

Lower Monumental North Shore Fish Ladder (Dewatered)
27 January 2011
Inspection Report
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Purpose – A brief field inspection of the partially dewatered north shore adult fish ladder was performed to ascertain additional physical obstacles to lamprey migration.

Background - As part of the ongoing NWW-NWP Lamprey program, NWW inspects all dewatered project fish ladders during the fish ladder outage season to identify lamprey passage issues and evaluate measures to improve lamprey passage.

Departure and Attendance

Brett Morris and Derek Fryer left the District and arrived at Lower Monumental at approximately 10:15. Steve Juhnke, Fishery Biologist, accompanied the team. The NWW team met Bill Spurgeon, LoMo Project Biologist, at his office to begin the inspection.

INSPECTION ACTIVITIES (See Figure 1 for North Shore Fish Ladder Plan)

New Pit Tag Antennas

The team observed the newly installed pit tag detectors installed in the lower diffuser section of the fish ladder. Two detection antennas were installed on the upstream face of the weir wall, presumably enveloping the fish orifices. Most of the detector was submerged by tailwater except near the crest of the weir notches where the antennas were visible.

Lower Diffuser Grating (See Figure 2)

The team walked over the locations of the lower diffusers 2A, 2B, 3, 4, and 5 (1 is located on the south shore ladder). The grating was submerged and couldn't be inspected, however the project has indicated that the grating is overdue for replacement.

Entrances (See Figures 3-5)

The team next observed the north shore and south powerhouse fish ladder entrances, designated as NSE1 and NSE2, and SPE1 and SPE2, respectively. All entrances were temporarily bulk headed shut for dewatering of the fish ladder. NSE1 and NSE2 utilize 4 feet wide by 18 feet high, upstream skin plated, single leaf overflow weir gates and face powerhouse outflow with a 30° downstream skew. SPE1 and SPE2 utilize 6 feet wide by 15.5 feet high, upstream skin plated, single leaf overflow weir gates and face directly downstream. It should be noted that SPE3, another south powerhouse entrance that faces the spillway tailrace in the lateral direction, has been permanently closed.

Sloped Fish Ladder Section

The team proceeded up the sloped section of the north shore fish ladder toward the north shore counting station. The fish orifice inverts in the sloped section of the fish ladder are predominately 18" x 18" chamfered square orifices located on the bottom of the fish ladder, centered at 3 feet from each end of the weir wall. The slope of the fish ladder is 1:10 and at 10 foot spacing, the weir wall elevations are incrementally varied by 1 foot. There didn't appear to be any expansion joints located at fish orifices or other locations where high flow velocities are expected.

Fish Ladder Turning Pools (See Figure 6)

The team observed sheet flow moving down the ladder, no more than a couple tenths of a foot deep, probably due to leaky bulk head seals. At the ladder turning pool in the sloped section of the fish ladder, the sheet flow was observed to form reverse eddies in the filleted corners of the turning pool. These eddies may be present during full flow conditions in the ladder.

Counting Station (See Figures 7 and 8)

At the counting station, the team noted the clean smooth surfaces throughout the counting station: all grating and vertical projections of the counting window slot have been removed and replaced with smooth plating, including the window slot ramp. Steel blocking 1.5 inches high was observed to be welded to the bottoms of the picketed lead framing. The observed spacing of the adjustable flow vanes within the picketed lead section should provide adequate clearance for lamprey passage. Bill indicated that north shore vanes are configured differently than the south shore adjustable vanes that were removed some time ago, and that the north shore vanes have never been adjusted and have remained in the open position since they were installed. The picketed lead clear spacing was measured to be $\frac{3}{4}$ ".

Control Section (See Figures 9-16)

After the counting station inspection was completed, the team continued up the sloped section of the fish ladder to the ladder control section, located between weirs 534 and 539, and designated as Sections 7 and 8 on the contract drawings. The control section has a much milder slope at 1:32. The upper fish ladder is fed by an uncontrolled channel entrance located in the forebay. From the forebay, the fish ladder channel conveys flows through the non-overflow dam to weir 539, where the channel makes a 90° bend to the south, parallel to the dam.

Diffuser 6, a grated channel floor diffuser located between weirs 534 and 533, provides supplemental transport flow to the upper fish ladder to account for variation in the forebay pool elevation. The grating for diffuser 6 appeared to be intact but may be replaced when the lower diffuser grating is replaced.

Weirs 534 to 539 are configured with a combination of 1 foot wide chamfered vertical slots on the east side of the weir wall, and 18" x 24" chamfered rectangular orifices on the west side. The sill heights of the vertical slots are incrementally increased in the upstream direction by 6", from weir 534 at a sill height of 0'-9", to weir 538 at sill height of 2'-9". The vertical slot sill height of weir 539 repeats weir 538's height at 2'-9". Similarly, with the exception of weir 535, the orifice invert heights are incrementally increased in the upstream direction, from weir 534 at an orifice invert height of 0'-0", to weir 539 at an orifice invert height of 2'-6". The orifice invert height at weir 535 is 0'-7" above the channel bottom.

Cooling Water Strainers

The team concluded the inspection at the cooling water strainers, which have been inspected monthly for juvenile lamprey.

CONCLUSIONS AND DISCUSSION

Lower Diffuser Grating (See Figure 2)

As indicated earlier, the grating on the lower diffusers 2A, 2B, 3, 4, and 5 is overdue for replacement, and diffuser 6 grating will likely be replaced should the lower diffuser grating get replaced. Adult lamprey friendly grating clear spacing has been shown to be $\frac{3}{4}$ inch or smaller. Currently, the grating has a 1 inch clear spacing. The smaller grating clear spacing will prevent lamprey from entering the diffuser chamber and being trapped or delayed. If the diffuser grating spacing is reduced to $\frac{3}{4}$ inch, any supply system intake screens must be replaced in-kind to prevent entrapment and subsequent clogging of debris behind the diffuser grating. The costs associated with replacement of both the diffuser grating and the supply system intake trash screens could be prohibitively high, in particular given the uncertainty of the degree of the lamprey separation problem.

Entrances (See Figures 3-5)

As noted earlier entrance gates at the north shore (NSE1 and NSE2) and south powerhouse (SPE1 and SPE2) are single leaf overflow gates, unlike the double leaf (telescopic) overflow entrance gates at McNary and Ice Harbor Dams. The telescopic gate configurations at McNary and Ice Harbor allow the bottom of the lower gate leaf to be raised above the sill while the upper leaf functions normally, adjusting for varying tailwater elevations. The resulting gap between the sill and bottom of the lower gate leaf allows the installation of a lamprey passage device such as the current ported lamprey hood box and baffle section being tested at McNary via physical modeling at ERDC. The current single leaf gate configuration cannot operate normally while simultaneously maintaining a constant gap at the sill for the installation of a McNary-style lamprey passage device. Should a McNary style lamprey passage device be considered for the entrances at Lower Monumental Dam, the design and installation of a telescopic gate modification may be necessary.

Sloped Fish Ladder Section

The sloped section of the fish ladder has a smooth continuous sticking surface along the bottom of the fish ladder to facilitate lamprey passage, given the configuration and location of the fish orifices. Flow velocities through the orifices are about 8.0 fps, which may act as a discrete velocity obstacle for lamprey. However lamprey have been video documented to pass through orifices installed at the McNary south shore fish ladder control section, which exhibit similar flow velocity. Consequently, the sloped section of the fish ladder should be able to function adequately for lamprey passage without any lamprey passage modifications.

Fish Ladder Turning Pools (See Figure 6)

The reverse eddies observed in the corners of the turning pools for sheet flow conditions does not necessarily indicate that full ladder flow conditions would exhibit similar flow patterns. However, it could indicate the need for additional observations or evaluations of turning pool hydraulics. Tag studies have documented that turning pools cause both salmonid and lamprey delays. Enlarging the turning pool corner radii and reducing the tangent length may eliminate or reduce the ineffective flow areas that induce eddies, which may reduce eddy size and vorticity.

Counting Station (See Figures 7 and 8)

As mentioned earlier, the team noted very clean smooth surfaces throughout the counting station and picketed lead section, as well as permanent blocking to raise the picket leads frames that will allow adult lamprey a more velocity-friendly alternative passage route behind the picketed leads along the channel bottom.

Removal of the unused adjustable flow vanes behind the picketed leads should not impact the hydraulic functioning of the counting slot given that they have never been adjusted and have remained in the open position. Their removal would probably reduce maintenance requirements behind the picketed leads,

however the observed spacing of the adjustable flow vanes within the picketed lead section should provide adequate clearance for lamprey passage.

Control Section (See Figures 9-16)

The elevated fish orifices and vertical slots are vertical projective obstacles for lamprey that impede their passage thru, and along the bottom of the fish ladder. It is recommended that orifices be installed through the weir walls along the channel bottom in the ladder control section to facilitate lamprey passage. Since the fish ladder control section and weir wall configuration is similar to Ice Harbor's, the orifices should be configured and located similarly to the requirements of the current lamprey orifice installation plan for Ice Harbor. More specifically, a stainless steel lined, 2-1/2 inch by 18 inch rectangular orifice filleted to a minimum 4 inch radius should be installed on the vertical slot side of the weir wall, 12 inches to 24 inches from the sidewall along the bottom of the channel. The final size and configuration of the lamprey orifice should be confirmed with the PDT biologist prior to the generation of design documents and construction.

Basic hydraulic computations will be completed to evaluate the flow volume and velocity anticipated through the orifice and will be compared to the total documented design flow through the fish ladder control section. The hydraulic behavior within each individual control pool must be preserved, as well as head differential requirements (1.0 feet) across the weirs and at applicable staff gages. While the comparison of the orifice flow to the total control section flow will give an idea as to the potential of the orifice to impact pool hydraulics, no theoretical means are available to evaluate impacts to pool hydraulics. Physical modeling could be used to evaluate the impacts of the orifice, but the expense of a physical model isn't justified given the low cost to install the orifices and remove them if hydraulic issues are observed. It is anticipated that plans to install orifices in the control section must be reviewed and discussed at both FPOM and FFDRWG.

The Hydraulics Section will perform the aforementioned hydraulic evaluation and provide the lamprey PDT partial plan exhibits that show the weir locations where the orifice work is to be performed. The lamprey PM will then coordinate with applicable design branch sections (Structures and General Engineering) and Contracting to generate and finalize construction documents to be executed the following FY. Hydraulics will then provide technical assistance throughout the life of the project as needed.

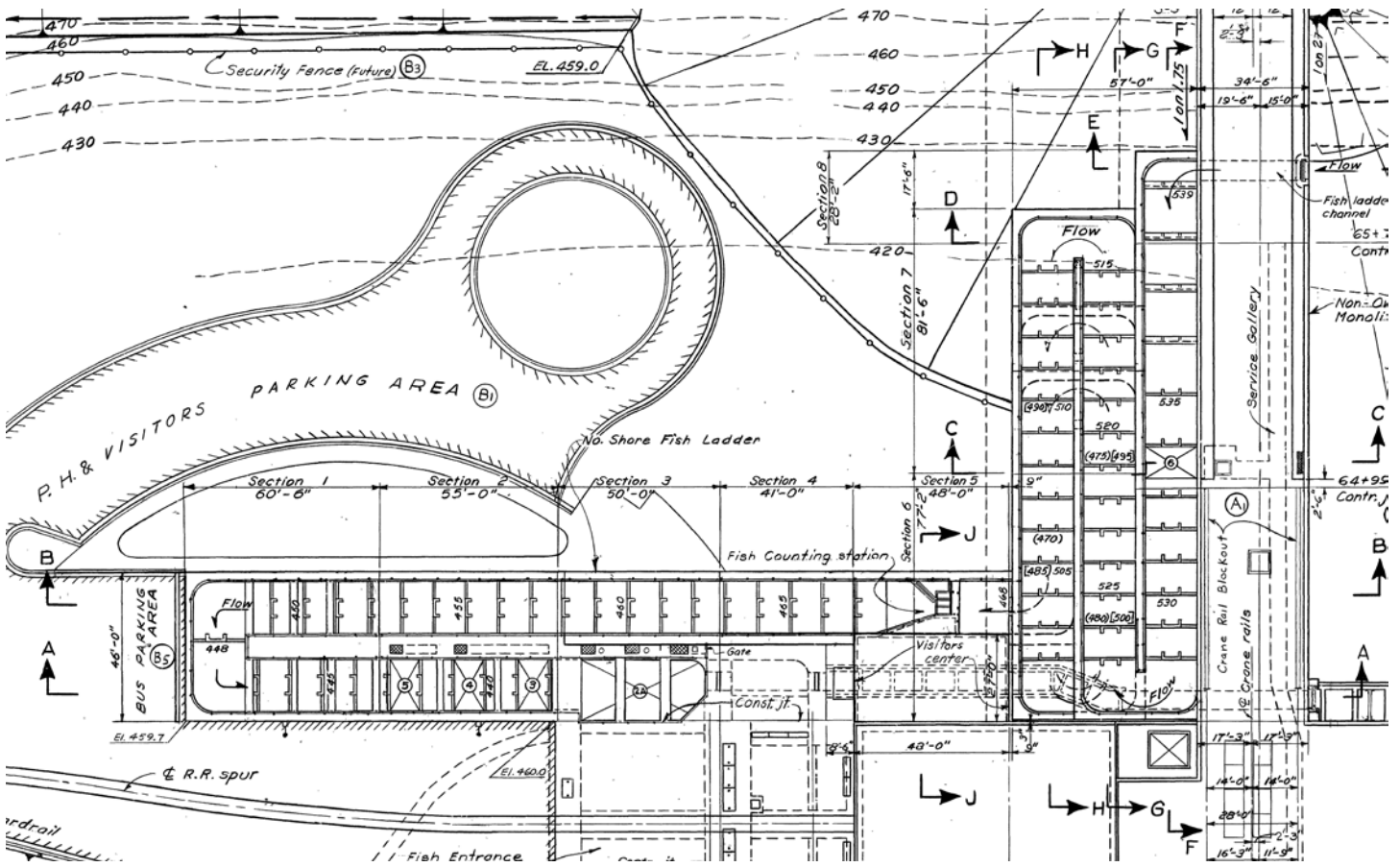


Figure 1 – Lower Monumental North Shore Fish Ladder Plan

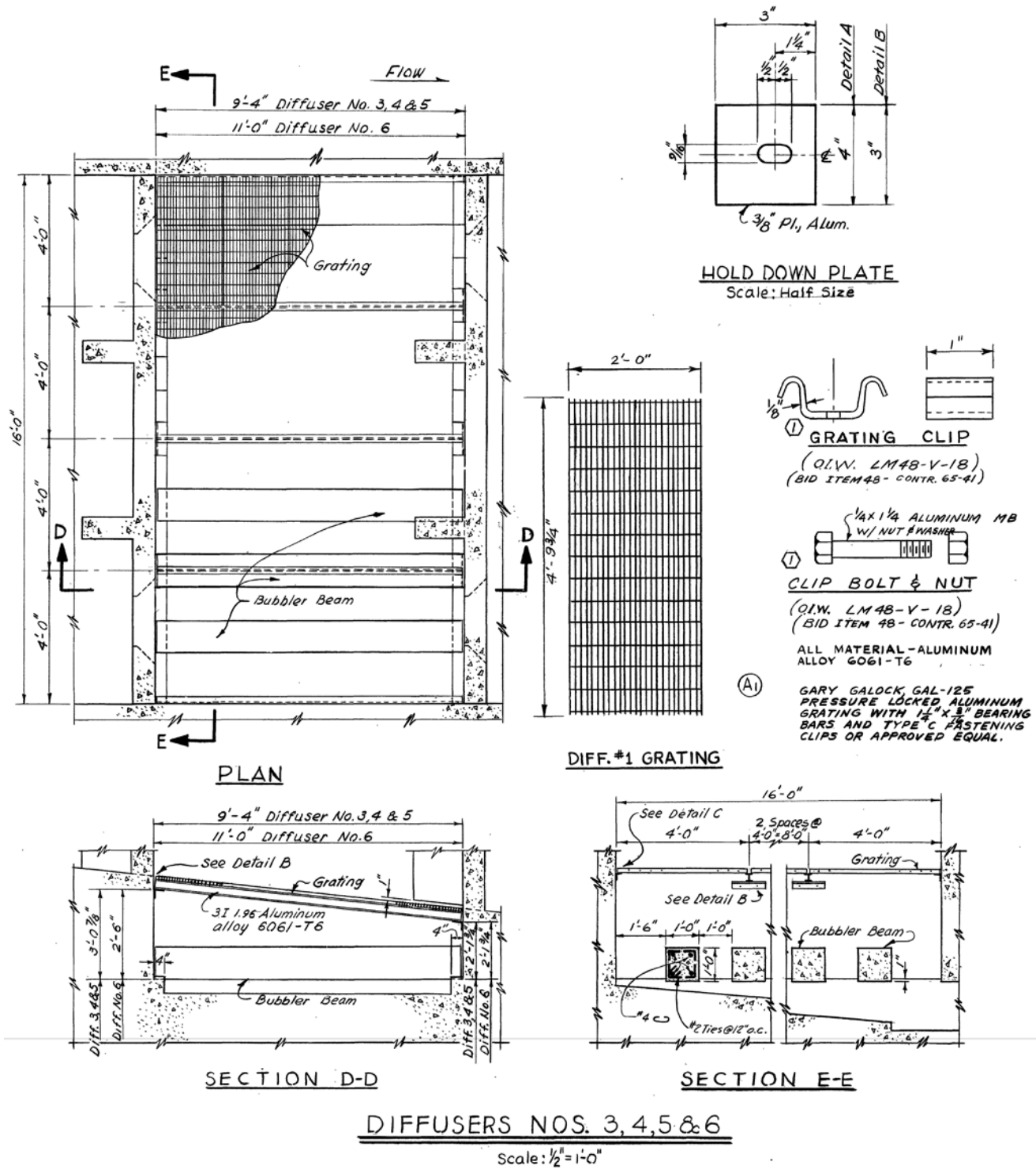


Figure 2 – Lower Monumental North Shore Fish Ladder Diffuser Grating Details (2A and 2B similar)



Figure 3 – North Shore Entrances NSE1 and NSE2 Looking Downstream.

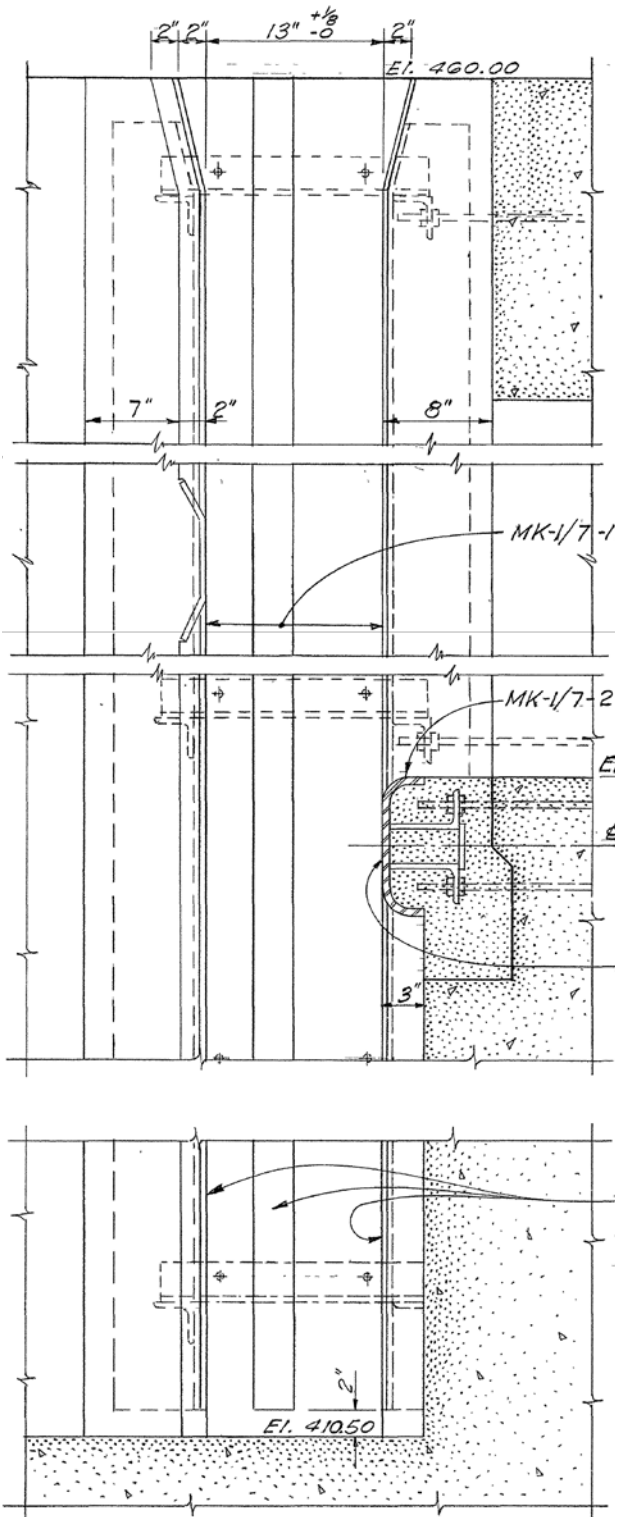


Figure 5 – North Shore Entrances NSE1 and NSE2 Gate slot and sill. Sill Elevation is 429.0.

Figure 6 – North Shore Fish Ladder Turning Pool Plan, Typical. Sheet flow from leaking bulkheads formed eddies in filleted corners of turning pool.



Figure 7 – North Shore Fish Ladder Counting Station Looking Upstream. Note the spacing on the channel bottom of the flow control vanes located behind the raised picketed lead panel and permanent blocking (1 ½ inch) welded to the bottom of the picketed lead frame at each end.



Figure 8 – North Shore Fish Ladder Counting Station Looking Upstream. Note the smooth plate ramps in lieu of grating on the approach to the counting slot.

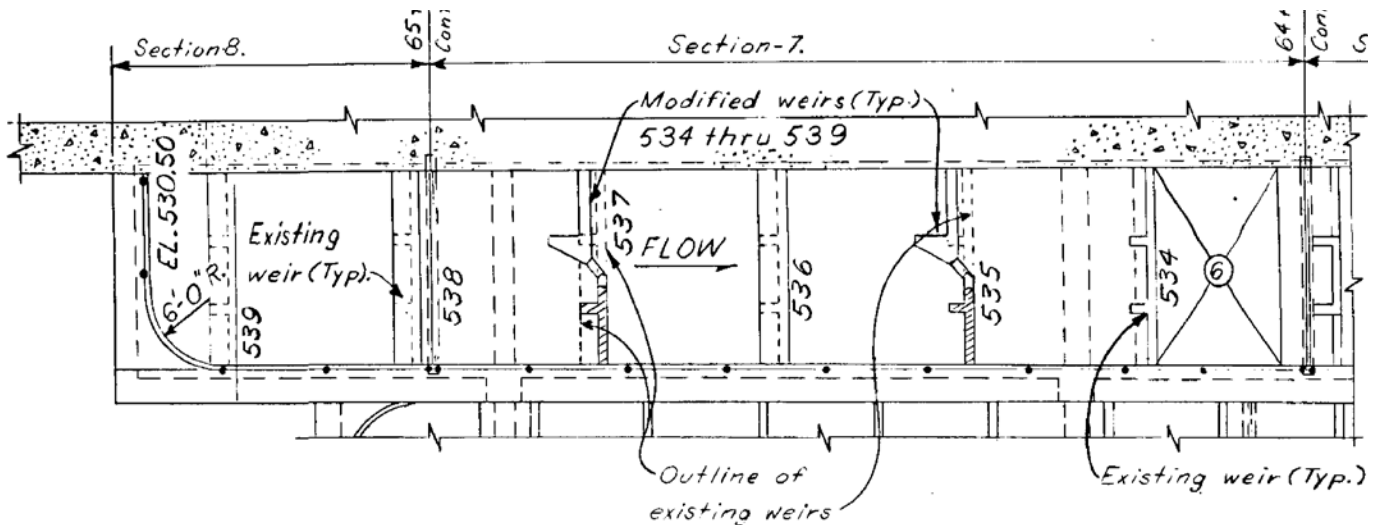


Figure 9 – North Shore Fish Ladder Control Section Plan. Weirs 534 to 539 are to receive lamprey orifices.

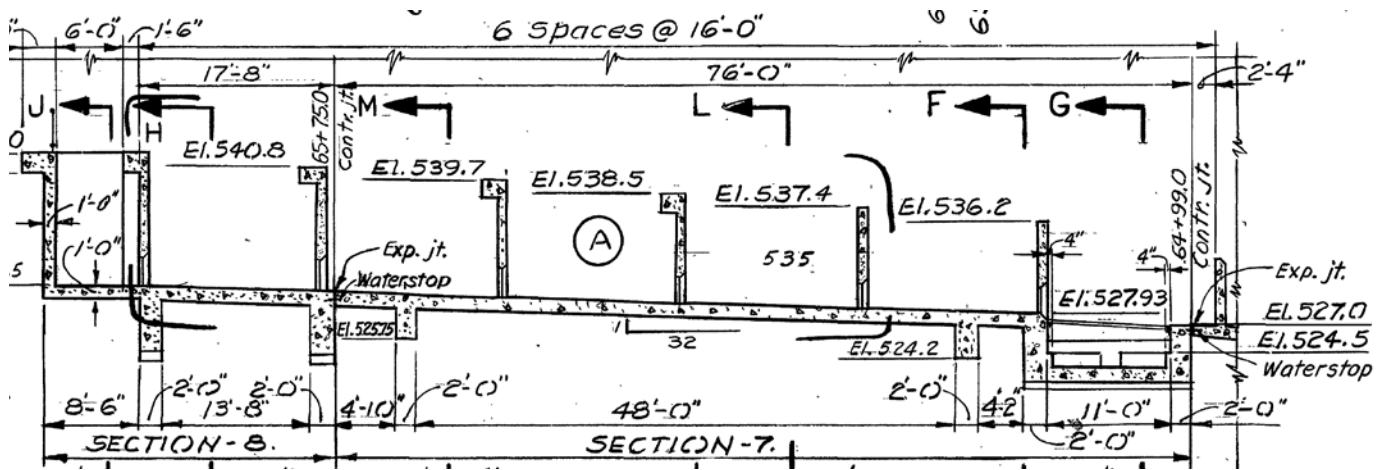
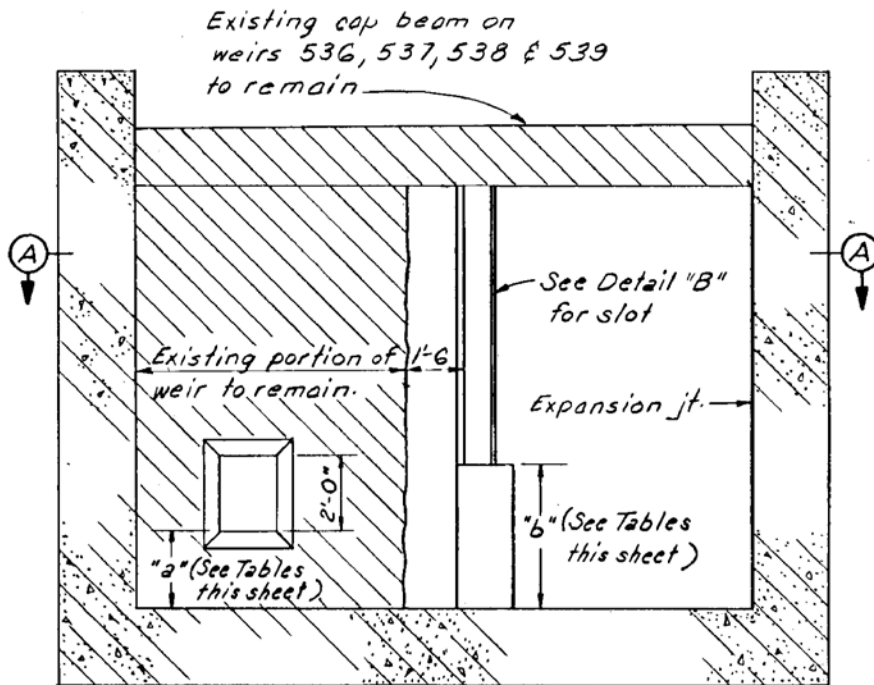
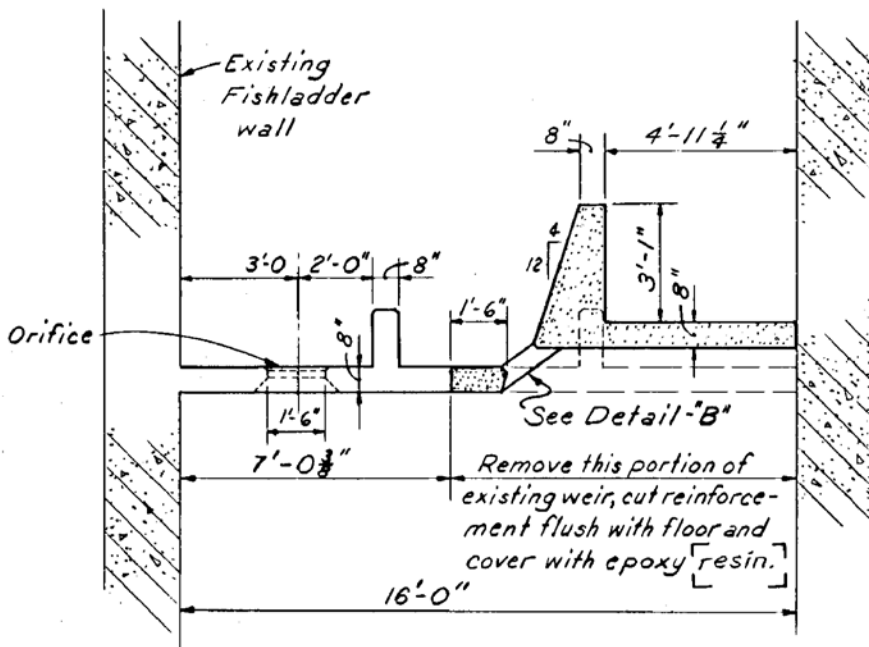


Figure 10 – North Shore Fish Ladder Control Section Profile. Weirs 534 to 539 are to receive lamprey orifices.



WEIR ELEVATION - CONCRETE OUTLINE



SECTION A

Figure 11 – North Shore Fish Ladder Control Section Weir Details. Weirs 534 to 539 are to receive lamprey orifices. The orifice is to be located to right of the vertical slot, 12 inches to 24 inches from the sidewall, at the bottom of the channel.

TABLE OF DIMENSIONS

Weir No.	North Shore			South Shore		
	"a" ft. Exist.	"a" ft.-in. NEW	"b" ft.-in. NEW	"a" ft. Exist.	"a" ft.-in. NEW	"b" ft.-in. NEW
534	0'	0'-0"	0'-9"	0'	0'-0"	0'-9"
535	0'	0'-7"	1'-3"	0'	0'-6"	1'-3"
536	2'	1'-0"	1'-9"	0'	1'-0"	1'-9"
537	3'	1'-6"	2'-3"	0'	1'-6"	2'-3"
538	4'	2'-0"	2'-9"	0'	2'-0"	2'-9"
539	5'	2'-6"	2'-9"	0'	2'-6"	2'-9"

Figure 12 – North Shore Fish Ladder Control Section Weir Table of Dimensions. Refer to Figure 11 for dimensions "a" and "b". Weirs 534 to 539 are to receive lamprey orifices. The orifice is to be located to right of the vertical slot, 12 inches to 24 inches from the sidewall, at the bottom of the channel.



Figure 13 – North Shore Fish Ladder Control Section Weir 534 and Diffuser 6 Photo, Looking Upstream.



Figure 14 – North Shore Fish Ladder Control Section Weir 534 and Diffuser 6 Photo, Looking Downstream.



Figure 15 – North Shore Fish Ladder Control Section Typical Weir, Looking Upstream.



Figure 16 – North Shore Fish Ladder Control Section Typical Weir, Looking Downstream.