevation 171.5 feet), and left abutment parking lot at Basin Lane (elevation 173.0 feet). The pond level was also determined for each flood with the recurrence intervals from the 2-year and up to the 100-year (Table 2). A schematic sketch of the dam in Figure 1 shows elevations and dimensions of each structure considered in the analysis. The results of the hydraulic calculations for each structure including the pond stage, discharges, overtopping head, and corresponding flood recurrence intervals are summarized in Table 3.

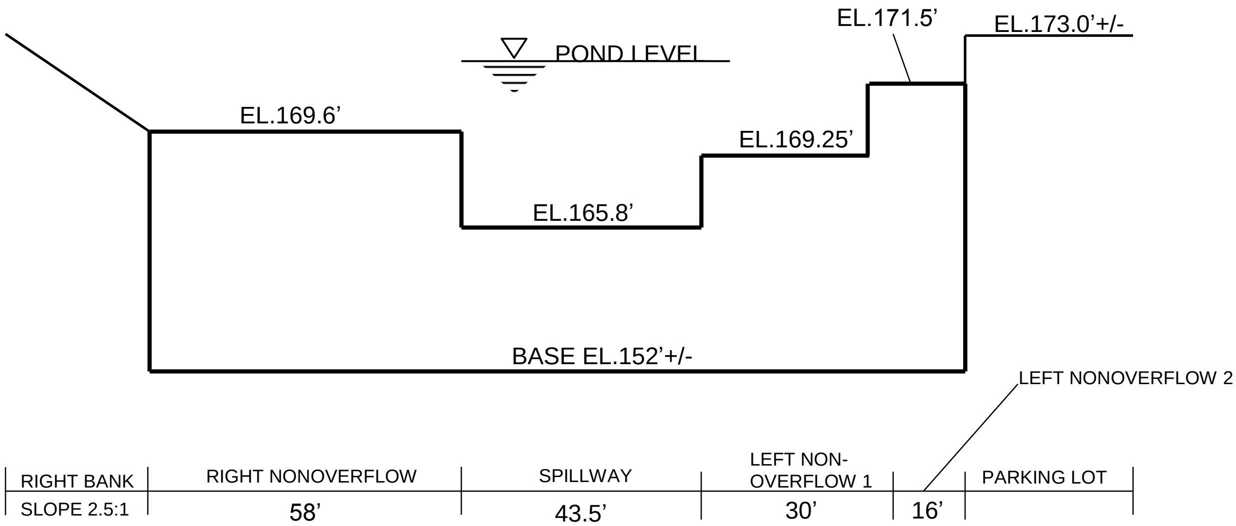


Figure 1. Schematic Elevation of Coopers Mills Dam.

Table 3
Dam Discharge Versus Pond Level

Pond Elevation (ft)	Discharge (cfs)	Structure Prior to Overtopping	Flood Recurrence Interval	Remarks
165.8	0	Spillway		
169.25	736	Left Nonoverflow 1		Spillway maximum capacity
169.6	867	Right Nonoverflow		
170.0	1,079		2-year	
170.8	1,642		5-year	
171.3	2,063		10-year	
171.5	2,244	Left Nonoverflow 2		
172.0	2,742		25-year	
172.6	2,407		50-year	
173.0	3,887	Left Abutment Parking Lot		
173.2	4,137		100-year	Parking lot overtopped by 0.2’

As can be seen form Table 3, the maximum spillway capacity without overtopping the lowest section of the dam, the left nonoverflow 1 (elevation 169.25 feet), is 736 cfs which is less that the 2-year flood of 1,071 cfs and is only 18 percent of the SDF. The dam would pass the 2-year flood at the pond elevation 170.0 feet overtopping the right nonoverflow by 0.4 feet (5 inches). The 25-year flood of 2,775 cfs with the pond elevation 172 feet would overtop the highest section of the dam, the left nonoverflow 2, by 0.5 foot. The 100-year flood would occur with the pond elevation

173.2 feet resulting in slight overtopping of the parking lot on the left abutment at the location of the dry fire hydrant by about 0.2 foot (2 ½ inches). Due to the insufficient spillway capacity, it is expected that the dam would be overtopped relatively frequently during the 2-year to 10-year floods. The latest recorded flood of unknown recurrence causing overtopping of the dam occurred in April 2006 and is shown in Figure 2.

Photo Courtesy of Coopers Mills Dam Committee

Figure 2. Coopers Mills Dam Overtopping During Spring Runoff, 23 April 2006.

Due to the undersized dam hydraulic capacity and frequent overtopping, the existing spillway can be can be considered as a main spillway and the nonoverflow sections as auxiliary spillways where the left nonoverflow 1, the lowest section, is experiencing more frequent overtopping. The overtopping of nonoverflow dam sections could require downstream protection against potential erosive action of the fallen water jet causing potential scour and undermining of the base of the structures. Signs of erosion and deterioration of the downstream face and the toe area of the left nonoverflow were observed during the dam inspection (Section 3 of this report).

Several conceptual modification options were evaluated to lower the pond SDF level and reduce overtopping of the dam. The options considered: (1) No action (existing condition), (2) Rounded weir edge of a new concrete overlay to improve the hydraulic weir efficiency, (3) Lowering the right nonoverflow, (4) Lowering the spillway and installation of a concrete ogee at the current crest elevation, (5) Spillway lengthening by reducing the thickness of the side piers (6) Spillway lengthening by removing a portion of the right nonoverflow structure, and (7) Lowering the spillway and installation of a flood crest gate. Option 8, raising the left nonoverflow to reduce the overtopping frequency, was also evaluated. The description of each modification option, corresponding the SDF pond elevation and the opinion of cost are summarized in Table 4.

Table 4
Effect of Conceptual Modification Options on SDF Pond Level

Option Number	Modification Option Description	SDF Pond Elevation (ft)	Change in SDF Pond Elevation[1/] (ft)	Opinion of Cost
1	No Action: Existing Condition	173.2	0	No additional cost
2	Rounded Upstream Weir Edge	172.6	-0.6	Relatively inexpensive
3	Lowering Right Nonoverflow by 3’	172.0	-1.2	Expensive
4	New Concrete Spillway Ogee	172.5	-0.7	Expensive
5	Spillway Lengthening by Reducing Side Pier Thickness by 6’	173.0	-0.2	Relatively inexpensive; fishway may affect left pier modification
6	Spillway Lengthening to 60’ by Shortening Right Nonoverflow	172.7	-0.5	Expensive
7	Installation of 7’ High Spillway Flood Gate	169.3	-3.9	Very expensive
8	Raising Left Nonoverflow by 1.5’ to Reduce Area Overtopping Frequency	173.4	+0.2	Relatively inexpensive

[1/] Pond elevation lowering(-) / raising (+).

A brief consideration of modification options presented in Table 4 show that all options, except Option 7, results in relatively small reduction of the SDF pond level, by 0.2 foot to 1.2 feet, and do not prevent overtopping of the dam structures. The remedial measures involving rounded upstream weir edge (Option 2), and lengthening the spillway by reducing the thickness of the spillway piers (Option 5), could protect the Basin Lane roadway of the left abutment from overtopping and are relatively inexpensive. All other options involving removal of considerable volume of masonry, placement of new concrete or installation of a large flood gate are costly and appeared not feasible.

5. CONCEPTUAL REMEDIAL DESIGN

Three options suitable to adequately control leakage through the dam, the main purpose of the dam repair, were considered and evaluated based on their reliability, proven technology, constructability, and cost. The leakage control options selected for evaluation included dam grouting, an upstream face PVC liner, and an upstream face concrete overlay.

Option 1, Dam Grouting. Dam grouting to stop leakage would be performed by drilling a number of holes from the top of the dam into foundation and injecting a cement grout. The grouting will likely result in partial sealing of the existing culverts. A specialty contractor, Hayward Baker in Cumberland, RI, contacted to provide a quotation for the dam grouting, estimated that 16-18 weeks of work at a total cost of $700,000 to $900,000 would be required. HB assumed that cofferdamming, river flow control and related construction activities will be performed by a general contractor.

Option 2. PVC Liner. In the last 20-25 years a PVC liner is getting acceptance and increasingly used to reduce seepage through dams. An Italian product, a 100-mil CARPI geomembrane clamped to the surface with stainless steel strips, is typically used for this purpose. The CARPI liner was considered for installation on the masonry Cambridge Pond Dam in Cambridge, ME which is slightly smaller than the Coopers Mills Dam (CMD). The CARPI's estimate in 2009 for that dam was $392,099 with the unit price $141.30 per square foot of dam surface. Considering a

5 percent cost increase for a 6-year period, the PVC liner installation for the CMD was estimated at $411,704. The estimate does not include the cost of surface preparation, repair of the spillway crest and culverts, cofferdamming, or water control.

Option 3. Concrete Overlay. An impermeable barrier in the form of a concrete overlay would be installed on the upstream dam face. The cost for this measure which also included the spillway crest renovation, decommissioning of one culvert and installation of a new gate on another culvert was estimated at about $254,200. Table 5 summarizes the results of cost estimates and advantages and disadvantages for different repair options considered.

Table 5
Cost Estimate of Repair Options for Leakage Control

Repair Option	Cost Estimate	Advantages	Disadvantages
1. Dam Grouting	$700,000-$900,000	Proven technology, more stable dam (weight increase)	Potential stream pollution, specialty contractor, expansive
2. PVC Liner	$411,700	Good performance, environmentally friendly	No winter construction, specialty contractor, expensive
3. Concrete Overlay	$254,200	Proven technology, local contractors, good performance	Potential cracking, relatively expansive

As can be seen in Table 5, repair Option 1, dam grouting, is the most expensive of three remedial measures considered. This option requires a specialty contractor, may cause environmental damage by polluting the pond and stream with cement grout, and could interfere with general contractor's activities. Option 2, a PVC liner, is the second expansive repair measure. The liner is harmless to environment but cannot be installed during the winter and require a specialty contractor. Option 3, a concrete overlay, is the least expansive remedial measure of three measures considered. This option has a proven record of satisfactory performance, can be implemented by local contractors and integrated into overall repair work including sealing the culverts and restoration of deteriorated portions of the dam. Based on this considerations, the concrete overlay was selected for the conceptual design to control dam leakage.

General criteria to the conceptual repair design included to achieve the following:

- Stable pond level for fire control and upstream fish passage year round.
- Safe and reliable operation of the dam for the design life of least 50 years.
- Use of present dam engineering criteria and practice including the requirements of the state and federal regulatory agencies.
- Preservation of the existing dam footprint to minimize the impact on the environmental resources of the project area and mitigate the permitting process.

The conceptual design should address three major dam deficiencies: excessive leakage, masonry deterioration, and insufficient spillway capacity. A general arrangement drawing and dam sections with proposed repairs are included in Attachment C to this report. The location of the dam sections is shown on the arrangement drawing.

To control leakage, the concrete overlay would be installed on the upstream face of the spillway and left and right nonoverflow structures, the spillway crest would be resurfaced with new concrete overlay, left leaking culvert outlet would be permanently plugged with concrete, and right leaking outlet would be fitted with a new PVC pipe and watertight slide gate. The overlay would also seal the deteriorated surface containing loose masonry, cracks, and voids and protect dam structures from further deterioration. A 10-inch thick reinforced concrete overlay would be anchored to the existing masonry and rock foundation with steel dowels. The overlay would be advanced about 12 inches deep in foundation to isolate a potentially water conveying contact between the dam and its base. The details of the concrete overlay to be placed on the upstream dam face and spillway crest and restoration of the right outlet are shown in Sections 1-3, 7 included in Attachment C.

The deeply deteriorated downstream face of the left nonoverflow structure would be repaired by installation of a concrete overlay similar to the upstream face overlay and large cavities in the masonry would be filled with reinforced concrete. The severely deteriorated 7-foot wide left spillway pier which appeared marginally stable would be replaced with a 2-foot thick concrete pier re-connected to the left nonoverflow with a concrete wall. The pier base masonry would be replaced with a reinforced concrete slab. The details of this repair are shown in Sections 3-5 included in Attachment C.

The downstream areas of the dam experiencing an erosive impact from a relatively frequent overtopping due would be reinforced. The deteriorated, most frequently overtopped area between the left nonoverflow and fishway would be armored with grouted riprap and protected from the spillway discharges with a new concrete training wall. The remediation of the area downstream of the left nonoverflow and left spillway pier are shown in Sections 4, 5 included in Attachment C. The dam abutments and the toe of the right nonoverflow structure would be protected against overtopping by placement of heavy riprap.

6. PRELIMINARY CONSTRUCTION COST ESTIMATE

A preliminary construction cost estimate of proposed dam repairs described above was determined based on the site survey drawings, inspection findings, a plan and sections developed for the conceptual repair design, and our understanding of the condition of the dam and experience with similar repair projects.

The cost estimate was based on quantity take-offs and unit prices. The construction items identified during the conceptual design included general site work (access roadways, clearing and grubbing, pond sediment removal to expose the dam) and specific work items (masonry removal, common soil excavation, rock excavation, riprap placement, steel dowels in rock and masonry, steel reinforcement, rubber waterstops at construction joints). Concrete quantities were estimated for each structural feature, such as horizontal and vertical overlays, slabs, and walls. The unit prices used were quoted by general contractors for our recent dam repair projects. The cost for gate fabrication and installation was estimated using a quote received from Rodney and Hunt, a gate manufacturer. The additional direct construction items, such as cofferdam and water management, construction easement, erosion and sediment control, and landscaping, were estimated on lump sum basis. The cost for mobilization and contractor's general conditions were added to determine the total direct cost. The indirect cost included contingency, engineering. construction administration, and permitting. The results of repair cost estimate for each dam structure and repair item are summarized in Table 6. The table includes direct and indirect construction costs and project cost total.

Table 6
Preliminary Construction Cost Estimate
Leakage Control, Deterioration Repair, Flood Protection

Structure	Repair Item	Cost	Cost Total
Spillway	Upstream Face Concrete Overlay	$31,917	$90,788
	Concrete Crest Cap	$37,500	
	Left Pier	$17,618	
	Right Pier	$3,752	
Left Nonoverflow	Upstream Horiz. Area Overlay	$2,346	$63,053
	Upstream Face Concrete Overlay	$35,164	
	Downstream Face Conc. Overlay, Grouted Riprap	$21,362	
	Downstream Concrete Training Wall	$4,181	
Right Nonoverflow	Upstream Face Concrete Overlay	$34,076	$37,169
Outlets	Left Outlet: Culvert Concrete Plug	$942	$19,942
	Right Outlet: New Culvert and Gate	$19,000	
Abutments	Erosion Protection	$10,361	$10,361
Miscellaneous	Pond Sediment Removal	$16,667	$47,667
	Construction Access Roads	4,000	
	Cofferdam and Water Management	$20,000	
	Construction Easement	$2,000	
	Erosion and Sediment Control	$3,000	
	Landscaping: loam, seed, fertilizer	$2,000	
	Direct Cost Subtotal		**$268,980**
	Mobilization (20% of subtotal)	$53,796	
	Gen'l Contr. Gen'l Cond. (15% of subtotal)	$40,347	$94,143
	Direct Cost Total		**$363,123**
	Indirect Cost		
	Contingencies (20% of subtotal)	$53,796	
	Engineering/Construction Adm. (20%)	$53,796	
	Permitting (6% of subtotal)	$16,139	
	Indirect Cost Total		**$123,731**
	Project Total		**$486,854**

Based on the results contained in Table 6, the cost for the leakage remediation only was determined to compare with the total dam repair cost. The results of this cost estimate are presented in Table

7. The table includes leakage control measures such as the upstream dam face concrete overlay, spillway crest cap, and sealing the outlets with concrete and a new gate. Due to insignificant leakage through the right nonoverflow observed during the inspection of the dam, only half of the overlay length was considered for that structure. The added cost included fill concrete to repair large cavities in the left spillway pier and left nonoverflow structure.

Table 7
Preliminary Construction Cost Estimate: Leakage Control

Structure	Repair Item	Cost	Cost Total
Spillway	Upstream Face Concrete Overlay	$31,917	$72,277
	Concrete Crest Cap	$37,500	
	Left pier cavity fill concrete (added)	$2,859	
Left Nonoverflow	Upstream Horiz. Area Overlay	$2,346	$38,695
	Upstream Face Concrete Overlay	$35,164	
	Left d/s block-cavity fill concrete (added)	$1,185	
Right Nonoverflow	Upstream Face Concrete Overlay-half length	$18,585	$18,585
Outlets	Left Outlet: Culvert Concrete Plug	$942	$19,942
	Right Outlet: New Culvert and Gate	$19,000	
Miscellaneous	Pond Sediment Removal	$16,667	$50,667
	Construction Access Roads	4,000	
	Cofferdam and Water Management	$20,000	
	Construction Easement	$2,000	
	Erosion and Sediment Control	$3,000	
	Clearing and Grubbing (added)	$3,000	
	Landscaping: loam, seed, fertilizer	$2,000	
	Direct Cost Subtotal		**$200,165**
	Mobilization (20% of subtotal)	$40,033	
	Gen'l Contractor's Gen'l Condition (15% of subtotal)		$70,058
	Direct Cost Total		**$270,223**
	Indirect Cost		
	Contingencies (20% of subtotal)	$40,033	
	Engineering/Construction Adm. (20%)	$40,033	
	Permitting (6% of subtotal)	$12,010	
	Indirect Cost Total		**$92,076**
	Project Total		**$362,299**

As can be seen from Table 6, the cost of dam repair which includes leakage control, restorative and overtopping protection measures would be approximately $487,000. If only leakage control measures considered (Table 7), the dam repair cost would be about \$362,000, a reduction by \$125,000 or 26 percent compare to the total dam repair cost.

7. CONCLUSIONS

Based on the available project information, inspection findings, hydraulic analysis, conceptual repair design, and preliminary repair cost estimate, the following conclusions can be made:

1. The dam is judged to be in stable and in fair to poor condition. Major deficiencies of the dam include material deterioration, excessive leakage, and insufficient spillway hydraulic capacity.

2. The dam has experienced significant deterioration including loose and missing masonry, cracked and eroded concrete cover, and development of large voids and cavities caused by weathering, freeze-thaw action, tree root penetration, ice and debris movement, and overtopping. The voids and cracks may facilitate water entry into the dam, increase leakage and reduce stability of the dam.

3. The leakage observed during the dam inspection with the pond level about 4 feet below its normal stage is caused by the inoperable and abandoned low level outlets and permeable stone masonry of the spillway and left nonoverflow structure. A total leakage discharge was estimated at 20 cfs which is close to the average August-September stream flow. The inability of the dam to maintain the normal pond level results in exposure of the fire hydrant intake and fishway dewatering.

4. The site 100-year flood of 4,133 cfs was selected as the spillway design flood (SDF) based on the dam hazard rating (low) and size (intermediate). The records also indicate the dam experienced the historic flood close to the SDF in April 1987. The hydraulic analysis indicated the dam spillway is undersized and can only pass about 736 cfs (18 percent of the

SDF) without overtopping the left nonoverflow and about 867 cfs (21 percent of the SDF) without overtopping the right nonoverflow. Both estimated flows are 19 to 31 percent less than the 2-year flood of 1,071 cfs.

5. The dam is not designed for the frequent overtopping. The left nonoverflow, the lowest section of the dam and overtopped most often, exhibited more advanced deterioration than other sections of the dam. The impacted areas included the downstream face, adjacent piers, masonry / rubble backfill, and fishway. Overtopping flows and dislodged rocks may impact operation of the fishway. A number of rocks deposited on the bottom of the lowest section of the fishway were observed during the inspection.

6. Several options were considered to increase the hydraulic capacity of the dam, lower the SDF pond level, and reduce the overtopping. The options included increasing a hydraulic efficiency of the spillway by rounding the upstream weir edge, replacing the existing broad-crested weir with a concrete ogee crest, widening the spillway by up to 16.5 feet, lowering the right nonoverflow by 3 feet, and installation of a 7-foot high crest gate. Most of these options are relatively ineffective in lowering the SDF pond level, do not prevent overtopping, and were judged not feasible due to high construction cost.

7. The conceptual repair design considered three leakage reduction options: 1) dam grouting, 2) a synthetic geomembrane on the upstream dam face, and 3) a concrete overlay on the dam upstream face and spillway crest. The concrete overlay was selected for the conceptual design due its reliability, proven performance, availability of experienced local contractors, and cost.

8. The proposed conceptual design would address the current dam deficiencies: excessive leakage, material deterioration, and overtopping. The reinforced concrete overlay installed on the upstream dam face and spillway crest would act as an impermeable barrier cutting leakage flow and at the same time sealing open cracks and voids in the existing masonry.

The deteriorated downstream face of the left nonoverflow would be encased with reinforced concrete. The left spillway pier, severely damaged, would be replaced with a new concrete wall. The frequently overtopped and deteriorated area downstream of the left nonoverflow would be armored with grouted riprap and protected from the spillway flows with a concrete wall. A riprap blanket would be installed to protect the abutments and the toe of the right nonoverflow from overtopping flows. Two heavy leaking low level outlets in the right nonoverflow would be sealed: the left outlet would be permanently plugged with concrete and the right outlet would be fitted with a new stainless steel slide gate. The conceptual remedial design, a general arrangement plan and cross sections, are included in Attachment C to this report.

9. The preliminary construction cost estimate was prepared to establish the cost baseline and to request project approval and funding authorization. The cost estimate of the proposed dam repair was based on the conceptual design presented above, estimated construction quantities and current unit prices prevalent in the region. The total construction cost for leakage control, deterioration repair, and overtopping protection including mobilization, contractor's general conditions, and indirect cost (contingency, engineering, permitting) would be about $487,000. The estimated cost for the leakage control only would be approximately $362,000.

10. Based on funding availability, the remedial construction could be performed in one, two or three phases. Considering a 3-phase construction approach, phase 1 would consists of installation of a cofferdam along the spillway and left nonoverflow, resurfacing the upstream face of the structures and spillway crest, and replacement of the left spillway pier. During this stage, the river flows would be diverted through the existing outlets. The following phase 2 would consist of installation of a cofferdam along the right nonoverflow, resurfacing the upstream face, sealing the left outlet and installation of a new gate in the right outlet. During this stage, the stream flows would be diverted over the renovated spillway. The final phase 3 would include resurfacing the downstream face of the left nonoverflow, placement of grouted riprap, and installation of a concrete training wall. A small downstream cofferdam

would be required for this phase. The phased construction may significantly increase a total project repair cost.

8. RECOMMENDATIONS

To improve the integrity, durability, operation and maintenance of the Coopers Mills Dam, the following is recommended:

1. The conceptual repair design developed to improve the performance of the dam and provide the reliable pond level for fire control and fish passage year round is proposed for a final design.

2. Rock elevation at the dam is largely unknown. Unexpected topography and condition of bedrock encountered during construction may cause significant modification or redesign of the proposed repairs and increase the cost. A geotechnical study to determine the topography of bedrock along the existing dam alignment is suggested. Information obtained from the study will permit verification of conservative assumptions used in the conceptual repair design and construction cost estimate and reduce the level of uncertainty regarding the dam and foundation.

3. The left nonoverflow structure, the lowest section of the dam, has experienced more frequent flood overtopping than other parts of the dam resulting in significant deterioration of the facility and downstream areas. To reduce the overtopping frequency, it is suggested to raise the left nonoverflow by about 1.5 feet and redirect minor floods to the right nonoverflow structure which appears in reasonable condition (downstream face and toe). This remedial measure would provide overtopping protection of the left nonoverflow against less frequent, 4 to 5-year floods, extend its useful life, and improve operation of the fishway. The raise of the structure could be accomplished by installation of flashboards or a concrete ~~pedestal~~ parapet on the top of the left nonoverflow.

4. Falling rocks dislodged by overtopping flows may hamper operation of the fishway and cause its premature deterioration or damage. The lower section of the fishway where rocks were observed lying on the bottom should be protected by placement of steel grating on the top of the structure, similar to the steel racks installed at the upstream fishway gate.

5. Trees and brush causing loosening and dislocation of the masonry in the left and right nonoverflow structures by root penetration should be cut and removed within 10-20 feet of the dam.

6. The dam was inspected with the pond dropped to unusually low level, 4 feet below the spillway crest. To better understand and assess the condition of the dam and its performance, the dam should be re-inspected under the normal hydrostatic load with the pond at or above the spillway crest.

7. Warning signs should be installed on both dam abutments to improve public safety and reduce the Town's potential liability in the event of an accident.

If you have any questions or need additional information regarding this report, please do not hesitate to contact me at (207) 773-5425 or at myronp@maine.rr.com.

Sincerely,

MBP CONSULTING

mbpetrovsky

Myron B. Petrovsky, P.E.
Principal

STATE OF MAINE
MYRON B. PETROVSKY
No. 5788
LICENSED
PROFESSIONAL ENGINEER

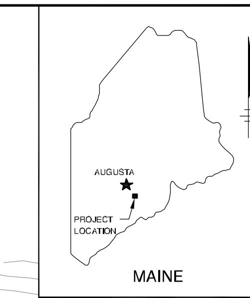
Attachments:

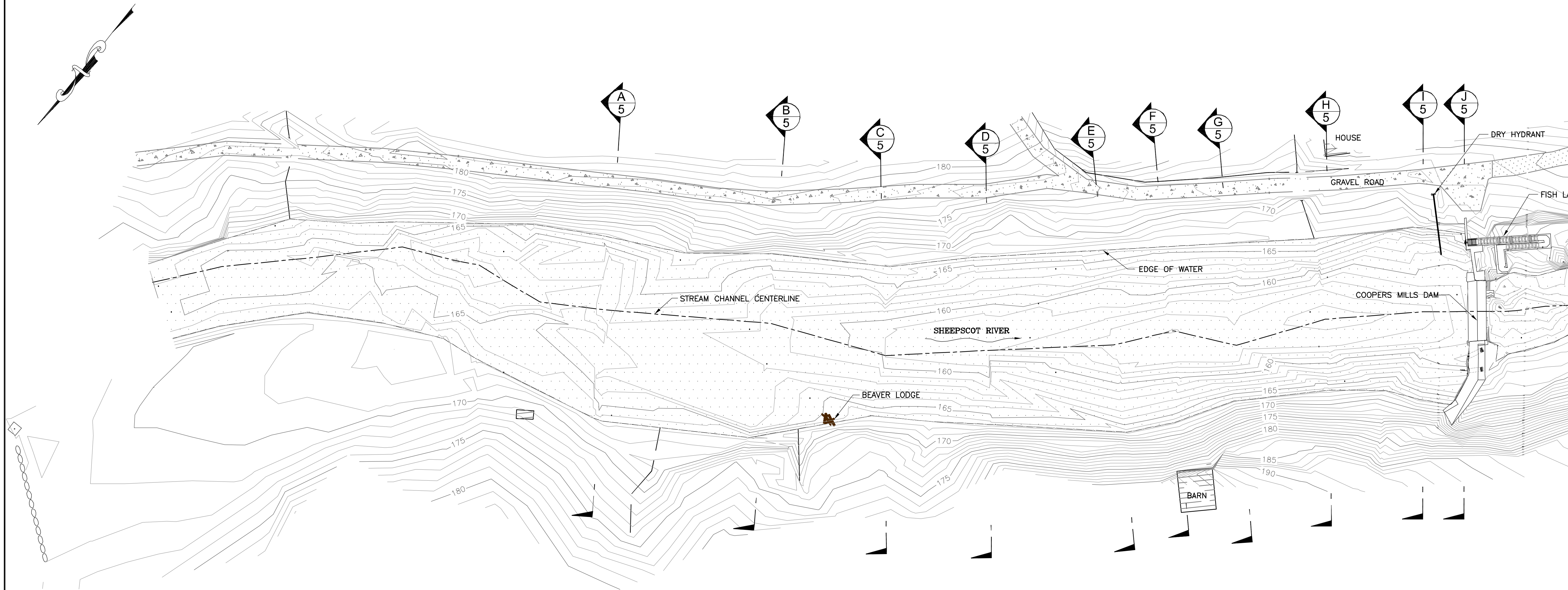
A. Existing Conditions: Project Drawings
B. Inspection Photographs
C. Conceptual Remedial Design

ATTACHMENT A

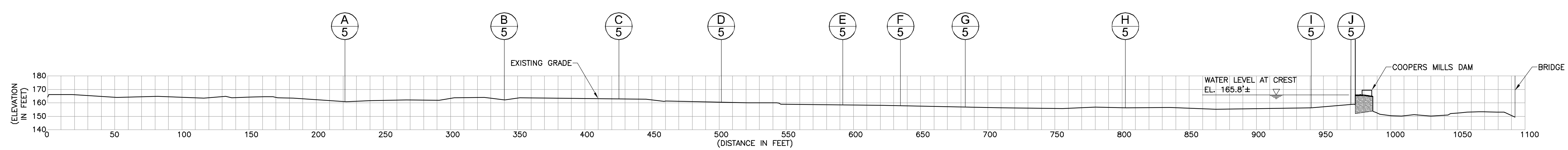
EXISTING CONDITIONS: PROJECT DRAWINGS

MBP Consulting
10 Woodfield Road
Portland, ME 04102





PLAN
1"=40'



STREAM CHANNEL CENTERLINE PROFILE
1"=40'

SURVEY PREPARED BY:

JOE LEBRANCHE LAND SURVEYOR, R.L.S.
27 OAK STREET, ROCKLAND, MAINE 04841

40 0 40 80
SCALE IN FEET

No.	Revision	Date

Scale:	AS SHOWN
Project No:	1289-001
AutoCad Release:	2005
Filename:	1289-001 SHT 1.2.dwg
Design By:	
Drawn By:	PJ
Checked By:	MEB
Date Revised:	10-13-05

COOPERS MILLS DAM
WHITEFIELD, MAINE

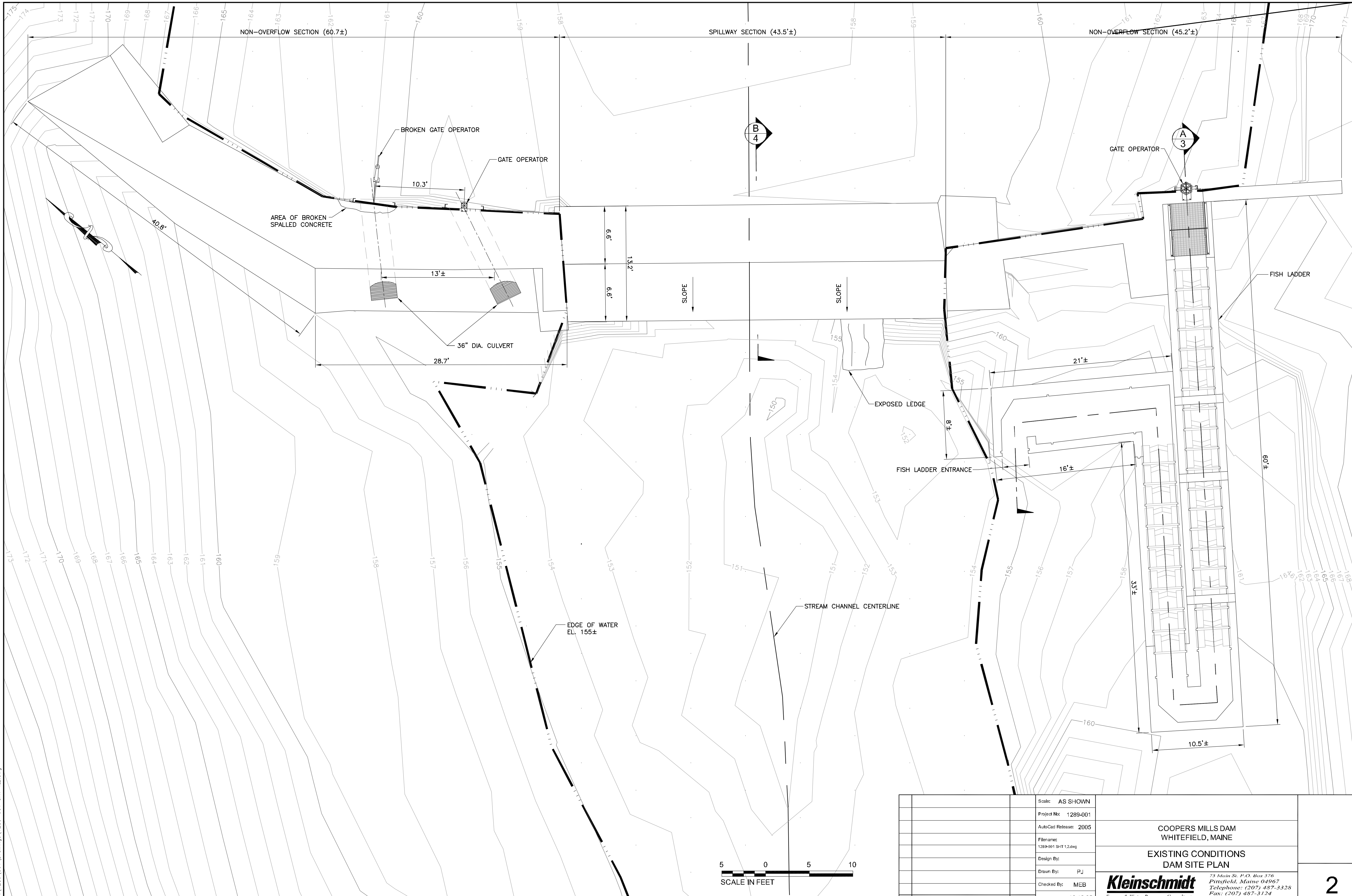
EXISTING CONDITIONS
OVERALL SITE PLAN

Kleinschmidt
Energy & Water Resource Consultants

75 Main St. P.O. Box 576
Pittsfield, Maine 04967
Telephone: (207) 487-3328
Fax: (207) 487-3124
www.KleinschmidtUSA.com

1

J:\1289\001\Drawings\1289-001 SHT 1.2.dwg



No.	Revision	Date

Scale: AS SHOWN
Project No: 1289-001
AutoCad Release: 2005
Filename: 1289-001 SHT 1,2.dwg
Design By:
Drawn By: PJ
Checked By: MEB
Date Revised: 10-13-05

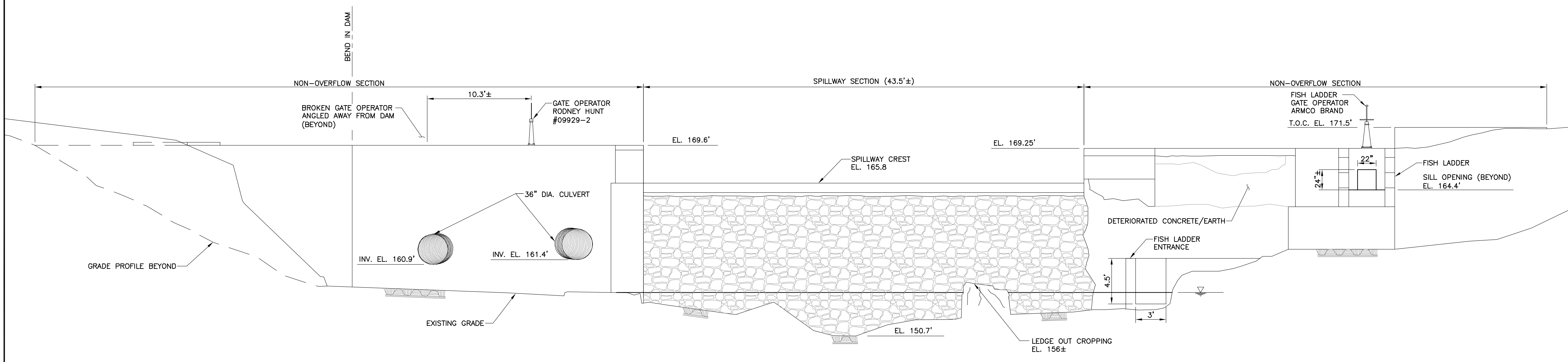
COOPERS MILLS DAM
WHITEFIELD, MAINE

EXISTING CONDITIONS
DAM SITE PLAN

Kleinschmidt
Energy & Water Resource Consultants
75 Main St. P.O. Box 576
Pittsfield, Maine 04967
Telephone: (207) 487-3328
Fax: (207) 487-3124
www.KleinschmidtUSA.com

2

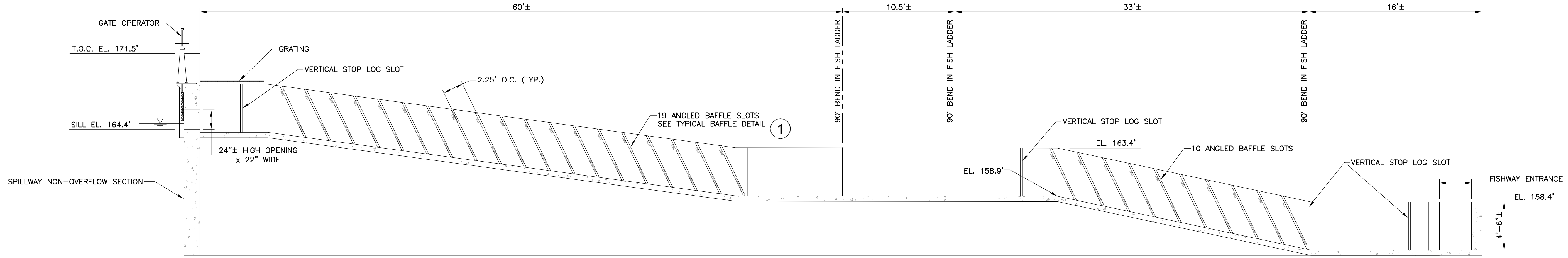
J:\1289\001\Drawings\1289-001 SHT 1,2.dwg



UPSTREAM DAM ELEVATION

1"=5'-0"

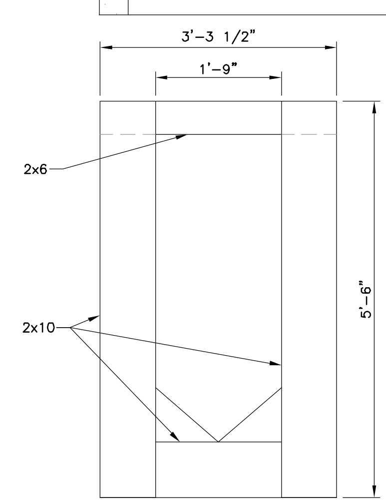
5 0 5 10
SCALE IN FEET



FISH LADDER CENTERLINE PROFILE (A/3)

1"=5'-0"

5 0 5 10
SCALE IN FEET



TYPICAL BAFFLE DETAIL (1)

3/4"= 1'-0"

Scale:	AS SHOWN
Project No:	1289-001
AutoCad Release:	2005
Filename:	1289-001 SHT 3,4,5.dwg
Design By:	
Drawn By:	PJ
Checked By:	MEB
Date Revised:	10-13-05

No.	Revision	Date

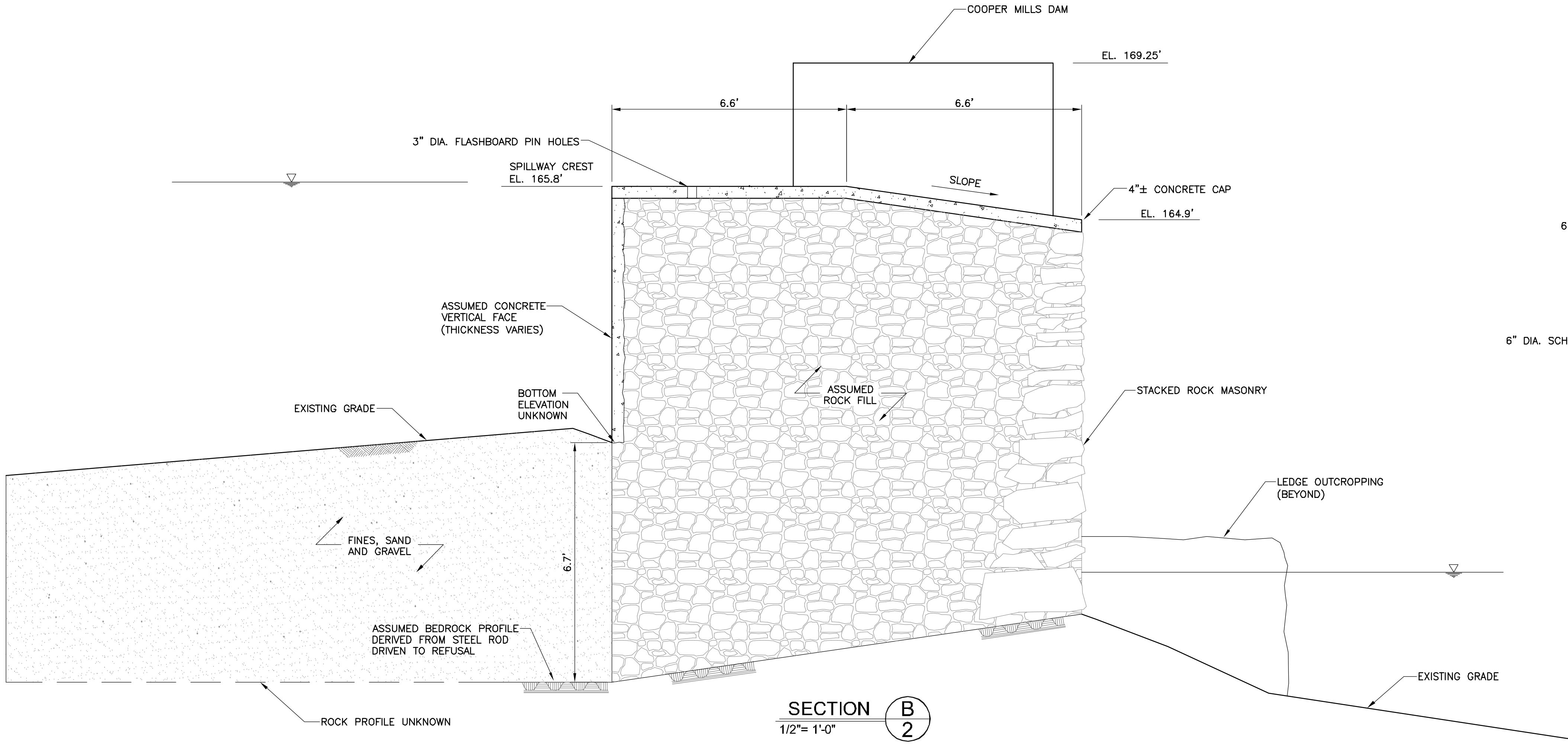
COOPERS MILLS DAM
WHITEFIELD, MAINE

EXISTING CONDITIONS
DAM ELEVATION & FISH LADDER PROFILE

Kleinschmidt
Energy & Water Resource Consultants
75 Main St. P.O. Box 576
Pittsfield, Maine 04967
Telephone: (207) 487-3328
Fax: (207) 487-3124
www.KleinschmidtUSA.com

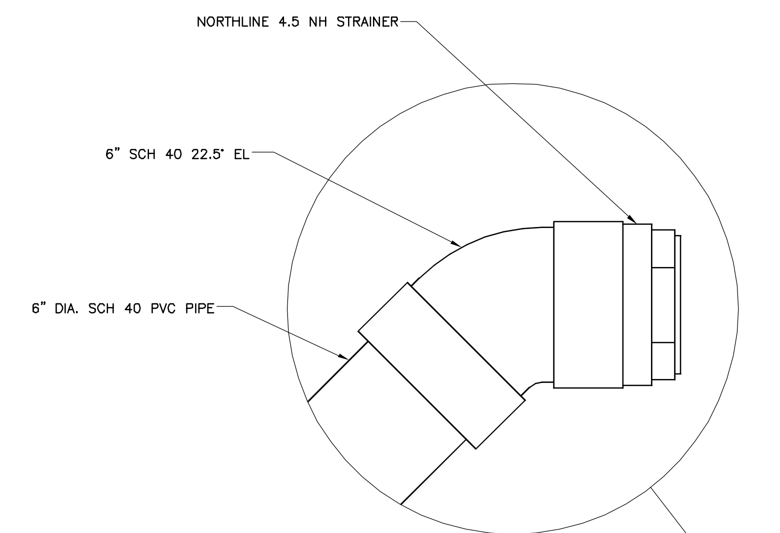
3

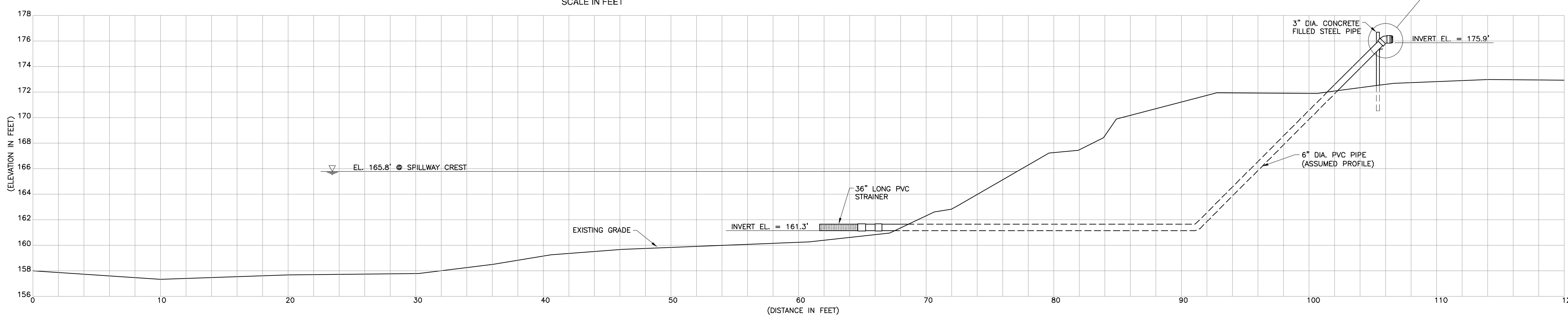
J:\1289\001\Drawings\1289-001 SHT 3,4,5.dwg



SECTION B/2
1/2"= 1'-0"

4 0 4 8
SCALE IN FEET



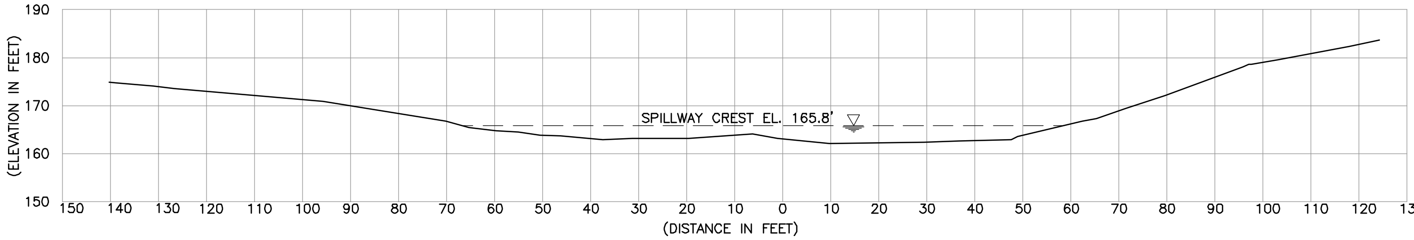


DRY HYDRANT PROFILE
1/4"= 1'-0"

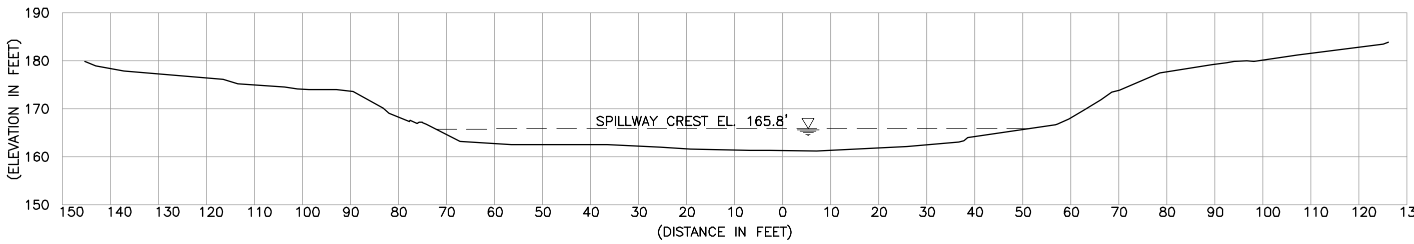
2 0 2 4
SCALE IN FEET

No.	Revision	Date		
			Scale: AS SHOWN	COOPERS MILLS DAM WHITEFIELD, MAINE
			Project No: 1289-001	
			AutoCad Release: 2005	
			Filename: 1289-001 SHT 3,4,5.dwg	EXISTING CONDITIONS DRY HYDRANT PROFILE & DAM SECTION
			Design By:	
			Drawn By: PJ	Kleinschmidt Energy & Water Resource Consultants
			Checked By: MEB	75 Main St. P.O. Box 576 Pittsfield, Maine 04967 Telephone: (207) 487-3328 Fax: (207) 487-3124 www.KleinschmidtUSA.com
			Date Revised: 10-13-05	4

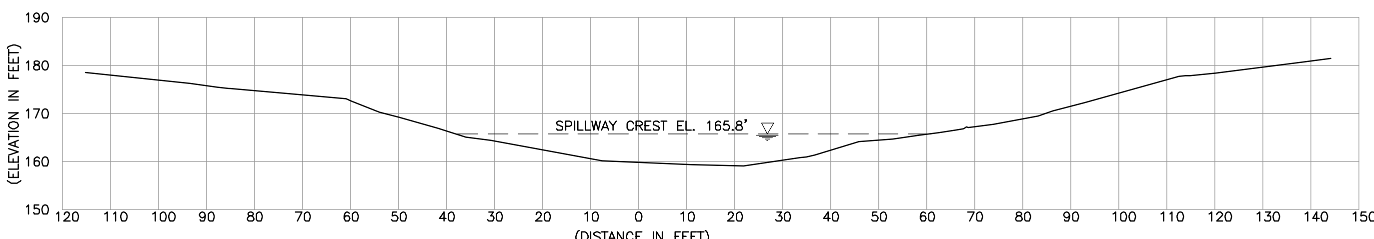
J:\1289\001\Drawings\1289-001 SHT 3,4,5.dwg



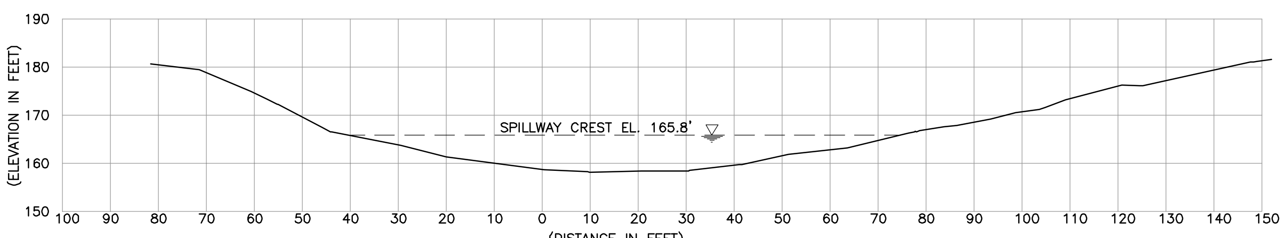
SECTION A/1
1"=20'



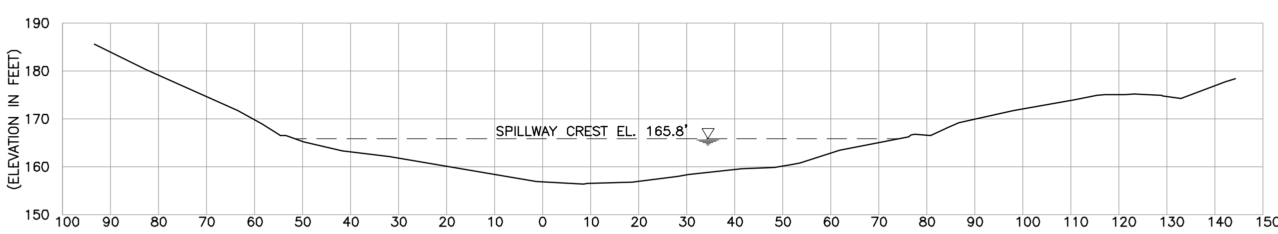
SECTION B/1
1"=20'



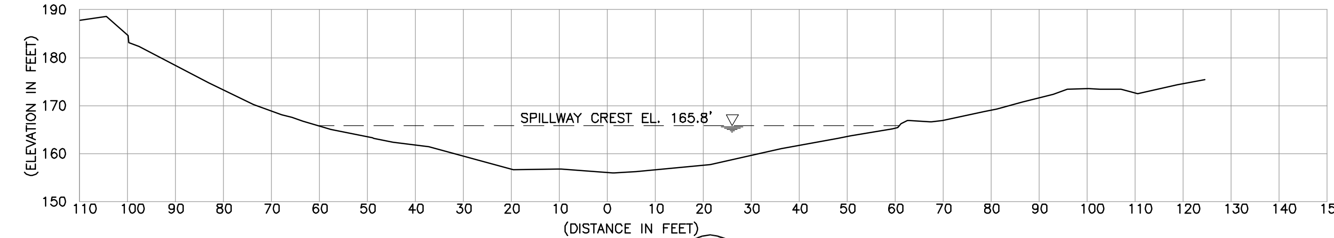
SECTION C/1
1"=20'



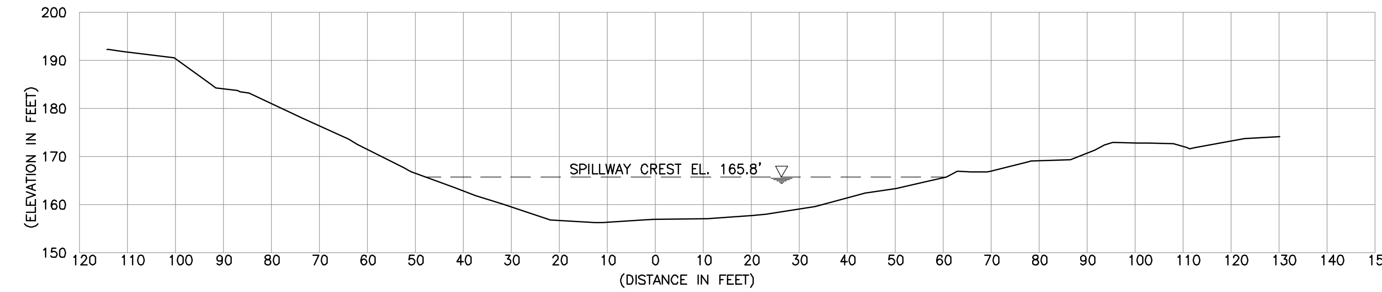
SECTION D/1
1"=20'



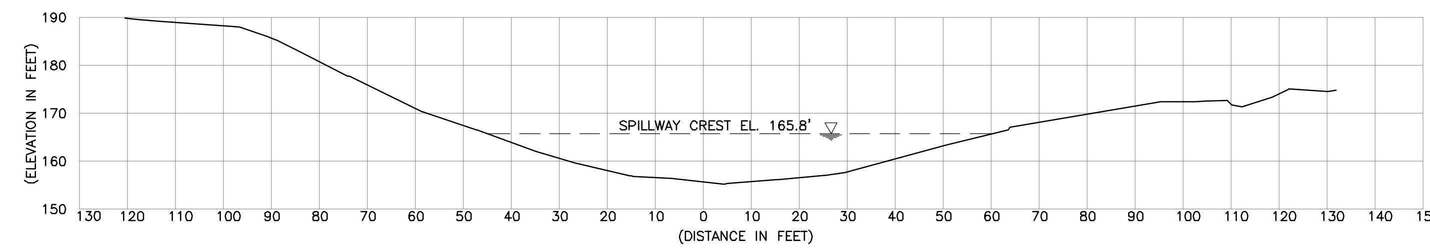
SECTION E/1
1"=20'



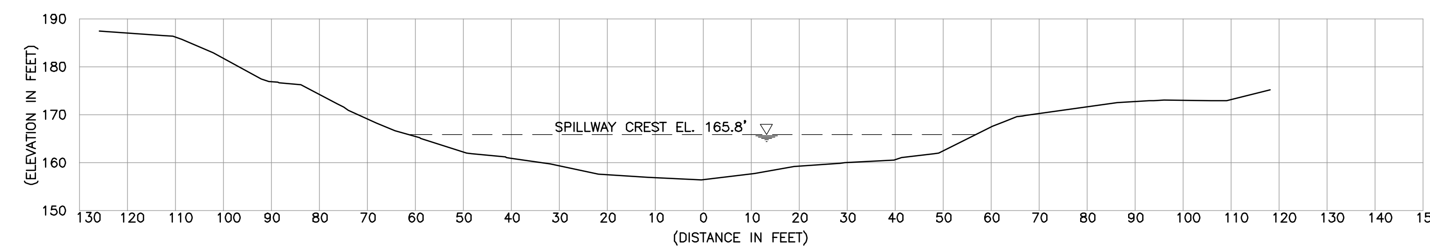
SECTION F/1
1"=20'



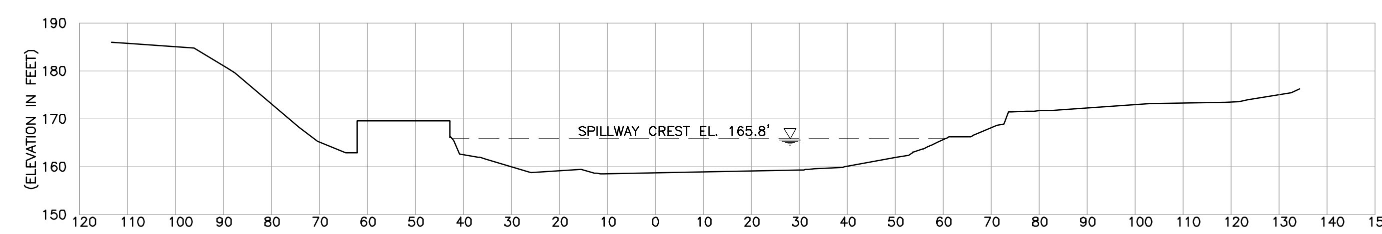
SECTION G/1
1"=20'



SECTION H/1
1"=20'



SECTION I/1
1"=20'



SECTION J/1
1"=20'

No.	Revision	Date

Scale:	AS SHOWN
Project No:	1289-001
AutoCad Release:	2005
Filename:	1289-001 SHT 3,4,5.dwg
Design By:	
Drawn By:	PJ
Checked By:	MEB
Date Revised:	10-13-05

COOPERS MILLS DAM
WHITEFIELD, MAINE

EXISTING CONDITIONS
SECTIONS

Kleinschmidt
Energy & Water Resource Consultants
75 Main St. P.O. Box 576
Pittsfield, Maine 04967
Telephone: (207) 487-3328
Fax: (207) 487-3124
www.KleinschmidtUSA.com

5

J:\1289\001\Drawings\1289-001 SHT 3,4,5.dwg

ATTACHMENT B

INSPECTION PHOTOGRAPHS
September 1, 2015

MBP Consulting
10 Woodfield Road
Portland, ME 04102

Photo 1. Spillway Crest and Right Pier.

Photo 2. Large Cavity in Spillway Crest Extension at Left Nonoverflow Structure.

Photo 3. Upstream Face of Spillway and Left Nonoverflow: Note Voids and Deep Deterioration.

Photo 4. Extensive Leakage at Spillway Toe near Fishway.

Photo 5. Left Spillway Pier Undermined Base.

Photo 6. Downstream Face of Left Spillway Pier: Cavity and Base Undermining.

Photo 7. Left Spillway Pier Landside Large Cavity.

Photo 8. Left Nonoverflow: Deteriorated Downstream Face and Backfill. Note Vegetation and Large Tree.

Photo 9. Left Nonoverflow: Large Cavity in Masonry Block Adjacent to Fishway (Arrow).

Photo 10. Top of Right Nonoverflow at Right Outlet Gate Operator: Note Heavy Overgrowth.

Photo 11. Right Nonoverflow Structure: Upstream Face Concrete Spalling and Deterioration.

Photo 12. Right Nonoverflow Upstream Face: Masonry Rubble Uplifted by Vegetative Roots.

Photo 13. Right Nonoverflow: Left Outlet Timber Gate and Deteriorated Upstream Face.

Photo 14. Leaking Gate of Left Outlet.

Photo 15. Leakage Discharge from Left Outlet Culvert.

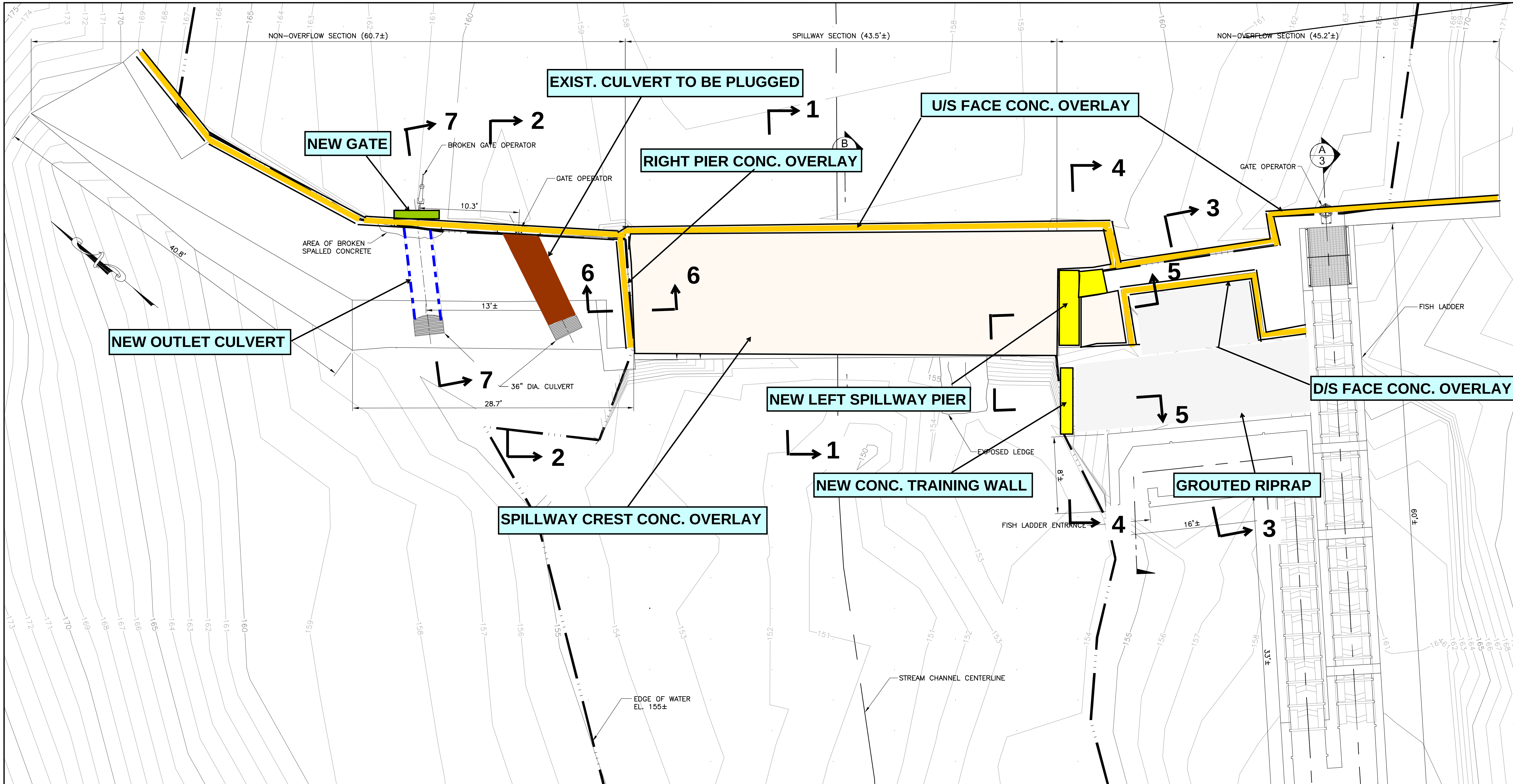
Photo 16. Leaking Gate of Right Outlet.

Photo 17. Leakage Discharge from Right Outlet Culvert.

Photo 18. Exposed Upstream Opening and Timber Gate of Fishway.

ATTACHMENT C

CONCEPTUAL REMEDIAL DESIGN



PROJECT:

COOPERS MILLS DAM REPAIR, WHITEFIELD, ME

CONCEPTUAL DESIGN: GENERAL ARRANGEMENT

CLIENT:

ATLANTIC SALMON FEDERATION, BRUNSWICK, ME

ENGINEER:

MBP CONSULTING, PORTLAND, MAINE

October 2015

Scale:	AS SHOWN
Project No:	1289-001
AutoCad Release:	2005
Filename:	1289-001 SHT 1,2.dwg
Design By:	
Drawn By:	PJ
Checked By:	MEB
Date Revised:	10-13-05

No. | Revision | Date

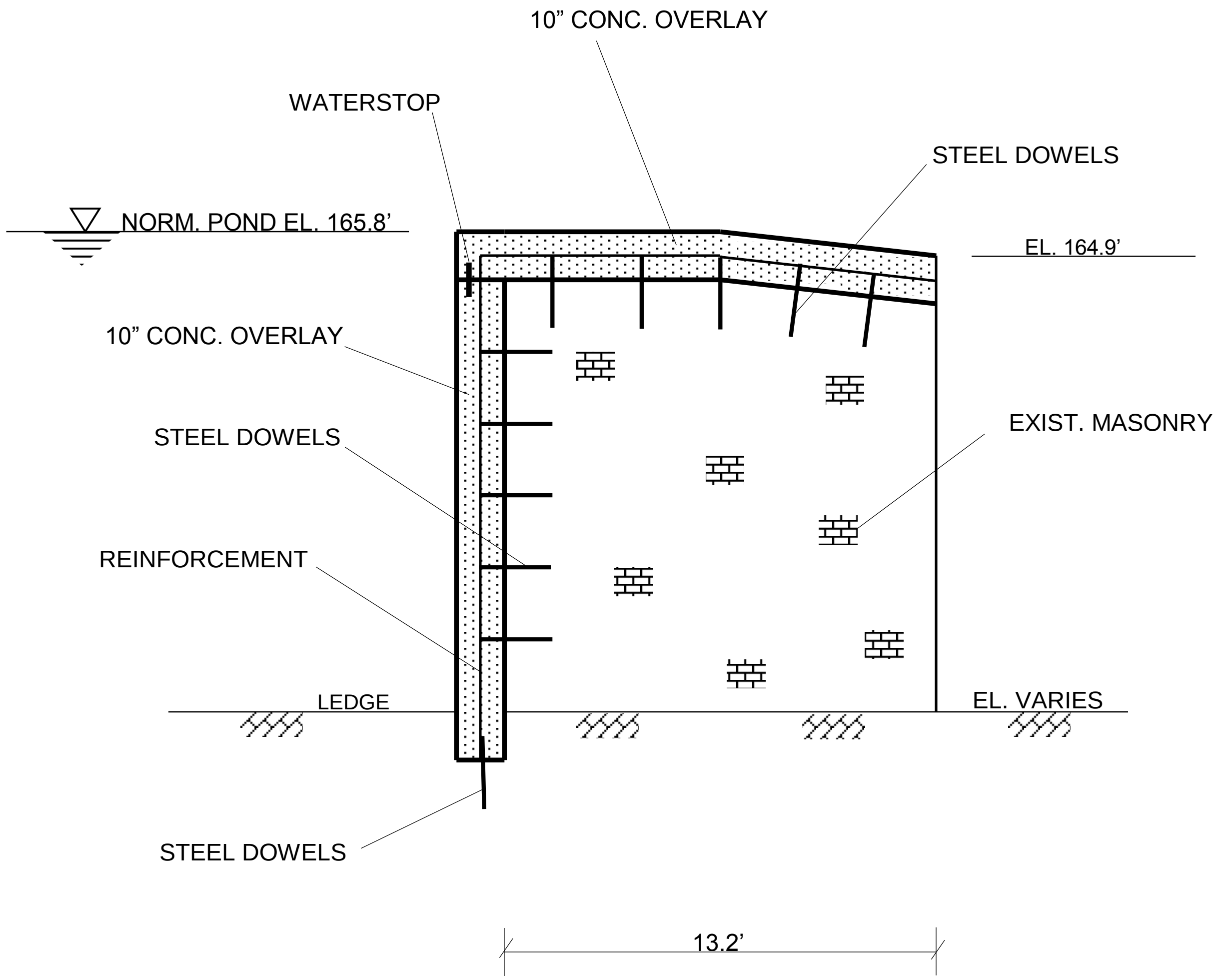
COOPERS MILLS DAM
WHITEFIELD, MAINE

EXISTING CONDITIONS
DAM SITE PLAN

Kleinschmidt
Energy & Water Resource Consultants
75 Main St. P.O. Box 576
Pittsfield, Maine 04967
Telephone: (207) 487-3328
Fax: (207) 487-3124
www.KleinschmidtUSA.com

2

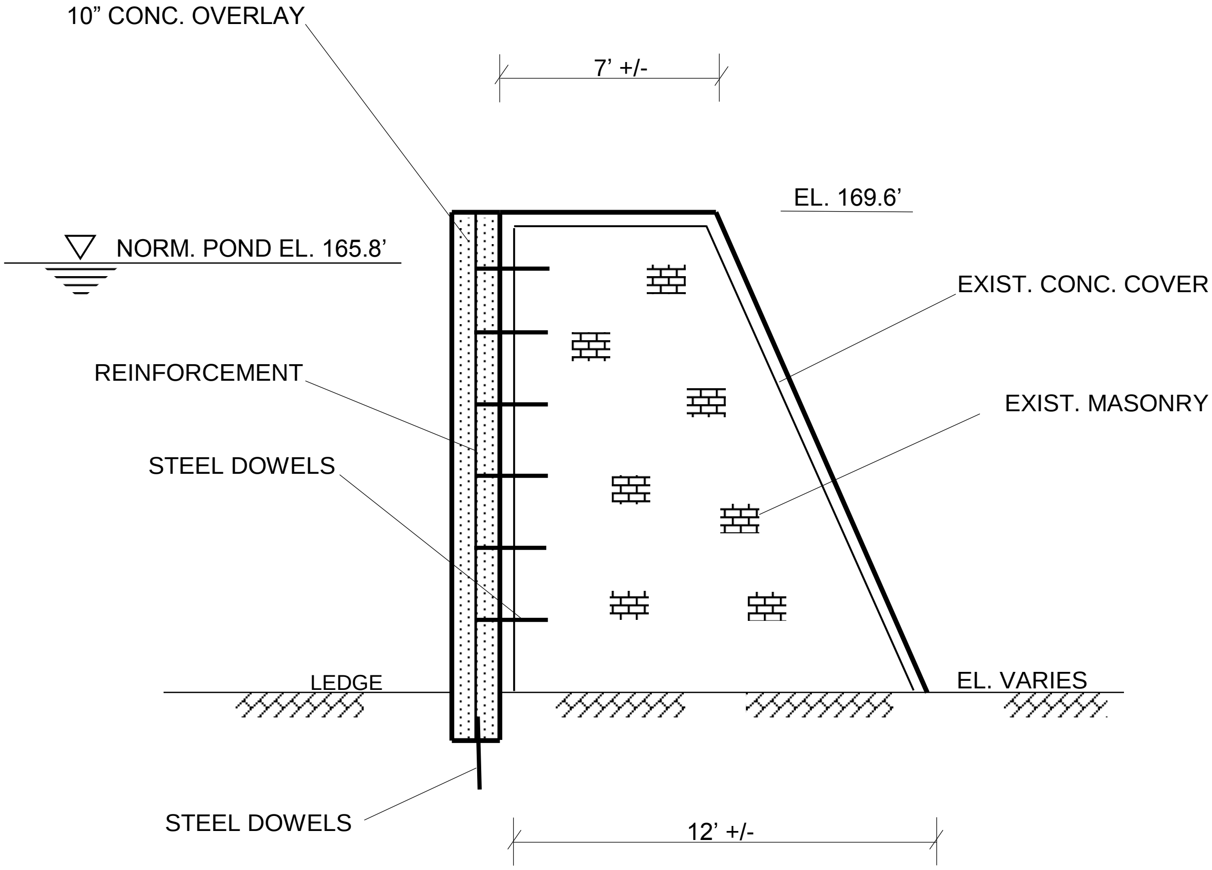
J:\1289\001\Drawings\1289-001 SHT 1,2.dwg



SECTION 1

SPILLWAY OVERLAY

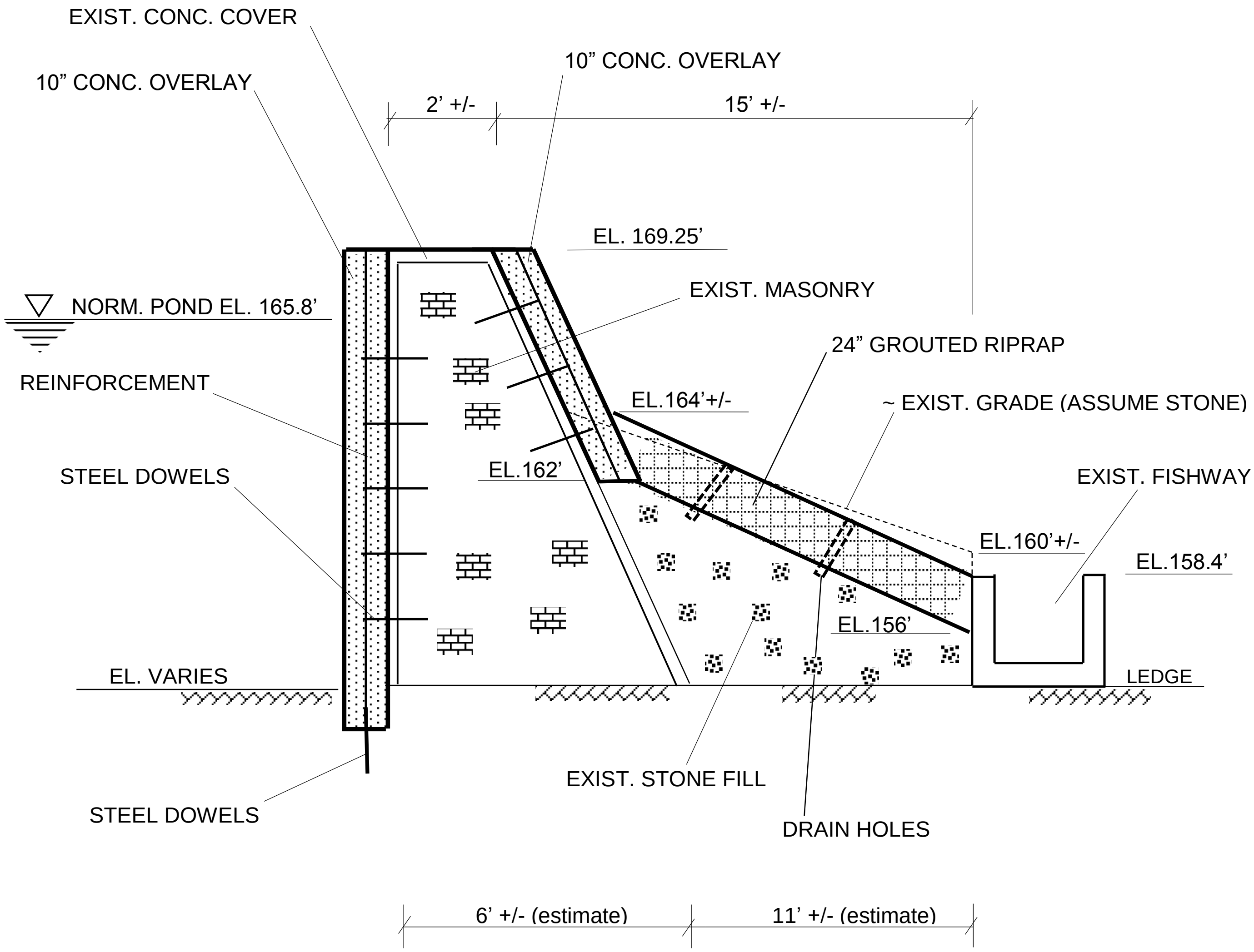
NOT TO SCALE



SECTION 2

RIGHT NONOVERFLOW

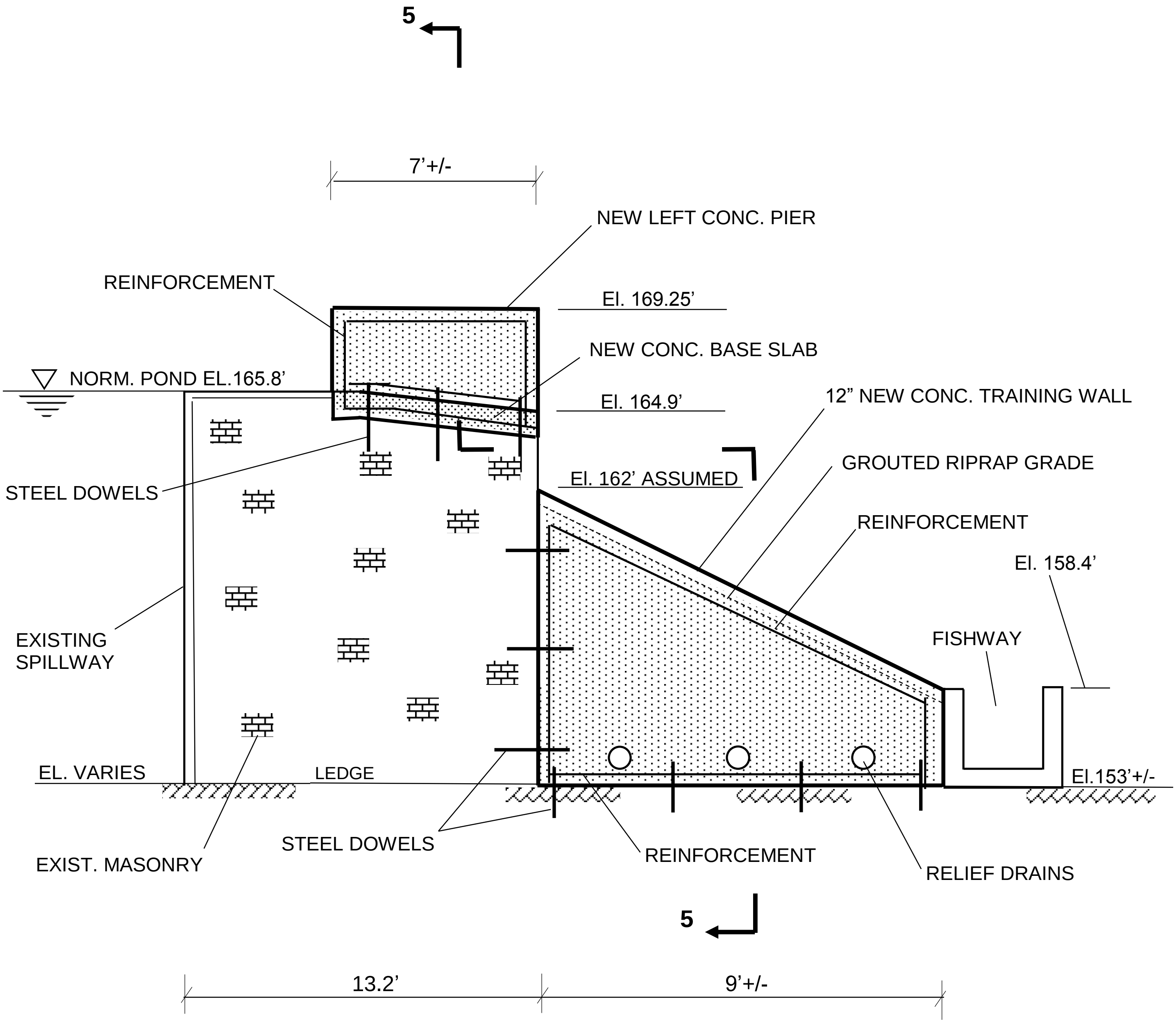
NOT TO SCALE



SECTION 3

LEFT NONOVERFLOW

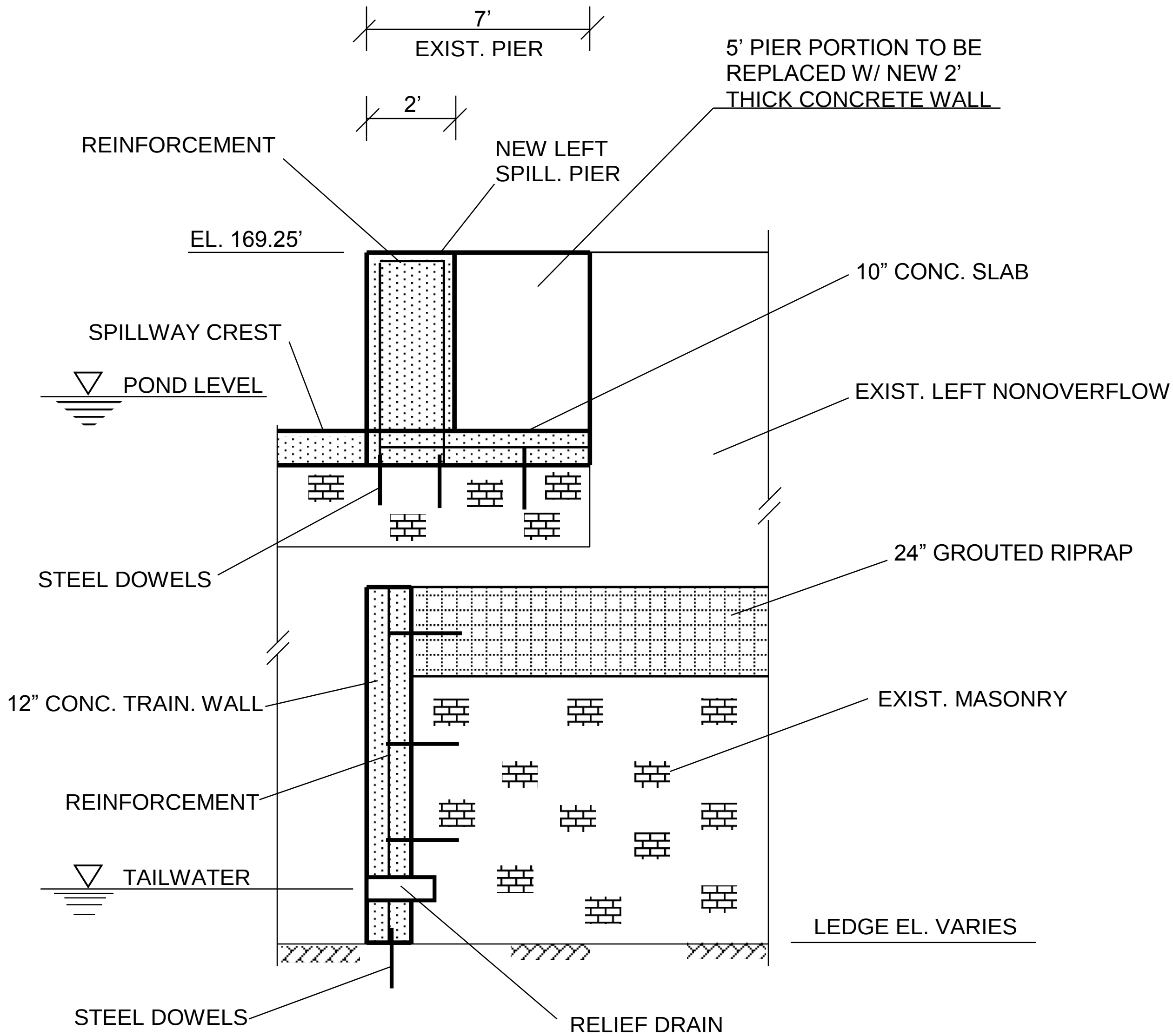
NOT TO SCALE



SECTION 4

LEFT SPILLWAY PIER AND DOWNSTREAM TRAINING WALL

NOT TO SCALE

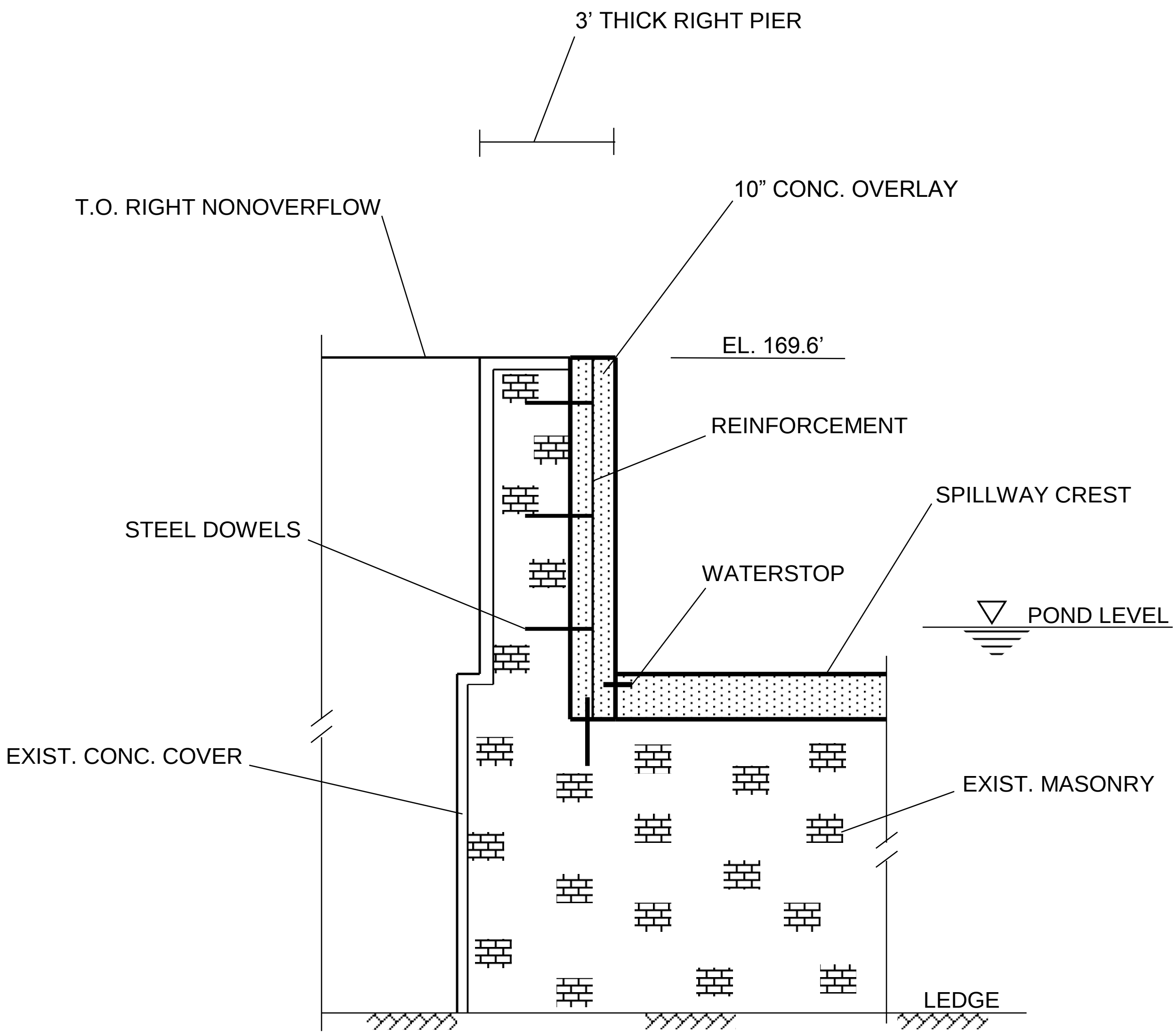


SECTION 5

LEFT SPILLWAY PIER AND NEW TRAINING WALL

NOT TO SCALE

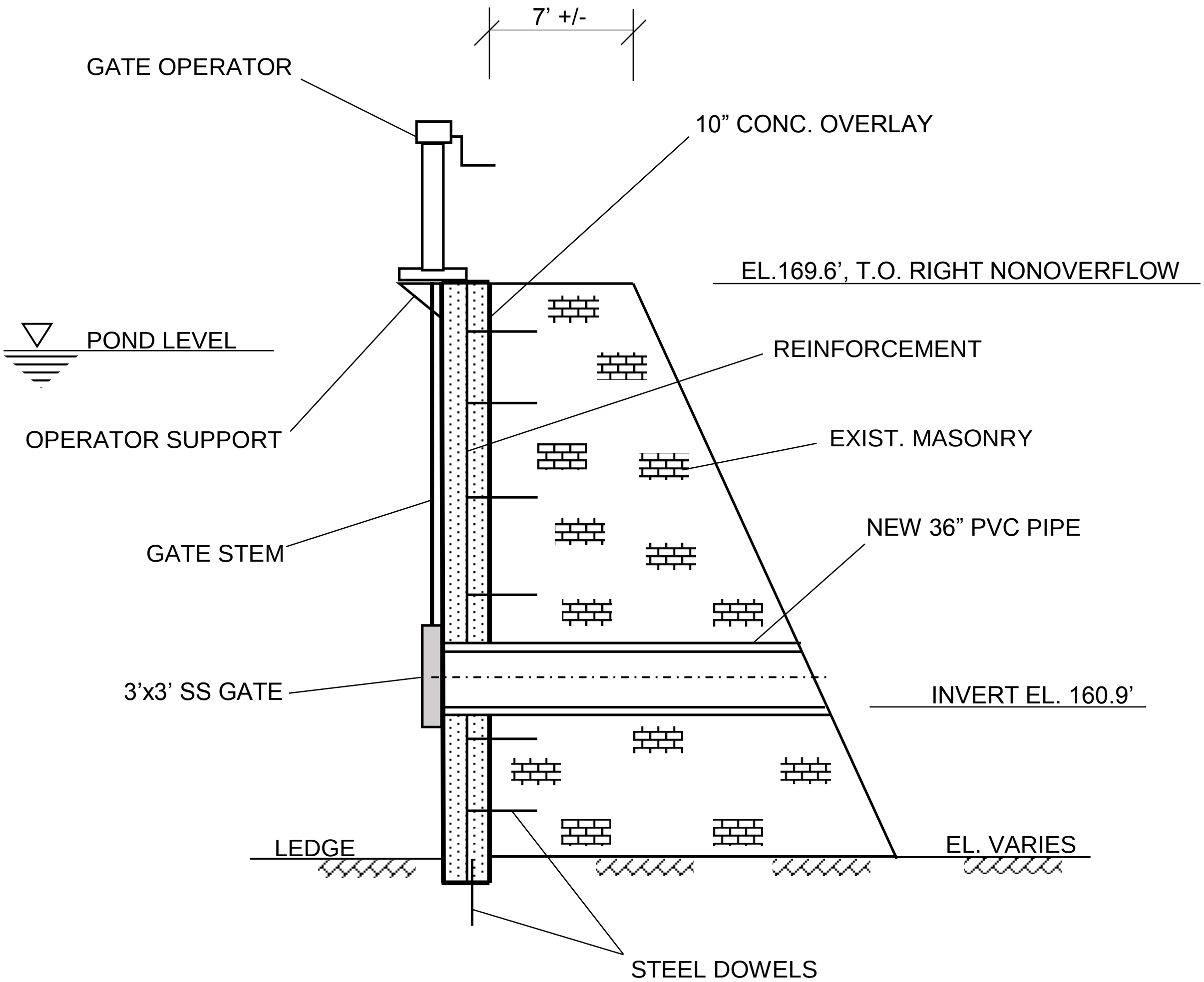
NOTE: SEE ALSO SECTION 4 FOR SECTION 5 LOCATION



SECTION 6

RIGHT SPILLWAY PIER OVERLAY

NOT TO SCALE



SECTION 7

GATED OUTLET

NOT TO SCALE