Vern Freeman Dam
Vertical Slot Fish Ladder

Project Feasibility Report

July 20, 2018

Prepared for:

United Water Conservation District

Prepared by:

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Abbreviations

AWS	Auxiliary Water System
BiOp	Biological Opinion
CDFW	California Department of Fish and Wildlife
cfs	Cubic feet per second
fps	Feet per second
NMFS	National Marine Fisheries Service
NTU	Nephelometric Turbidity Unit
PLC	Programmable Logic Controller
RCC	Roller Compacted Concrete
Sf	Square feet
UWCD	United Water Conservation District
VFDD	Vern Freeman Diversion Dam

1.0 INTRODUCTION

1.1 BACKGROUND

In 2008, the National Marine Fisheries Service (NMFS), Southwest Region issued a final Biological Opinion (BiOp) (Administrative Record File #151422SWR01PR6149) to the United Water Conservation District (UWCD) which concluded that the operations of Vern Freeman Diversion Dam (VFDD) were likely to jeopardize the continued existence of the steelhead trout in the Santa Clara River. The first element of the Reasonable and Prudent Alternative of the BiOp was to convene “a panel of qualified fish passage engineers, hydrologists, and fish biologists, and serve as facilitator of this panel.” The Panel’s charge was to make recommendations for modifying or replacing the exiting fish passage facilities. The Panel conducted a formal alternative study to identify both interim and long term physical and operations modifications to pass steelhead above the dam.

The Panel completed their task with a Conceptual Design Report in September 2010. The report evaluated possible long term modifications by narrowing down a list of alternatives to five: a vertical slot ladder, a nature-like fishway, a rock ramp, a hardened ramp, and dam removal. Dam removal was judged to be beyond the purview and expertise of the Panel and was removed from further analysis. Using a Pugh score matrix the characteristics among the four alternatives were evaluated and estimates of probable costs were made. The results of the evaluation was that the scores of the remaining four were very close. In the conclusions of their report, “...the Panel recommends that additional work be focused on the development of the Vertical Slot Fishway and the Hardened Ramp alternatives.” Further in their conclusions, the Panel states, “In addition to the upstream passage issues, the Panel concludes that the existing screen structure is deficient and should be upgraded. If updates are desired, the project would benefit from a coordinated planning and design effort for the upstream and downstream passage features.” To identify which of the alternatives was most appropriate, the Panel recommended further study such as additional engineering analysis, drawings, and operational studies. Studies of the hardened ramp were started in 2011 and have been underway through 2017. UWCD elected to develop further the vertical slot fish ladder option from the Conceptual Design Report of 2010 and incorporate an updated fish screen design as recommended by the Panel.

1.2 OBJECTIVE

The objective of this report is to document the further development of the vertical slot fish ladder and evaluate its feasibility. This report describes the fish ladder components and their operation. It also describes the alternatives for these components and the reasons for selecting or not selecting them for inclusion in the passage project. The design also incorporates up-to-date fish screens in the design.

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2.0 EXISTING SITE, CRITERIA, AND CONSTRAINTS

2.1 EXISTING FACILITIES AND THEIR OPERATION

VFDD, constructed in 1991, is used to divert water from the Santa Clara River for irrigation and recharging local groundwater supplies. The diverted water is conveyed to a series of infiltration facilities located downstream of the dam. VFDD consists of a 28-foot tall roller compacted concrete (RCC) gravity dam, sediment flushing gate and sluice, canal gates, Denil fish ladder, fish screen and bypass, and head gates. Figure 2-1 shows the existing dam, fish ladders and diversion facilities.

VFDD is located approximately 10.5 river miles from the Santa Clara River's outflow into the Pacific Ocean, in Ventura, California. The Santa Clara River has a high sediment load and is very turbid during high flows. The high suspended sediment load during high flows renders the water unsuitable for infiltration. Therefore, when the turbidity levels are high, the canal gates are closed, and diversion ceases. This action is called "turning out". When the turbidity levels drop sufficiently, usually on the receding limb of the hydrograph, the water is "turned in" to the canal. The turn out and turn in of flows is based on staff measurements of river sediment load and not river flow amount.

UWCD is currently allowed to divert up to 375 cfs at the VFDD, which is then conveyed through the canal for deliveries to the infiltration basins. Flow in the canal is controlled by the head gates located immediately downstream of the fish screens. Currently, UWCD operates the fish ladder January through May when water is available in the river.

2.2 PROJECT CRITERIA AND CONSTRAINTS

2.2.1 Fish Species

The southern California steelhead population is listed as an endangered distinct population segment. The objective of this project is to pass steelhead but passage for Pacific Lamprey is also expected to be a requirement. The adults return from January 1 through May 31. Smolts generally migrate downstream during high flows from January to March, although observed migration has occurred as late as June on the nearby Ventura River.

2.2.2 Design Flows

2.2.2.1 Canal Flows

UWCD plans to file a water right for an additional 375 cfs of diverted Santa Clara River water, making its total allowed instantaneous diversion right 750 cfs. The fish screen for canal flows will be sized for 750 cfs in this study. A fish bypass flow will be required in addition to the 750 cfs to carry fish back to the river.

2.2.2.2 Upstream Passage Flows

The river flow, at which passage will be required, depends on a number of requirements such as criteria guidance from the NMFS and the suspended sediment load in the water. A flow of 1,800 cfs was set as the criteria for maximum flow that the facility would be operated to meet NMFS standards under (NMFS 2011). The fish passage facilities can operate above this flow, but all criteria might not be met.

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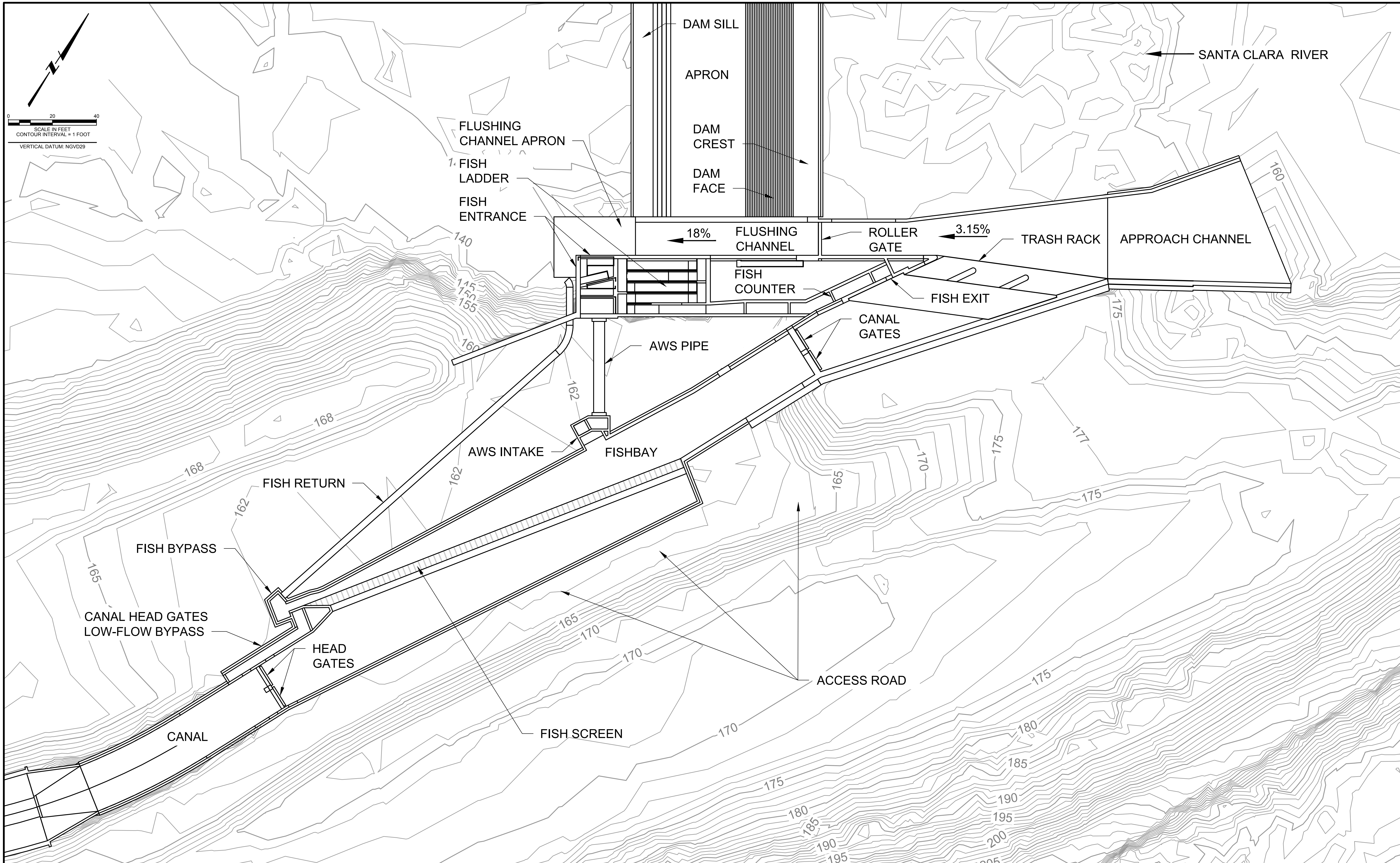

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CONCEPTUAL DESIGN PHASE - JULY 18, 2018

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Stantec

UNITED WATER CONSERVATION DISTRICT

VERN FREEMAN DAM FISH PASSAGE IMPROVEMENTS

SITE PLAN, EXISTING FACILITIES

FIGURE 2-1

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The fish ladder will be designed to pass 32 cfs at the design upstream water level of 161.0. The ladder flow ranges between 27 cfs and 38 cfs for upstream levels between 160.0 ft and 162.0 ft, respectively, which are typical flows for a vertical slot ladder with a 1-foot wide slot and 1-foot pool to pool drop. The auxiliary water flow will be a maximum of 180 cfs. This in addition to the ladder flow and fish screen return flow provides nominally 10 percent of the design river flow of 1,800 cfs.

2.2.2.3 Fish Facility Design Criteria

The new fish facilities are designed to the criteria and guidance stated by the NMFS in the northwest (NMFS Northwest Region, July 2011) and southwest (NMFS Southwest Region, January 1997) and to California Department of Fish and Wildlife Statewide Fish Screening Policy and applicable sections of the *California Salmonid Stream Habitat Restoration Manual (Part XII, 2009)*.

2.2.2.4 Hydraulic Design Data

The rating curves above and below the dam were taken from the Vern Freeman Dam Fish Passage Conceptual Design Report (September 2010). See Figures 2-2 and 2-3. Flood flows were also taken from this reference, and flood elevations upstream and downstream of the dam were taken from the Flood Insurance Rate maps issued by Ventura County.

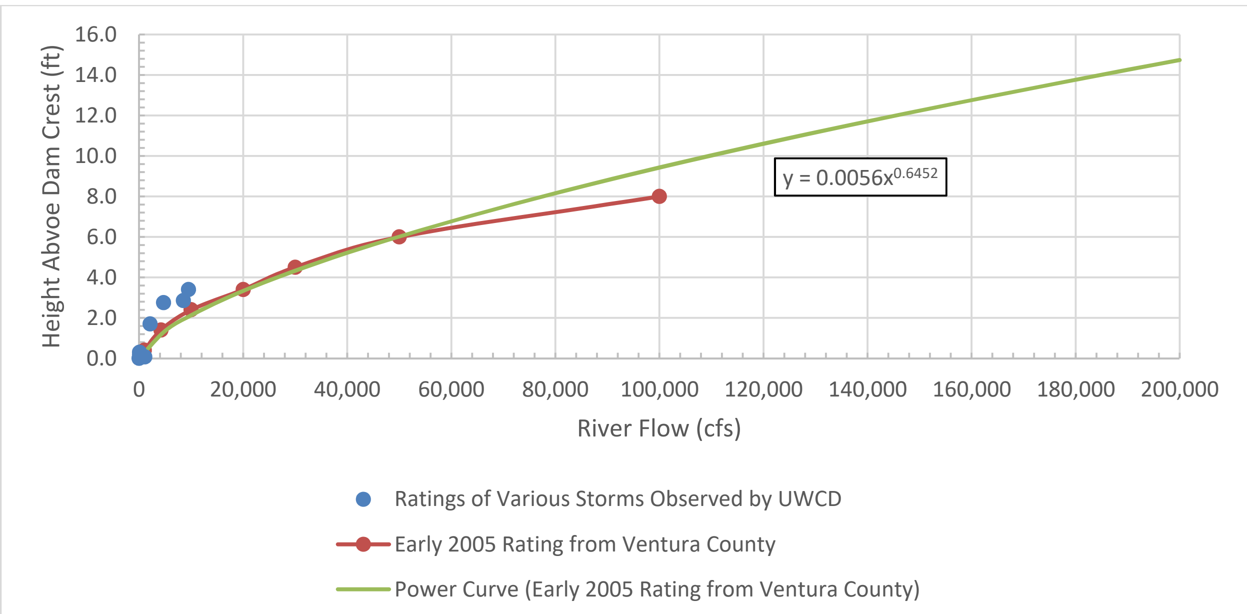

Figure 2-2 Upstream Rating Curve at Vern Freeman Dam

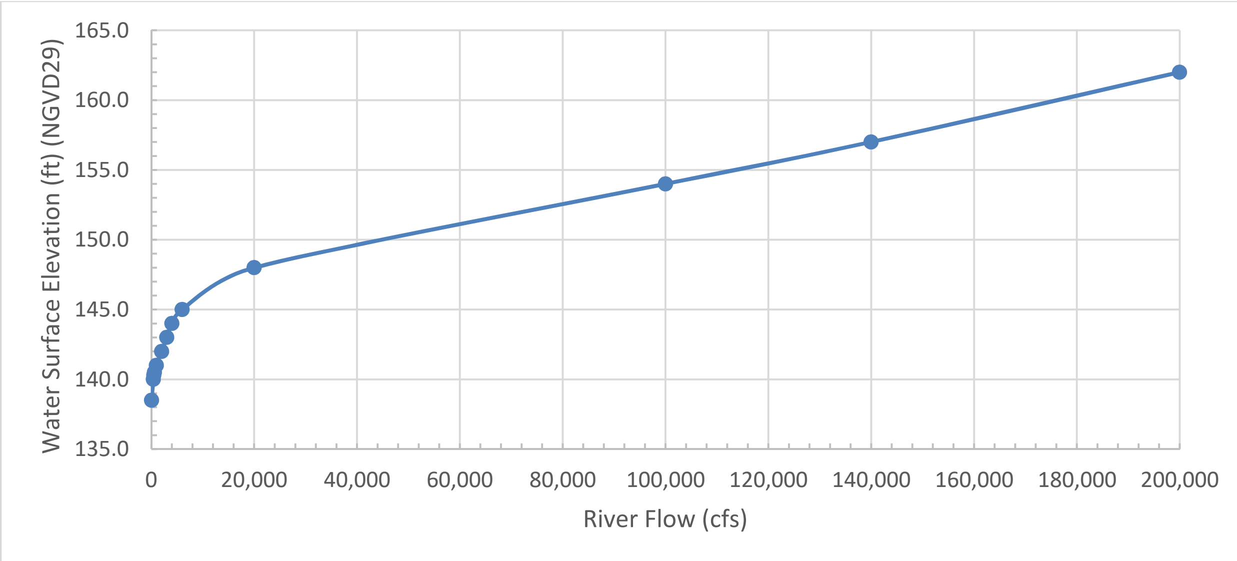

Figure 2-3 Downstream Rating Curve at Vern Freeman Dam

2.2.2.5 Other Criteria

Other criteria and guidance include the requirement to be able to handle sediment in the facilities to preclude adverse effects on facility operation. For this report, it was decided to use the vertical datum of NGVD 1929 because as-built drawings of the original dam and intake facilities were on that datum as was the canal capacity analysis (Northwest Hydraulic Consultants, January 7, 2015). Further it was assumed that in order for the proposed canal facilities to properly operate, the canal piped section located between the end of the open channel section of the canal and the sedimentation basins would be replaced so that they cause no backwater within the canal under a 750 cfs flow.

3.0 PROJECT DESCRIPTION

The fish ladder project consists of the following components: a crest gate, a vertical slot fish ladder, an auxiliary water system (AWS), and canal facilities. See Figure 3-1 through Figure 3-9 at the end of this section for details of the proposed new facilities described below.

3.1 CREST GATES

Operating the fish ladder and the fish screening facilities for the canal and AWS system is facilitated by maintaining a constant forebay water level. To better control the headwater level in the forebay of VFDD and to concentrate initial spill over the diversion crest, a new crest gate will be installed in the dam adjacent to the flushing channel. The RCC dam will be notched about 7 feet deep and about 39 feet long adjacent to the flushing channel. Reinforced concrete sidewalls will be placed on the top and sides of the cut to seal the exposed concrete and provide a smooth sealing surface. The new reinforced concrete sill provides a mounting surface for an Obermeyer dam 6 feet high and 35 feet in length as shown on Figure 3-2. Reinforced concreate will also be placed over the downstream stair-step spillway to provide a smooth surface. Spill over the crest will fall and contact the smooth spillway face almost parallel. This will provide a much safer path for downstream migrating fish passing over the crest gate.

Downstream of the crest gate the stilling basin has been extended downstream. The floor of the extended stilling basin is at elevation 134.0 to match the floor of the stilling basin to the north, the extended flushing channel apron, and the ladder entrance floor. See Figure 3-1 for the extents of the new apron. This arrangement allows fish access from the stilling basin pool to the fishway entrances at low or declining water levels.

The crest gate is expected to be an Obermeyer System that consists of a rubber bladder, which can be inflated to raise shaped steel plates to form the dam. In the fully raised position the crest will be at elevation 162.0 feet matching the existing dam crest. In the fully lowered position the crest will be elevation 156.0 feet. The elevation of the crest is controlled by inflating or deflating the rubber dam. The compressor and other equipment for the Obermeyer dam will be located on a new platform over the flushing channel. Actuation of the crest gate can be controlled several ways but typically the logic will be based on upstream water level and will include setpoints for high, low, and flood conditions.

3.2 FLUSHING CHANNEL

The existing flushing channel is located between the dam crest to the north and the intake and fish ladder to the south. From upstream to downstream, the flushing channel consists of an approach channel, a roller gate, and chute. See Figure 3-1. The flushing channel and roller gate will not be changed as part of the fish ladder project. Due to the location of the proposed ladder exit, the operation of the roller gate in the flushing channel will require operational changes that are integrated with the fish ladder operation.

3.2.1 Approach Channel

The upstream end of the approach channel is 61 feet wide at an elevation of 155.5. The channel narrows to 15 feet wide 40 feet upstream of the roller gates. The approach channel slab slopes downstream at a slope of 3.15 percent. This geometry functions to remove deposited sediments in front of the trash rack and proposed fish ladder exit. Water levels and flow velocities in the approach channel are controlled by the roller gate during flushing operations.

3.2.2 Roller Gate

Flow through the flushing channel and back into the Santa Clara River is controlled by a single 15 foot wide by 10 foot high roller gate located at the downstream end of the flushing channel. The roller gate opens vertically against a headwall and is controlled with an electric multi-turn actuator above the gate, on a platform at elevation 177.0. The invert of the gate is at elevation 149.0, about 13 feet below the top of dam. Under the proposed operation, the roller gate will not be used to control the forebay water level at river flows below 1,800 cfs. Current practice for flushing cycles for sediment management in the approach channel will be maintained.

3.2.3 Chute

The flushing channel chute is located downstream of the roller gate and returns water from the channel back into the Santa Clara River. The chute is approximately 83 feet long with a slope of 18.05 percent. Just below the flushing channel there is a 37-foot long horizontal concrete apron at elevation 134.0. Adjacent to the chute is the fish ladder to the south, and the dam and apron to the north. No structural changes are proposed to the chute walls or slab.

3.3 VERTICAL SLOT FISH LADDER

The vertical slot fish ladder facility, also called a fishway, consists of an entrance pool, vertical slot style ladder, a fish counting station, a transport channel, and an exit. See Figure 3-3.

3.3.1 Entrance Pool

The purpose of the entrance pool is to attract fish from the tailwater pool into the fishway and then to guide fish to the ladder once inside the entrance pool. Attraction flow discharging from the entrance pool is a combination of fish ladder flow and AWS flow. See Figure 3-4. The entrance pool is 40 feet long in the east-west direction and 25 feet wide. The entire pool has a floor elevation of 134.0. There are two fish entrances on the north side and two on the west side. The entrance openings are 3 feet wide and 6 feet high with the bottom of the openings at the floor level. Flush bottom sluice gates are located on the outside of the openings. The openings are hydraulically sized to have two gates fully open for conditions with 1-foot of drop across the gates, under maximum AWS flow. The actuated entrance gates can be used to open/close entrances or, if required, they will be capable of modulating to vary the hydraulic drop. When the river flow is less than the maximum AWS flow, the gates can regulate the flow out of the entrance pool.

Water from the fish ladder enters at the southwest corner and AWS water enters on the east side of the entrance pool. AWS water is distributed over a weir from the energy stilling basin located on the east side of the pool. The AWS water then flows through a baffle wall consisting of perforated plates with holes about 2 inches in diameter and a porosity of about 6 percent. The drop (differential) across the baffle wall would be about 1 foot. This system evenly spreads out the flow over the whole baffle plate to provide an even distribution of flows through the diffuser panel as required by NMFS guidelines. The diffuser panels are oriented within the entrance pool to guide the fish to the first pool in the fish ladder at the southwest corner of the entrance pool.

3.3.2 Vertical Slot Ladder


Typ. Vertical Slot Ladder Pool

As fish travel through the entrance pool, they next come to the fish ladder. The ladder consists of 23 steps. There is an overall drop of 22.5 feet across the entire ladder under low flow conditions. Most ladder steps will have a 1-foot drop except the upper two pools. The upper two pools act to regulate the rest of the pools based on varying headwater elevations and flows. These two pools will have drops of approximately 0.6-0.8 feet. Each pool has inside dimensions of 8 feet wide and 10 feet long. As seen in the adjacent photo of a vertical slot ladder, the pools are designed to discharge through a slot into the corner of the next pool downstream. This creates hydraulic conditions allowing fish to rest. This is a standard type of ladder with a long history of successful operation in passing steelhead and salmon.

3.3.3 Fish Counting Station

It is imperative that fish passing the ladder be enumerated to provide data to aid in the recovery of endangered steelhead. Due to the high turbidity in the Santa Clara River, normal counting equipment cannot do an accurate job in counting fish, because they rely on seeing the fish through the water. Forcing the fish to the surface and partially above it, exposes them to an above-water camera. Such a system has been developed and is currently in use at the VFDD.

This proposed system utilizes a standard false weir to draw the fish to the surface, where the fish triggers a video camera to record the fish as it crosses the false weir. See Figure 3-5. About 6 cfs is drawn from the pool upstream of the counting station and is delivered to the false weir by a 15 inch diameter pipe. A valve in the pipe controls the false weir flow. About 1 foot of head drop across the upstream baffle is used to deliver the flow to the false weir. The rest of flow in the ladder, about 30 cfs, passes through a baffled wall to better distribute the flow evenly. This flow then passes through a picket lead fence, which guides the fish to the false weir. A gate is installed to block flow from passing the wall at the counting station. This gate is shut to prevent water from flowing out of the transport channel during a ladder shutdown. When this gate and the exit gate are shut water is retained in the transport channel to preserve fish in the channel. The gate would be about 4 feet by 5 feet.

3.3.4 Transport Channel

After traversing 23 ladder steps the fish enters a transport channel. The transport channel is 3 feet wide and has an invert elevation of 153.3. The existing channel bottom will be used. The flow in the channel would be moving at about 2 fps to facilitate fish movement through the channel and out the fish exit.

3.3.5 Fish Exit

As fish exit the transport channel they pass through the fishway exit gate, which is a flush bottom 3-foot-wide by 6-foot-tall sluice gate. This gate and the head wall above it will be strong enough to resist the head created by the 100-year flood elevation upstream. The exit then expands to a 5-foot wide channel, which has a trash rack over the exit. This trash rack has bar spacing of 10 to 12 inches. The approach velocity to the rack is about 1 fps.

3.4 AUXILIARY WATER SYSTEM

AWS flow enters through the existing main canal trash rack along with the canal flows. This flow then is separated at the canal gates. One gate serves the AWS and the other three gates pass the canal flows. The descriptions in this section follow the flow of the auxiliary water from the forebay to the entrance pool. See Figure 3-6.

3.4.1 Inlet

The entrance to the canal is protected by an existing trash rack, which has been modified to pass fish upstream, since the existing ladder exit gate is located on the canal side of the trash rack. The bar spacing in the trash rack was increased (by removing bars) near the bottom of the rack to allow passage of steelhead. In the proposed fish ladder layout, the new fishway allows fish to directly exit into the flushing channel immediately downstream of the canal inlet trash rack. Therefore, replacement bars can be installed on the trash rack to provide uniform and narrower bar spacing to reduce debris entering the screens and canal. The trash rack will continue to be cleaned with the Duperon trash rake system and the controls for the rake will be unchanged. The gross approach flow to the trash rack will be about 2.5 fps at maximum flow (978 cfs max.) based on the cleaned wetted area of the rack. The existing fishway exit gate will be removed and the opening will be filled.

3.4.2 Canal Gate

There are two existing canal gates, 9 feet wide and 8 feet high. These will be retained, and two additional gates of the same size will be added adjacent to the existing gates, on their south side. Water into the AWS fish screens would pass through the northern existing sluice gate. See Figures 3-6 and 3-7.

3.4.3 Approach Channel

Downstream of the canal gates the south wall of the AWS fish screens extends up to the pier between the two existing sluice gates. This allows the AWS water system to operate independently of the canal water supply. The approach channel to the AWS screens is 9 feet wide and the invert is at elevation 152.7 at the entrance to the screens. This is the same elevation of the canal invert. The flow will be deflected at an angle of about 9 degrees. This slight angle of flow may cause a small eddy at the fish screens, but these can be controlled with tight baffling behind the screens. Fixed porosity baffles will be used to remove any flow imbalance in front of the screens. A large amount of head (energy) must be dissipated in the AWS flow before it enters the entrance pool so the added head loss from the fixed baffling will not affect operation. The total flow entering the screen facility is 201 cfs, 24 cfs for fish bypass and 177 cfs for AWS water. See Figures 3-6 and 3-7.

3.4.4 Primary AWS Fish Screen

The fish screen structure has been laid out to provide a flow velocity by the screens of 3.0 fps. The surface of the water entering the screen structure will be at elevation of 160.5 providing a depth of about 7.9 feet. Vertical flat panel fish screens will be mounted on a sill providing a wetted height on the screens of about 7.0 feet. Screen panels will be stainless steel frames and profile wire screen material having 1.75mm slots to meet juvenile fry screening requirements. The screens will be installed along the right (north) side of the flow channel and will be 62 feet long including support piers. The maximum approach velocity to the screens will be less than the required 0.33 fps. Total flow through the primary AWS screens would be 132 cfs with another 72 cfs passing the primary screen into the secondary screen. See Figure 3-7 for details.

The AWS screen will have a single brush screen cleaner. The brush will be hung from a trolley, which runs on a rail. The trolley will be pulled by a wire rope wound around a drum powered by an electric motor. The motor will drive the brush the length of the screens, and its speed of travel can be adjusted. This type of a brush system has been used successfully on many similar installations. The back eddy formed by the brush lifts debris off of the screens into the flow to be carried down to the bypass.

Sediment deposition in the screen area can be a problem due to the high suspended sediment load in the Santa Clara River. High pressure pumps would be located behind the fish screens. They would deliver water to a rectangular tube steel located under the fish screens along the floor. Water jet orifices, one quarter or three eighth inch diameter would spray high velocity jets of water along the floor. These jets would suspend sediment deposited on both sides of the screens. The sediment would then be carried downstream in the AWS. This system has been used in other screen installations to re-suspend sediment out to 30 feet from the screens.

Alternate screen types, like vertical belt screens, that would replace the screen panels and cleaning systems described above could be adapted to this layout.

3.4.5 Secondary AWS Fish Screen

At the entrance to the secondary screens the channel is 3 feet wide and the invert is at elevation 152.6. This floor elevation maintains the same invert profile as in the existing canal up to the secondary screens. At the upstream end of the secondary screen, the floor is sloped upward at a grade of 1V to 7H. See Figure 3-7. To maintain or accelerate the free stream velocity in the channel as required by NMFS guidelines, the channel narrows from 3 feet wide to 1.5 feet wide at the downstream end. Vertical flat plate screens with about 144 square feet of wetted area installed on the north side of the channel to pass 48 cfs to the ladder dissipation chamber. Screen panels would be cleaned by a smaller brush or a back-spray system. The type would be selected after further evaluation. If the back-spray system is chosen, it could utilize the sediment suspension high pressure pumps described below.

The flow passing the secondary screen, 24 cfs, would reach critical depth (trapping velocity) at the end of the secondary screens. A weir gate at the end of the secondary screens would maintain a constant elevation below the upstream water surface to pass the desired 24 cfs under small variations in river level.

Sediment control features in the AWS channel will include floor jets a flushing gate and a floor drain. High pressure floor jets will be used for periodic resuspension of material while in operation. Jets are located under the screen panels and strategically in areas such as the toe of the ramp where normal operating accumulations are anticipated. A 4-foot square flushing gate installed in the wall between the canal screen and AWS screen for maintenance use to move material down to the canal and sedimentation ponds. A grated floor drain has been included also to allow drainage water and to help in recovery after severe accumulation events in the facility.

3.4.6 Fish Return and Finishing Screen

To accommodate a fish trapping and evaluation station used to monitor and evaluate the fish runs, finishing screens would be provided to reduce the flow to a manageable amount. The trapping velocity created at the downstream end of the secondary fish screens commits into the fish return either to go to the evaluation station or to the river. To reduce the velocity through the finishing screens, the channel would be expanded to 3 feet wide and 3 feet in depth. See details on Figure 3-9. A total gross screen area of 66 sf is provided. If the flow velocity through the structure is maintained (NMFS Guideline) then 19.6 cfs will be screened and removed leaving 4.4 cfs to return fish to the river or evaluation station. An additional 2 cfs can be removed without violating the 0.33 fps screen approach velocity if a reduced flow into the evaluation station is desired. Screened flow is controlled by a gate on the structure outlet. The channel at the downstream end of the finishing screens is reduced to 12 inches wide. The flume is rotated out of the structure toward the river through a 5-foot sweep. The channel then transitions to a 24-inch diameter fish return pipe that returns fish to the river near the fish ladder entrance pool. This is the normal operating configuration when not sampling. To sample fish, the channel must be reconfigured by replacing a short section of channel. A short shutdown of water to the finishing screens will be required. The channel design will accommodate gasketed guides for rapid removal and replacement of the channel sections and lifting assistance would be provided. Once the channel is installed the full 2.0 - 4.4 cfs bypass flow (with fish and any debris) is passed into the evaluation station.

In the normal configuration the fish return flow will be routed to the river in a 24 inch diameter fish return pipe. The pipeline will include 10-foot radius sweeps in accordance with NMFS guidelines. The alignment is shown on Figure 3-1. The pipe profile will be controlled to limit velocities in the pipe and at the discharge contact with the tailwater. The pipeline will be secured to the concrete wall and hardened to protect it from debris during floods.

Screened water from the finishing screens is regulated by a side gate at the pipe inlet. The screened flow from the finishing screens is combined with the finishing screen flow from the canal screens and water from the evaluation building and is all fish free. Flow can be routed either to the canal downstream of the headgates or to the river at the sluiceway to supplement the AWS flow in the ladder. The pipe size from the finishing screen will be 24 inch diameter to the common 30 inch diameter pipe that can convey water to either the canal or to the sluiceway.

3.4.7 Evaluation Station

Bypass flow would enter the evaluation station in an open channel into a holding pool. Figure 3-9 shows a concept layout for the evaluation station that could be used for monitoring and evaluation of the steelhead runs. Details of the station and equipment would be revised once the full scope of the sampling requirements are determined. The holding pool is 30 inches wide, 10-feet in length and designed for a nominal operating depth of 3 feet. The nominal volume of the pool is 105 cf. The holding pool would include a screen at the downstream end with a weir to maintain pool level. A 1-foot deep recess in the floor upstream of the belt screen would serve to store a brail tray to remove fish for sampling. An electric hoist would be installed to lift the brail tray. Holding pond crowding screens and picket panels for predator separation would be provided. To process fish the crowding panel would be moved to the edge of the brail and fixed in position while the brail is raised. The brail can be raised to the top of the wall for inspection or above the wall to transfer fish to separate holding tanks for evaluation. Fish would be returned to the screened water trench in the floor to be returned to the river. The evaluation station would contain a non-potable water sink, work bench, service water supply, and tagging equipment. This station would contain an identical set up for the bypass from the AWS screening facility.

3.4.8 Bypass Outlet

The bypass flows and fish from the evaluation station would be diverted to a 24-inch pipe to carry the fish back to the river. The flow in the fish return pipe would be about 4-8 cfs from both screening facilities. The fish return pipe is smooth interior and would require 10 foot radius sweeps at the elbows. The fish return also collects flow from the evaluation facility so fish can be released once the sampling is completed. The required pipe slope and the 24 inch pipe (per the NMFS guideline) would result in flow depths that would be 3 inches to 4 inches which would not meet the NMFS guideline for depth to diameter ratio. Pipeline velocities are within the NMFS guidelines. Further development of the design could include consideration of changing the pipe size to a 16 inch pipe to balance guideline for flow depth versus the physical pipe diameter. The bypass flow and fish would drop into the pool to the west of the fishway entrance. The discharge end of the pipe would be at about elevation 146.0. See Figures 3-4 and 3-6.

3.5 CANAL FACILITIES

This section follows the water from the forebay to the head gates and canal downstream. It describes the proposed facilities in this flow path. The existing head gates and canal downstream would not change. See Figure 3-6.

3.5.1 Inlet

The canal inlet is the existing canal inlet as modified as described in Section 3.4.1.

3.5.2 Canal Gates

Two new 9-foot-wide by 8 foot high sluice gates, identical to the existing canal gates, will be installed south of the existing gates and in line with them. The gates will be flush bottom with their inverts at elevation 152.7, the same elevation as the existing gates. See Figure 3-6. The new gates will have electric motor operators. Flow to the canal will pass through the southern existing canal gate and the two new canal gates.

3.5.3 Approach Channel

The channel between the canal gates and the entrance to the canal fish screens is rectangular in section and is 33 feet wide. The invert of the channel slopes at 0.08 percent. The elevation at the gates is 152.7, and the elevation at the entrance to the fish screens is 152.5. This is the same profile as the existing channel. The center line of the channel is a straight line from the center of the center canal gate to the center of the pier between the two head gates. Therefore, the flow approaching the fish screens will be down the center of the Vee screen, resulting in no unbalanced flow approaching the screens. The total flow entering the screen facility is 774 cfs, 24 cfs for fish bypass and 750 cfs for delivery to the canal downstream.

3.5.4 Primary Fish Screen

The fish screen structure has been laid out to provide a flow by the screens of 3.0 fps. The surface of the water entering the screen structure will be at elevation of 160.5 providing a depth of about 7.9 feet. The screens will be mounted on a sill providing a wetted height on the screens of about 7 feet. See Figure 3-8. The 1-foot high sill allows for sediment accumulation before interfering with the screens and the brush cleaners. The screens will be in the shape of a “V” with flow passing through screens on the sides of the Vee. The primary screens will be 166 feet long including support piers. Each screen panel will be 10 feet long and 7 feet high. Screen panels will be stainless steel frames and profile wire screen material having 1.75mm slots to meet juvenile fry screening requirements. There will be a blank panel on top of the screen up to elevation 162. The approach velocity to the screens will be 0.33 fps. The flow through the primary screens would be 702 cfs with 72 cfs passing into the secondary screen reach.

Each side of the Vee will have an independent single brush screen cleaner. The brush will be hung from a trolley, which runs on a rail. The trolley will be pulled by a wire rope wound around a drum powered by an electric motor. The motor will drive the brush the length of the screens, and its speed of travel can be adjusted. This type of a brush system has been used successfully on many similar installations. The back eddy formed by the brush lifts debris off of the screens into the flow to be carried down to the bypass.

Sediment deposition in the screen area can be a problem due to the high suspended sediment load in the Santa Clara River. Sediment control measures available in the main screen channel will include a system floor jets and a floor drain at the end of the primary screens and removable screen panels. High pressure floor jets will be used for periodic resuspension of material while in operation. High pressure pumps would be installed behind the fish screens. They would deliver water to a rectangular tube steel located under the fish screens along the floor. One quarter or three eighth-inch holes in both sides of the tube steel would spray high velocity jets of water along the floor. These jets would suspend sediment deposited on both sides of the screens. The sediment would then be carried downstream in the canal by the transport flow. This system has been used in other screen installations to re-suspend sediment out to 30 feet from the screens. A floor drain pipe would provide the ability to drain water and possibly sediment under limited conditions back to the river. Figure 3-1 shows the proposed routing of the pipe. The drain would be normally closed at a buried plug valve to prevent fish entrainment. Screen and baffle assemblies would be designed to be removable with lifting equipment to allow flushing of sediment into the canal if needed to restore operation. Raising screens in combination with the headgates and possibly the sediment jets would provide a rapid method to restore proper operating conditions at the fish screens.

Alternate screen types, like vertical belt screens, that would replace the screen panels and cleaning systems described above could be adapted to this layout.

3.5.5 Secondary Fish Screen

The secondary canal fish screens are similar to those for the AWS, described in Section 3.4.5. At the entrance to the secondary screens the channel is 3 feet wide and the invert is at elevation 152.5. At the entrance the floor starts to slope upward at a grade of 1V:6.6H. See Figure 3-8. The channel would decrease in width from 3 feet at the entrance to 1.5 feet wide at the bypass gate. About 144 square feet of wetted screen area would be provided to pass 48 cfs. There would be 72 square feet of screens on each side of the channel. The three screen panels on each side would be 3.5 feet high and 10 feet long. The screens would be cleaned by a set of smaller brushes or a back-spray system. The type would be decided after further evaluation. If the back-spray system is chosen, it could utilize the sediment suspension high pressure pumps described below.

The flow passing the secondary screen, 24 cfs, would reach critical depth (trapping velocity) at the end of the secondary screens. A weir gate at the end of the secondary screens would maintain a constant elevation below the upstream water surface to pass the desired 24 cfs under small variations in river level.

Sediment control measures provided in the screen channel will include a system floor jets and the floor drain at the end of the primary screens. High pressure floor jets will be used for periodic resuspension of material while in operation. Jets are located under the screen panels and strategically in areas such as the toe of the ramp where normal operating accumulations are anticipated.

3.5.6 Fish Return and Finishing Screen

The fish bypass would be the same as in the AWS screen facility. An 18 inch wide bypass weir would pass flow 2 feet deep into a flume attached to the top of the weir. The 24 cfs bypass would flow down the flume and into a transition channel to a 36 inch diameter pipe. The pipe would flow about half full at 6.7 fps. The pipe would bend in a long radius sweep to the evaluation station. Once outside of the channel the pipe would transition into the finishing screen as shown on Figure 3-1. The finishing screen and conveyance are the same as described in Section 3.4.6.

In the normal configuration the fish return flow will be routed to the river in a 24 inch diameter fish return pipe. The pipeline will include 10-foot radius sweeps in accordance with NMFS guidelines. The alignment is shown on Figure 3-1. The pipe profile will be controlled to limit velocities in the pipe and at the discharge contact with the tailwater. The pipeline will be secured to the concrete wall and hardened to protect it from debris during floods.

Screened water from the finishing screens is regulated by a side gate at the pipe inlet. The screened flow from the finishing screens is combined with the finishing screen flow from the canal screens and water from the evaluation building and is all fish free. Flow can be routed either to the canal below the headgates or to the river at the sluiceway to supplement the AWS flow in the ladder.

3.5.7 Evaluation Station

Fish return flow would be routed to the evaluation station through the same process as described for the AWS screen. The evaluation station accommodates flow from both screens and is described in Section 3.4.7.

3.5.8 Bypass Outlet

The bypass flows and fish from the evaluation station would be diverted to a 24 inch diameter pipe to carry the fish back to the river. The flow from the main canal screens is combined with the AWS fish return which is described in Section 3.4.8.

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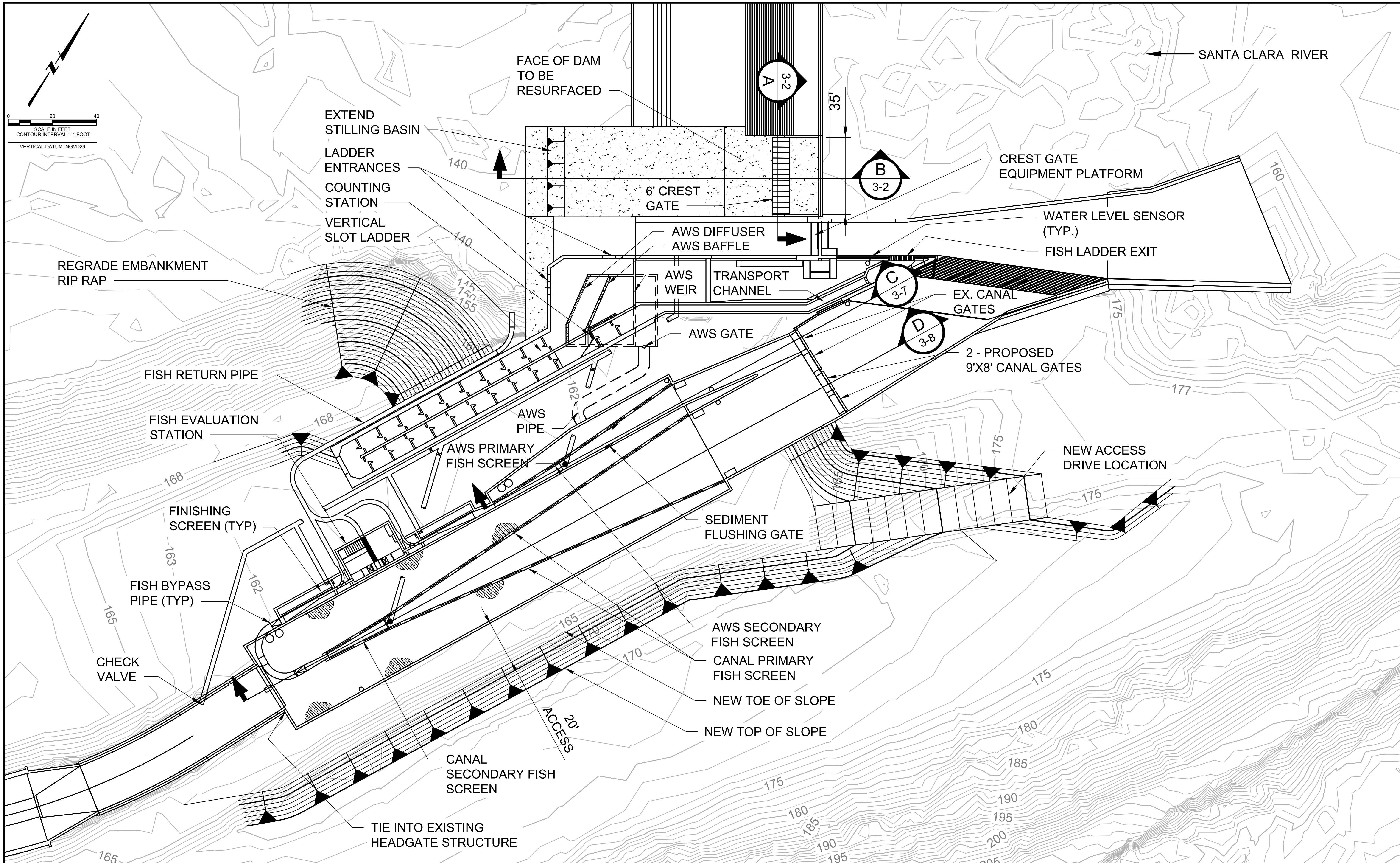

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UNITED WATER CONSERVATION DISTRICT

VERN FREEMAN DAM FISH PASSAGE IMPROVEMENTS

SITE PLAN, NEW FACILITIES

FIGURE 3-1

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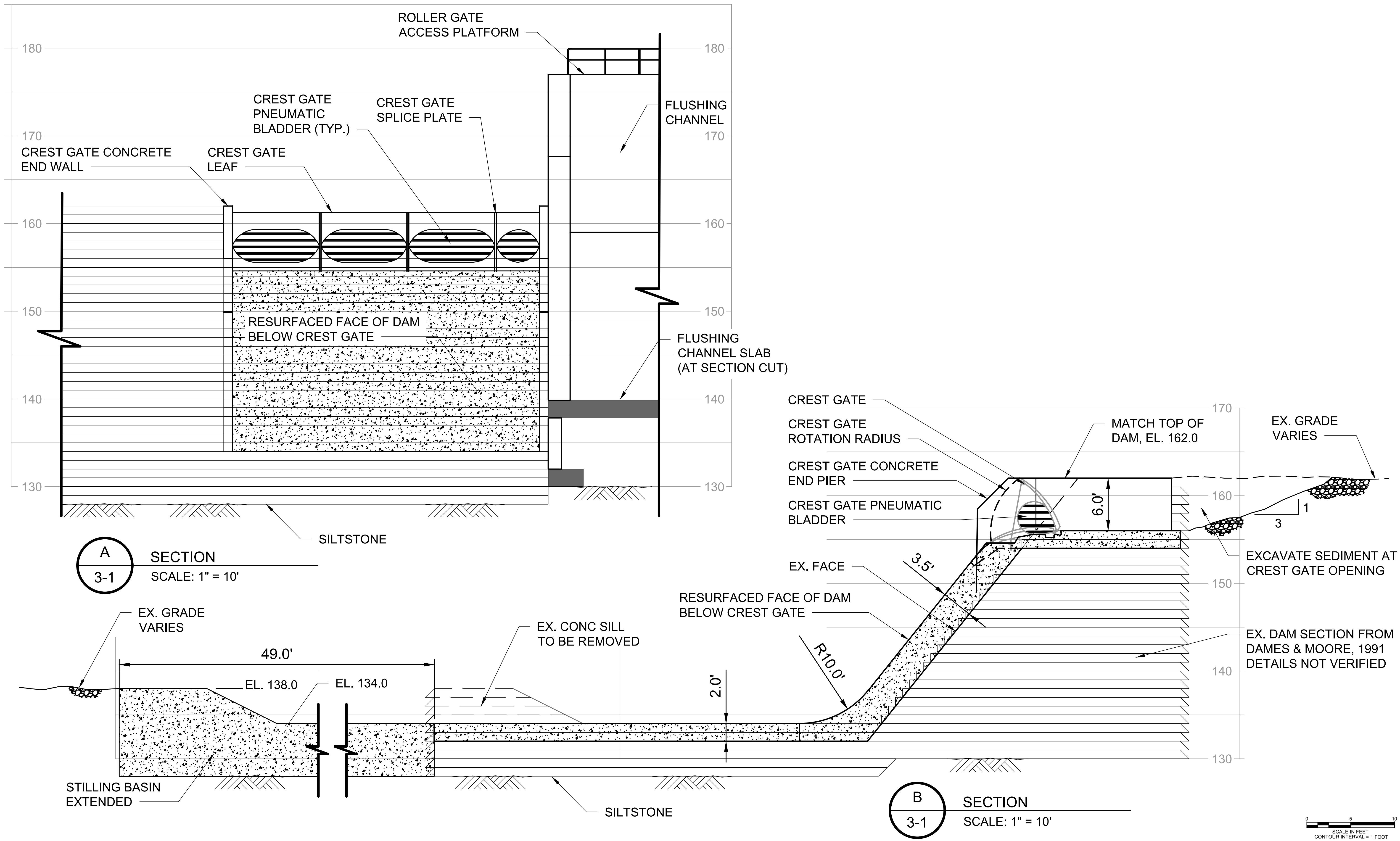

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VERN FREEMAN DAM FISH PASSAGE IMPROVEMENTS

CREST GATE SECTIONS

FIGURE 3-2

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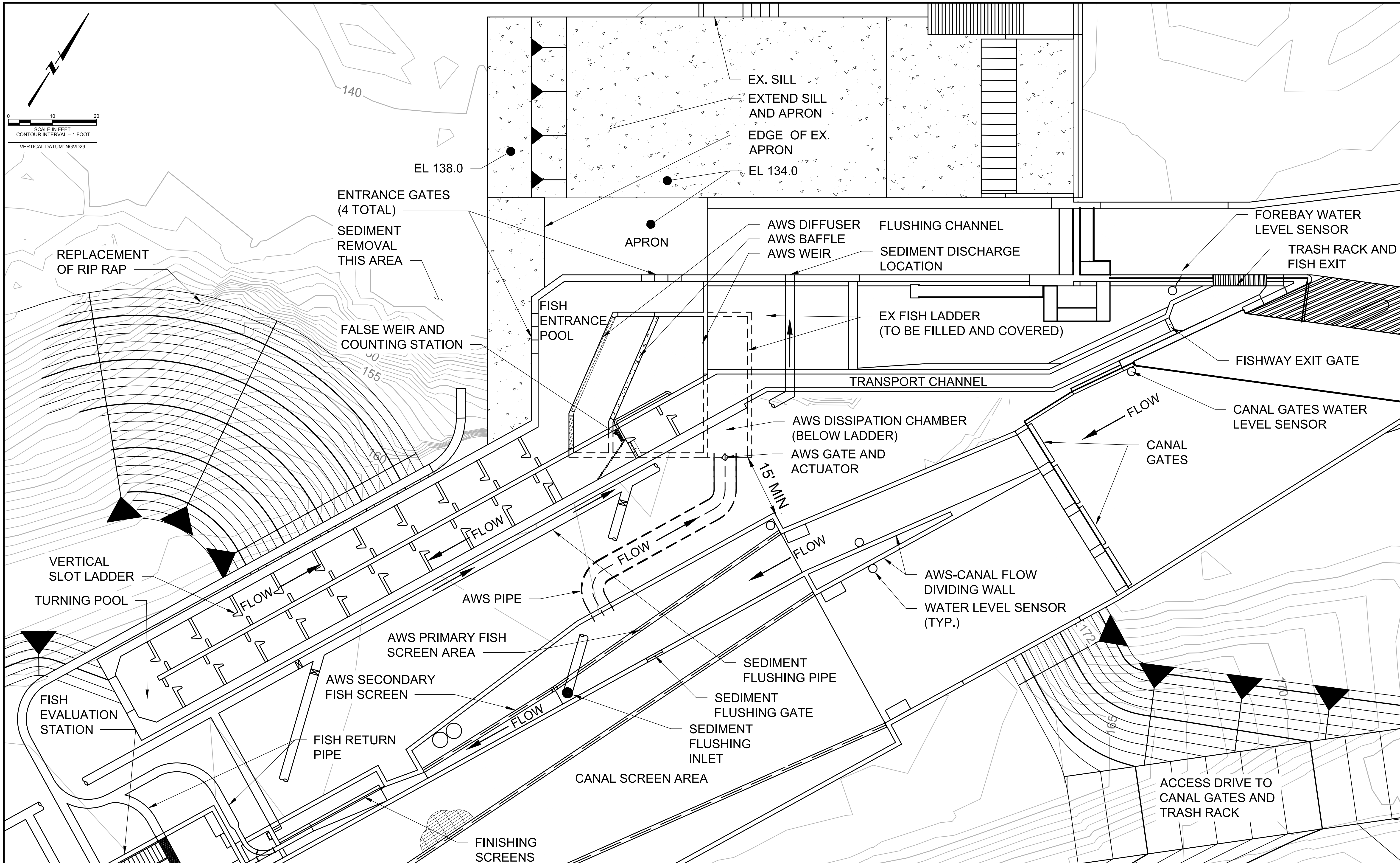

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VERN FREEMAN DAM FISH PASSAGE IMPROVEMENTS

FISH LADDER PLAN

FIGURE 3-3

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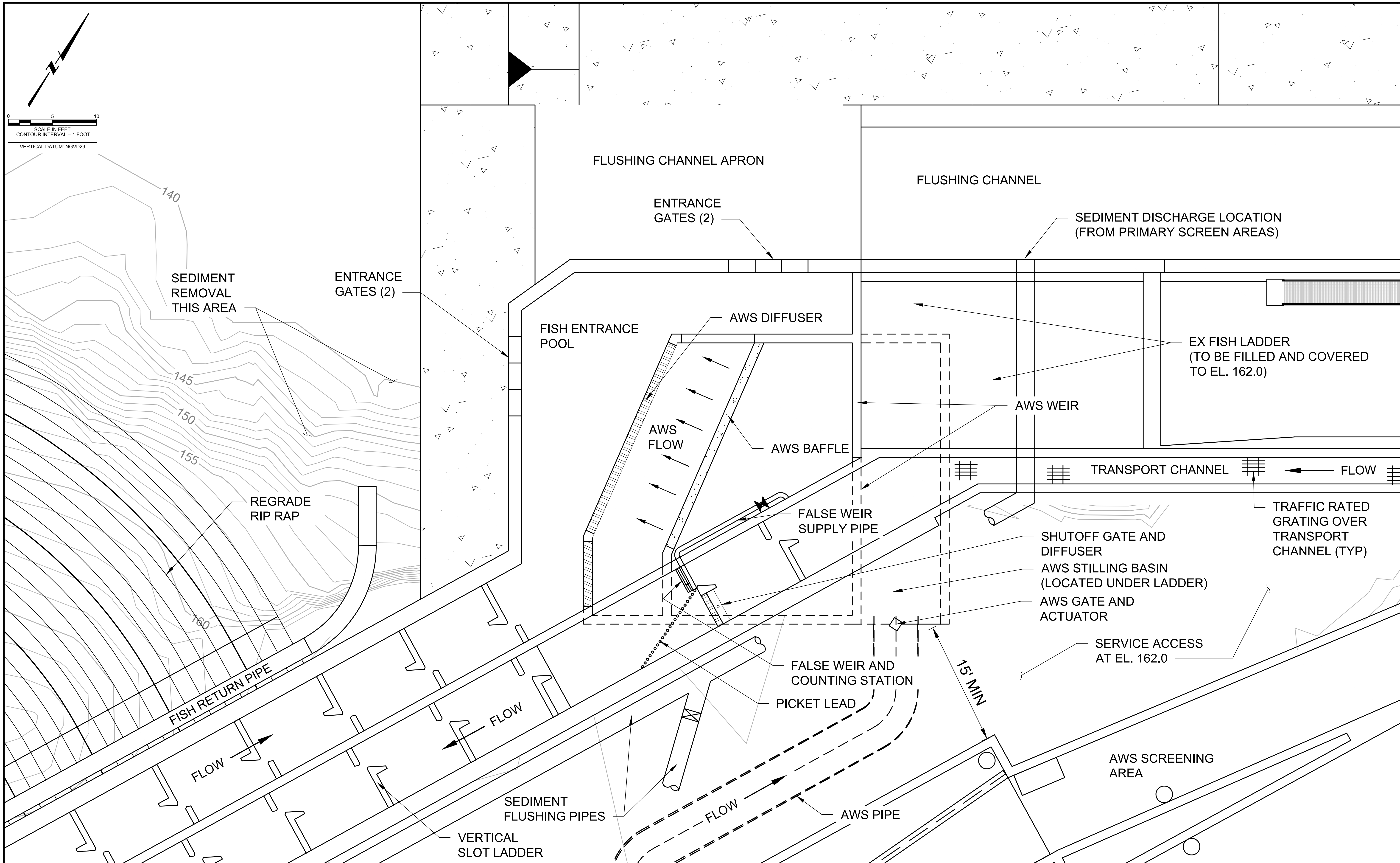

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VERN FREEMAN DAM FISH PASSAGE IMPROVEMENTS

FISH LADDER ENTRANCE POOL PLAN

FIGURE 3-4
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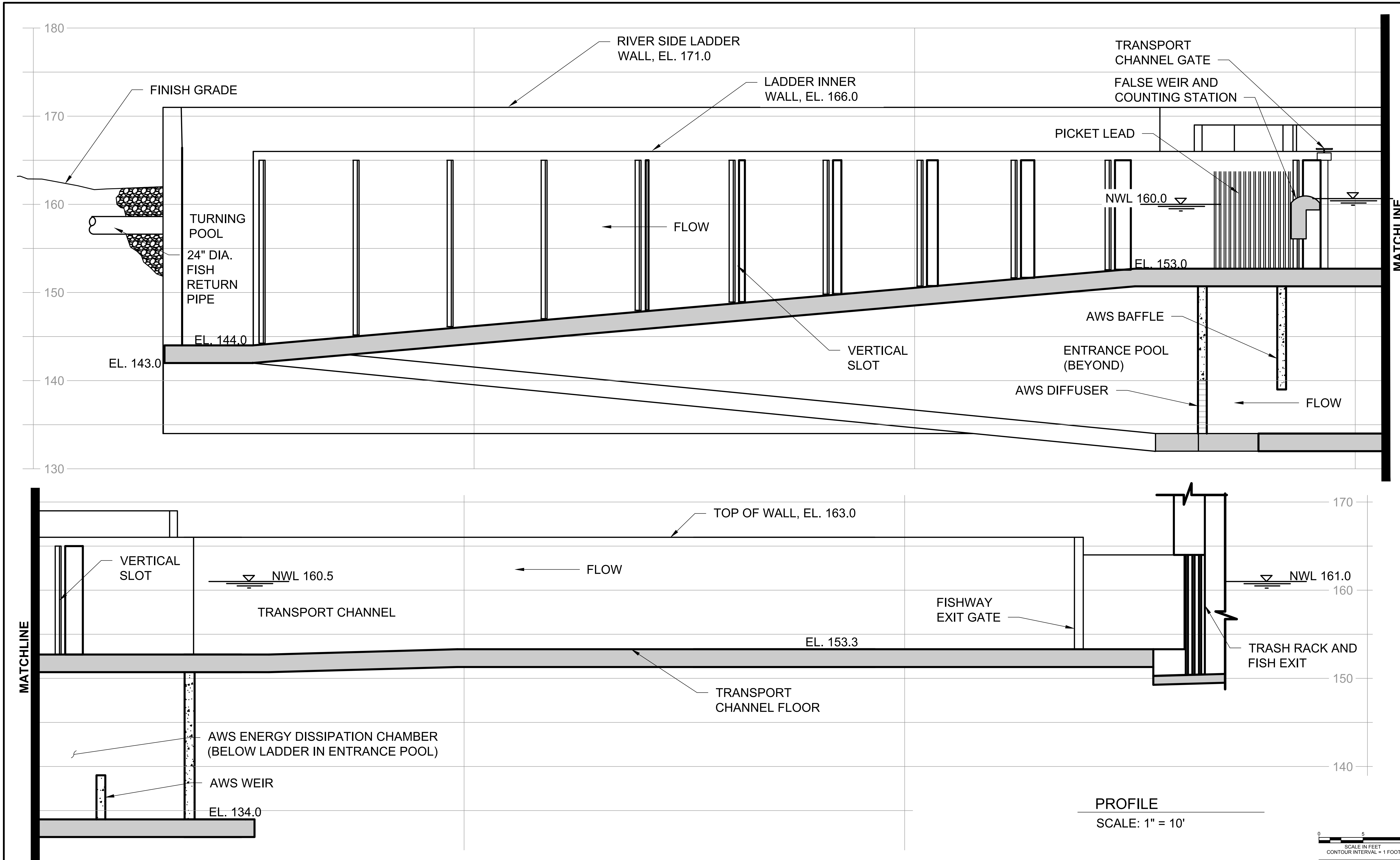

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VERN FREEMAN DAM FISH PASSAGE IMPROVEMENTS

UPPER FISH LADDER PROFILE

FIGURE 3-5

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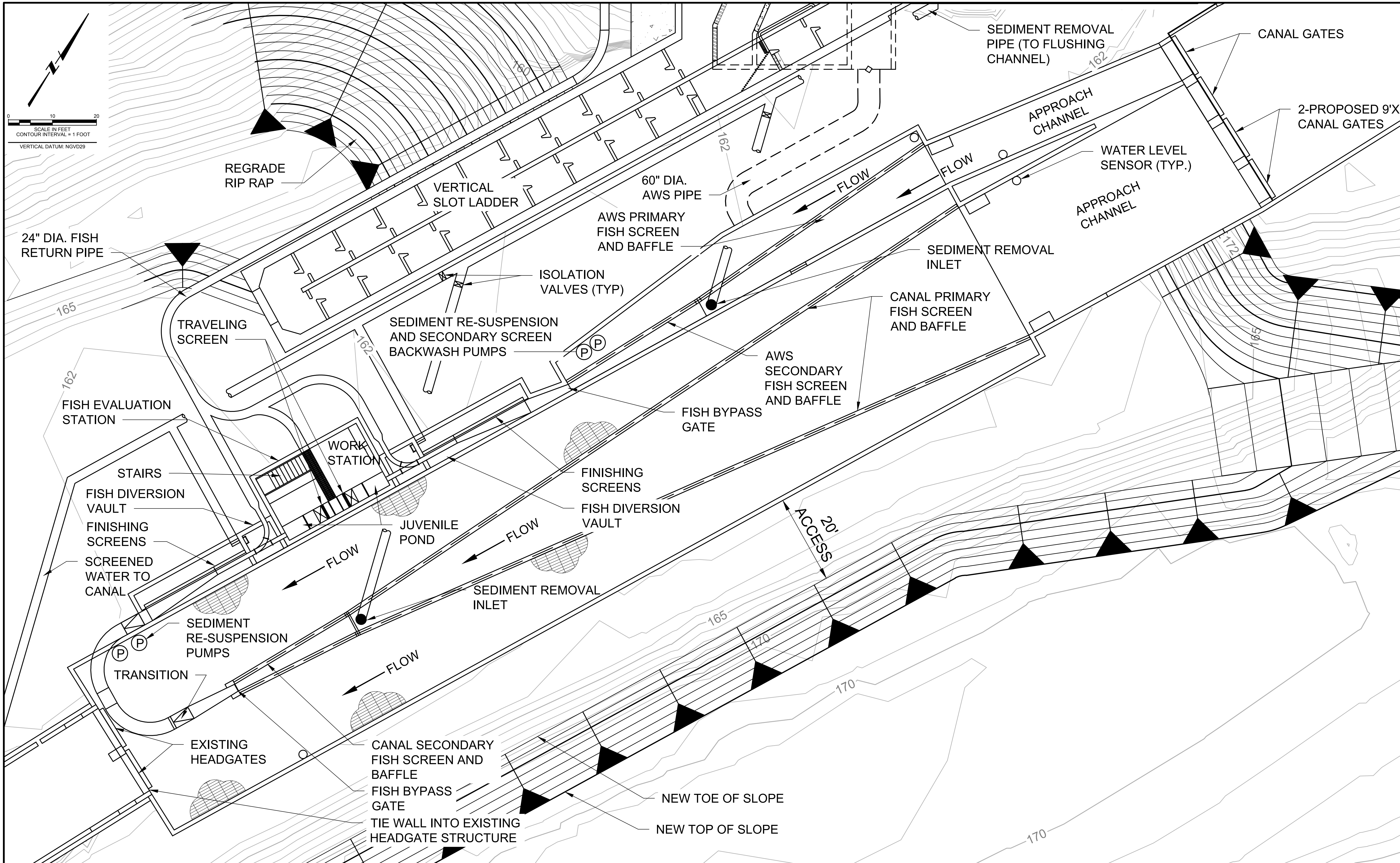

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VERN FREEMAN DAM FISH PASSAGE IMPROVEMENTS

AWS AND CANAL FISH SCREEN PLAN

FIGURE 3-6

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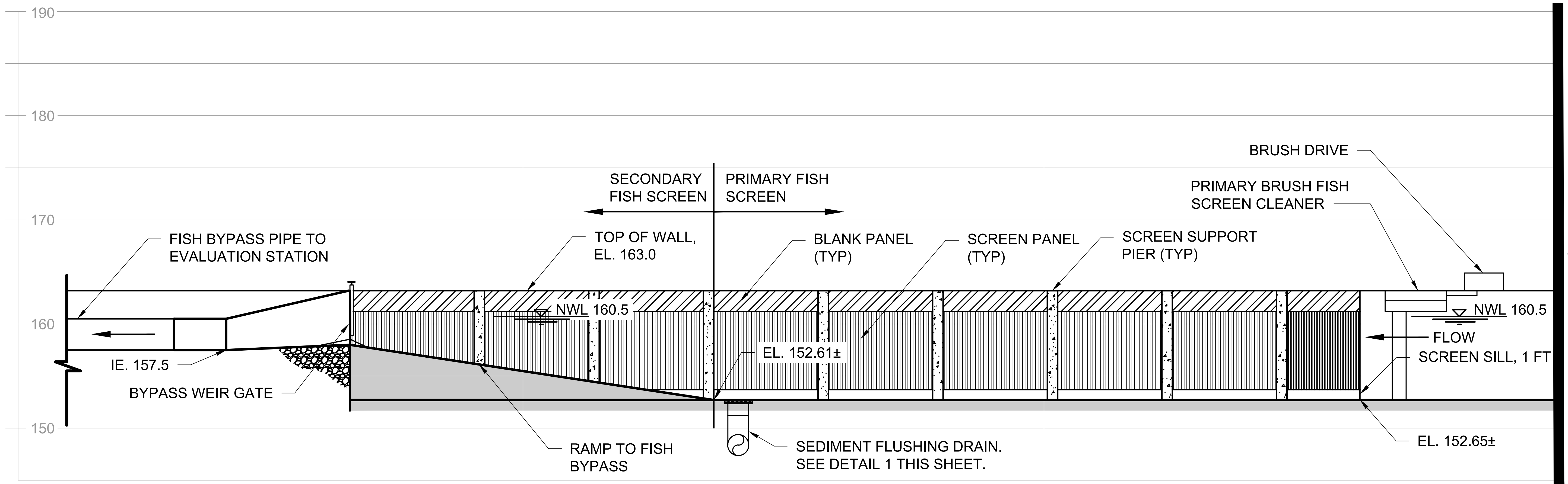

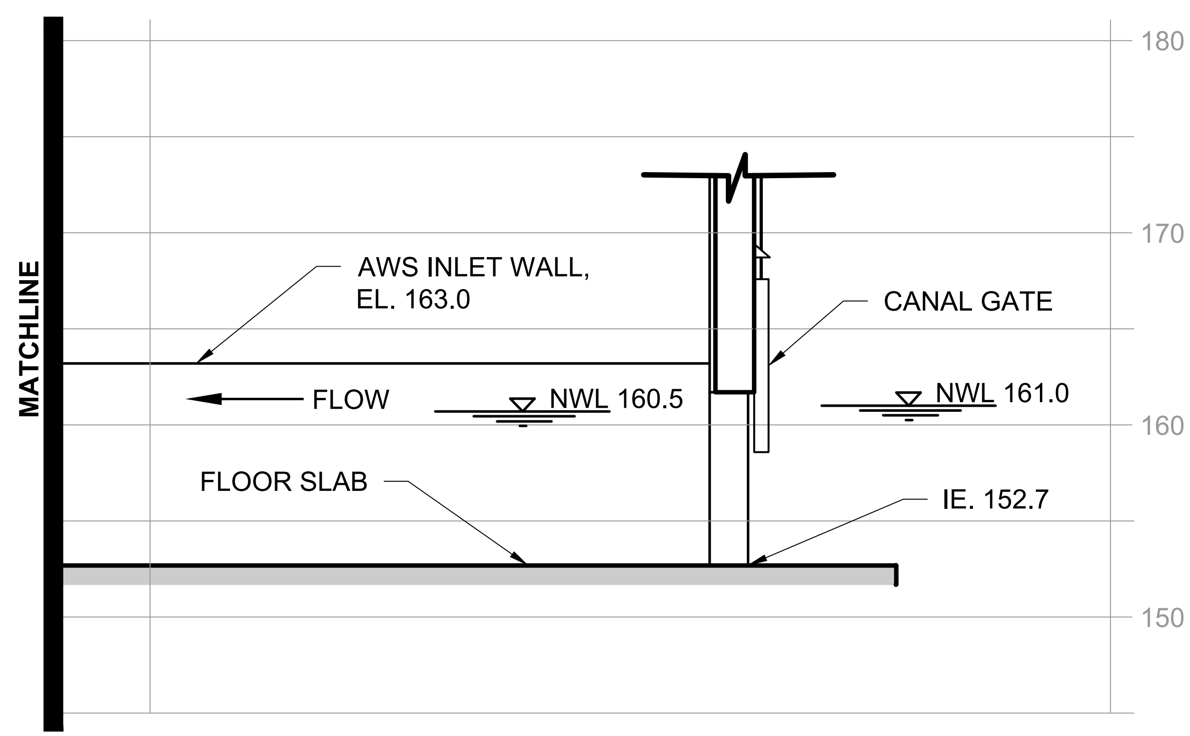

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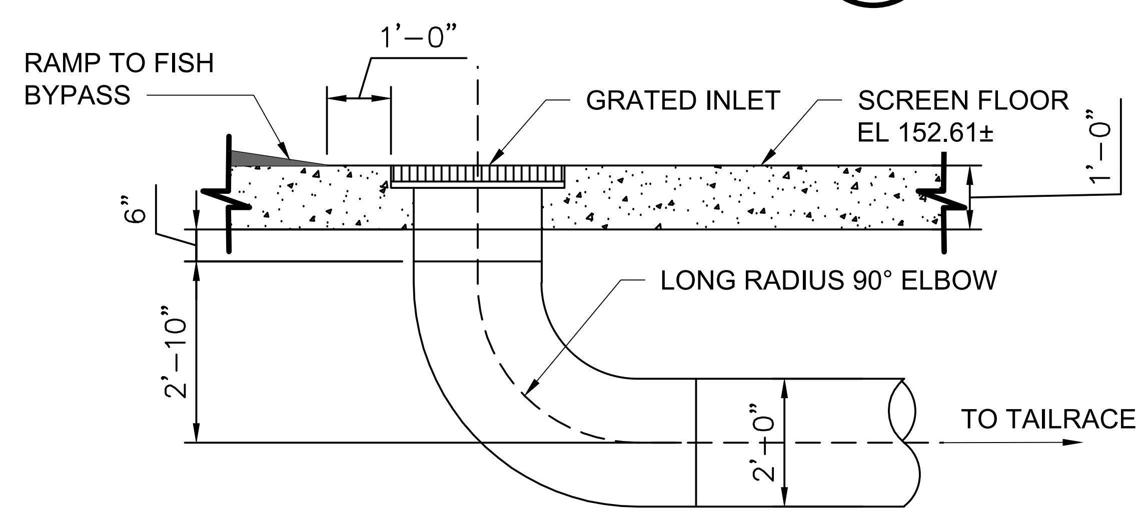

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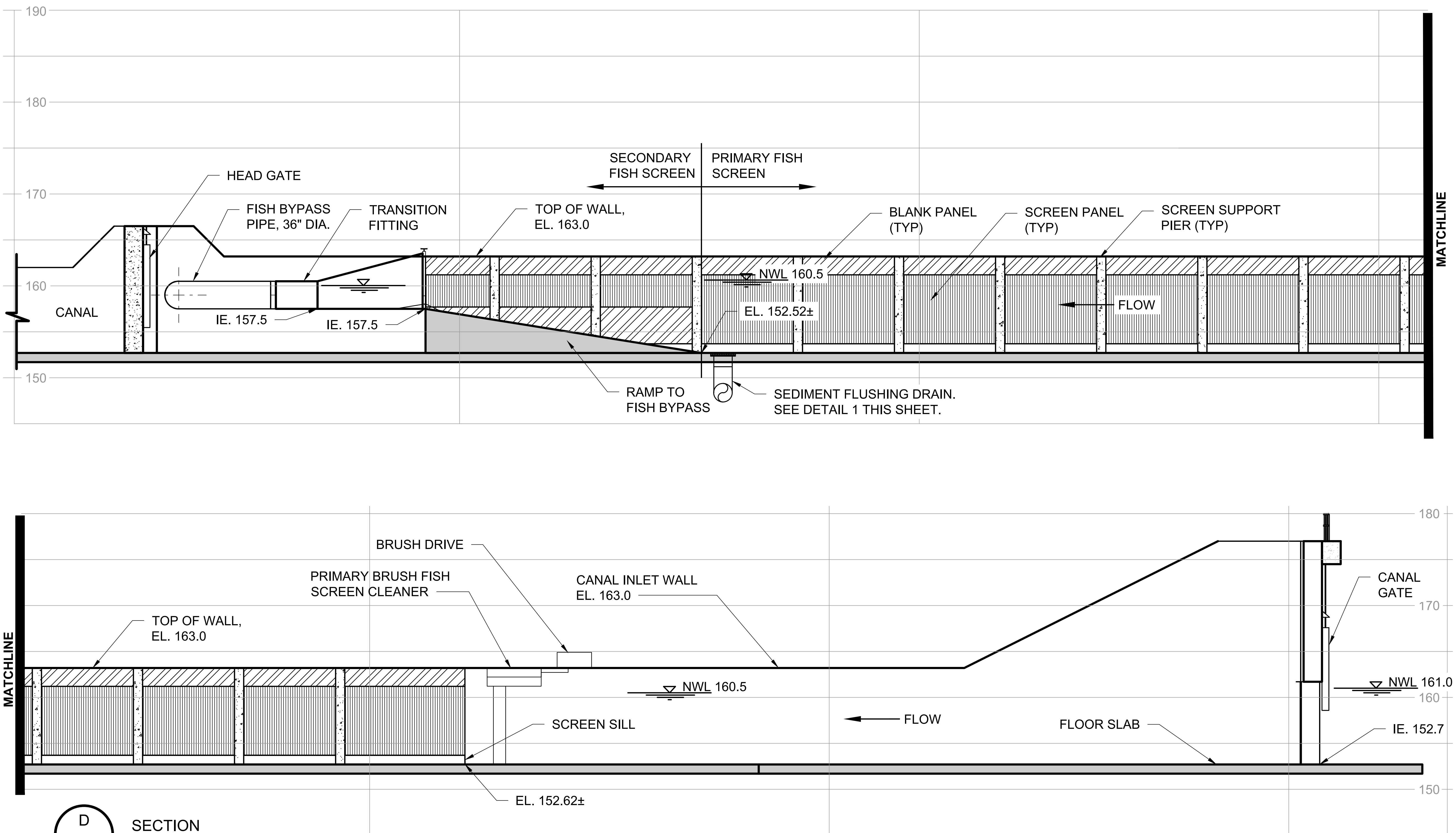

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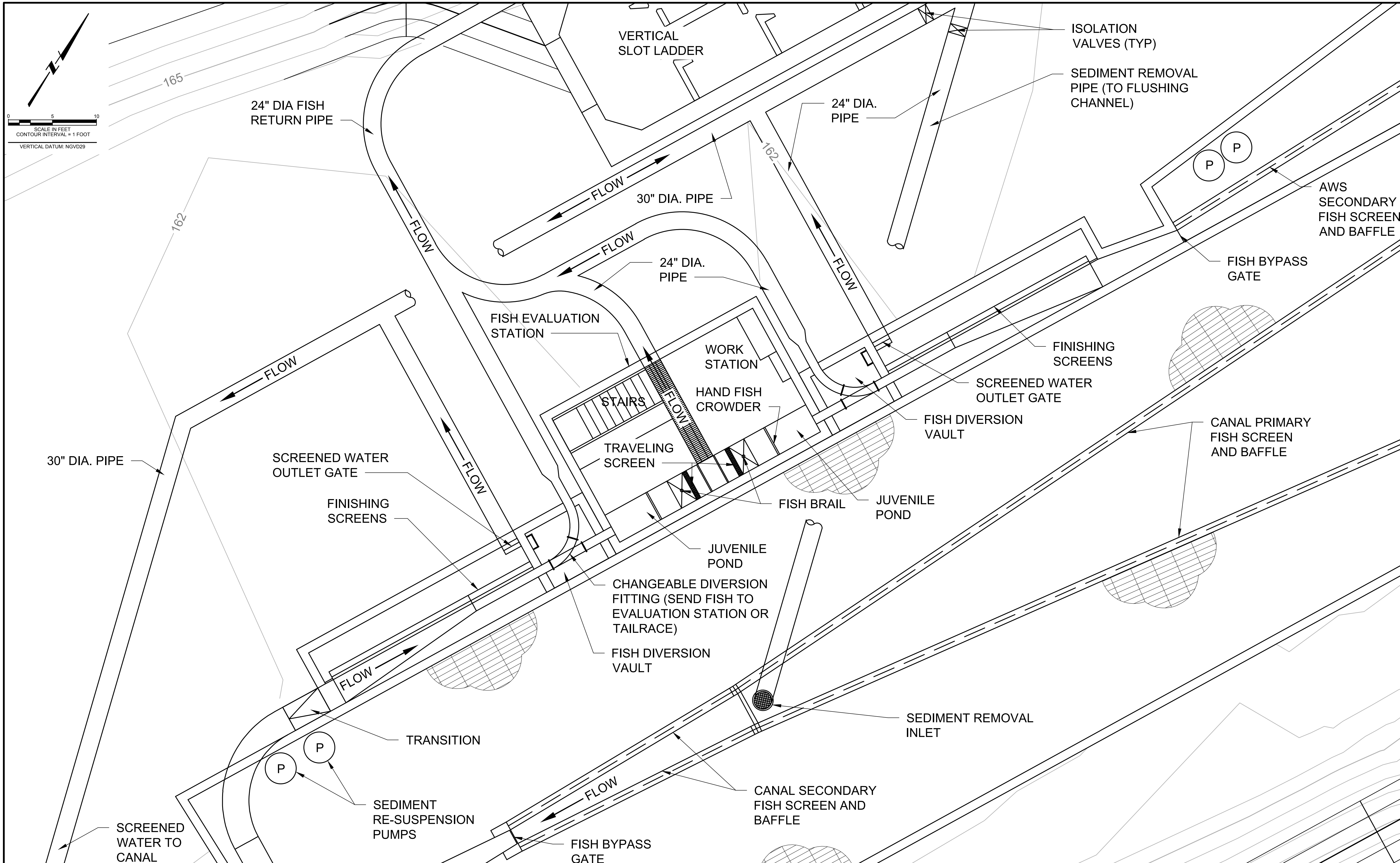

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VERN FREEMAN DAM FISH PASSAGE IMPROVEMENTS

EVALUATION STATION AREA PLAN

FIGURE 3-9

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4.0 PROJECT OPERATIONS

4.1 FLOW ALLOCATION

The flow in the Santa Clara River approaching the VFDD either passes the dam or is diverted and sent down the canal to the settling basins. Figure 3-1 shows the different routes that water can take through the VFDD facilities. All flow routes direct the water to the left bank immediately below the dam, except for the water that passes over the spillway and water diverted down the canal. Uncontrolled spill occurs when all other flow paths are at the design capacity of 1,800 cfs.

The flow paths through the dam and intake facilities can be opened to pass or divert water as desired. For the 1,800 cfs through the facilities, the discharges downstream can be sequenced for a canal diversion flow of 750 cfs or 375 cfs. Table 4-1 shows a sequence that includes a total canal diversion flow of 750 cfs after meeting the minimum flow release past the dam.

Table 4-1 Flow Allocation, 750 cfs Canal Flow

River Flow Upstream	Ladder	Canal	Canal Fish Bypass***	Auxiliary Water	Auxiliary Water Fish Bypass***	Crest Gate	Spillway	River Flow Downstream
45	45							45
70	45	1	24					69
819	45	750	24					69
844	45	750	24	1	24			94
1,023	45	750	24	180	24			273
1,024	45	750	24	180	24	1		274
2,618	45	750	24	180	24	1,595	*	1,868
2,619	45	750	24	180	24	1,595	1*	1,869
5,478	45	750	24	180	24	1,595	2,860**	4,728

* Water surface upstream of dam is at elevation 162.0
** Water Surface upstream of dam is at elevation 163.0, producing uncontrolled flow over the spillway.
*** The fish bypass flow is assumed to be prioritized over flow through the screens.

An alternate scenario would be to have a canal diversion flow of up to 375 cfs (similar to the existing canal diversion flow). Table 4-2 below shows flow scenario similar to Table 4-1 above, but the flow into the canal is up to 375 cfs.

Table 4-2 Flow Allocation, 375 cfs Canal Flow

River Flow Upstream	Ladder	Canal	Canal Fish Bypass	Auxiliary Water	Auxiliary Water Fish Bypass	Crest Gate	Spillway	River Flow Downstream
45	45							45
70	45	1	24					69
444	45	375	24					69
469	45	375	24	1	24			94
648	45	375	24	180	24			273
649	45	375	24	180	24	1		274
2,243	45	375	24	180	24	1,595	*	1,868
2,244	45	375	24	180	24	1,595	1*	1,869
5,103	45	375	24	180	24	1,595	2,860**	4,728

* Water surface upstream of dam is at elevation 162.0
** Water Surface upstream of dam is at elevation 163.0

For both the operating cases shown in Tables 4-1 and 4-2, flows released downstream of the dam are the same for river flows approaching the dam of 1,023 cfs and above. In estimating the effects on fish moving upstream to the VFDD, the difference between the two cases is limited to the amount of time that approaching river flow is less than 1,023 cfs. Other flow control scenarios are possible as well.

4.2 CANAL FLOW OPERATIONS

During operations at the VFDD, turning water into the canal depends on the suspended sediment load in the river flow. The turbidity of the water is analyzed, and, if the turbidity is acceptable, the flow is turned into the canal. In general, the sediment load approaching the dam is higher when:

- The river flow is high,
- The flow is on the rising limb of the hydrograph, and
- The event is at the beginning of the high-flow season.

The procedure for turning water into or out of the canal would be accomplished as described below.

4.2.1 Turn In

Once the decision is made to turn water into the canal, the following steps would be performed.

1. Flush sediment from in front of the intake, if required, to reduce the sediment load into the canal. See Section 4.3 below.
2. Set up the evaluation station to admit the screen bypass flow to capture fish or pass them through to the river, as desired.

3. Open the three southern canal gates to admit water into the canal fish screen area.
4. When the water is at the proper level in the fish screen facility, activate the automatic weir bypass gate to send bypass flows to the evaluation station
5. Open the two head gates downstream of the fish screen and adjust the gates to achieve the proper flow into the canal and the proper water level in the fish screen structure.
6. Start the auxiliary water system by opening the AWS canal gate, opening the bypass weir gate and opening the AWS supply gate.
7. During operation, the crest gate, the head gates, and the auxiliary water gate would work together to maintain the water level in the forebay at elevation 161.0. This would be done by the PLC located in the control building.

4.2.2 Turn Out

When the river turbidity and sediment concentration in the river increases to the point that the flow into the canal must be stopped, the following procedure would be used.

1. Start closing the canal gates for the canal flow.
2. Close the head gates to maintain an operating water level in the screening facility.
3. Activate the service water pump to provide water to the evaluation station holding tanks, if fish are to be maintained in the evaluation station.
4. Open the head gates slightly to drain the fish screen area. Personnel would be standing by to salvage fish in front of the screen and area up to the canal gates.
5. After the fish screen area has been drained, close the head gates.

4.3 FLUSHING OPERATION

The roller gate and flushing channel would be used for keeping the area in front of the trash rack and fish ladder exit free of sediment. The water level control upstream of the dam would not be controlled by the roller gate. When sediment needs to be removed upstream of the trash rack and fish ladder exit, the following procedure would be used to remove the sediment.

1. Close fishway as described in Section 4.6.4.1.
2. Open the roller gate. Depending on the flow in the river, the water surface in the flushing channel could fall below the sill of the trash rack and fish ladder exit. For upstream water levels below the dam crest, the flow under the roller gate will become free surface during the flushing operation. This is due to the slope of the flushing channel. The maximum flow for maintaining an upstream water surface elevation of 162.0 would be about 1,900 cfs.
3. After flushing is complete, close the roller gate.
4. Place the fishway back into operation. See Section 4.6.4.2.

Sediment is also deposited downstream from the trash rack through the fish screen structures. Removing sediment in this area is discussed in later sections.

4.4 TRASH RACK

The new trash rack will be cleaned by using an automatic rake system similar to the existing Duperon trash rake and debris will be carted away. Maintenance of the trash rake will be according to the manufacturer’s requirements.

4.5 CREST GATE

The crest gate is operated automatically with the dead gates and auxiliary water gate to maintain an upstream water surface elevation of 161.0. It is easier to control the water level with a weir gate than with the roller gate in the sluice channel. The crest gate will have to work together with head gates for the canal and the auxiliary water gate to effectively provide the required flows downstream and to maintain the upstream water level.

The control of the gate is by the compressor, which maintains the inflation of the bladder to control the height of the steel gate panels. The compressor is actuated by the PLC, which accepts input from the water level sensor located in the forebay.

4.6 FISH LADDER

4.6.1 Entrance and Auxiliary Water

There are four entrances to the fish ladder. Two are located to attract fish from the pool over the flushing channel apron on the north side of the entrance pool. These gates will provide a flow to attract fish from the spillway area. Two other entrance gates are located on the west side of the entrance pool. These would attract fish from the pool downstream of the entrance pool. Fish would be expected to hold here during flushing operations and during higher discharges from the crest gate and during higher flows when there is an uncontrolled discharge over the dam. The operation of the gates to best attract fish to the ladder would be first predicted in a CFD model. The fishway entrance gates would be opened and closed to best attract fish after the project is in operation.

Minimum flow requires delivering 45 cfs downstream. This would be done through the fish ladder, about 32 cfs, and fish bypass flow in the AWS screens or the canal screens, about 13 cfs, while maintaining the forebay water surface elevation at 161.0. In this case one entrance gate would be open 2.7 feet. Any of the four gates could be operated to provide the best fish attraction.

Under maximum flow conditions of about 1,800 cfs in the river upstream of the dam, while maintaining the forebay water level at elevation 161.0, the flow in the ladder would be about 32 cfs and the auxiliary water flow would be 180 cfs. Under these conditions two entrance gates would be in operation with the gates fully open and 1-foot of head differential across the gates.

4.6.2 Fish Counting

The turbidity in the river greatly limits the ability to see through the water. Therefore, the usual video and VAKI Riverwatcher counting systems will not accurately count fish. A false weir system will be used to bring fish to or above the water surface to expose the fish for counting. Fish going over the false weir will be sensed by a light system. When a fish is detected over the weir, a camera will be activated to take a video of the fish. This system is used presently and has been found to be effective.

The false weir and fish counter would be placed in the ladder west of the entrance. It would be easily accessed from the ground outside the ladder. About 6 cfs would be brought through a pipe from the upstream ladder pool to operate the false weir. The remaining flow in the ladder would be channeled beside the false weir and brought back into the ladder channel through a picket lead, which would also guide adult fish to the false weir. Flow velocities through the picket lead would be from 1.0 to 1.5 fps.

4.6.3 Fish Ladder Exit

The last ladder pool is upstream of the fish counter. Above this is the transport channel, which leads to the fishway exit. When nearing the exit, the fish will encounter the exit gate, then the trash rack before entering the flushing channel just west of the main trash rack. The exit channel invert is 3 feet above the flushing channel to exclude bed load sediment from entering the fish transport channel and ladder. The exit gate will remain open during fishway operation. The trash rack at the ladder exit will be cleaned by a mechanical trash rake activated manually or by a timer.

4.6.4 Maintenance

The fishway and trash rack are to be inspected once per year. This requires dewatering the fishway by a procedure described below. The Duperon trash rake and gates would be maintained according to the manufacturer's requirements.

4.6.4.1 Fishway Dewatering

Maintenance of the fishway is required once per year and would take place when adult steelhead are not anticipated to be present in the river. At times during the high flow season sediment accumulates in front of the fishway exit and canal intake trash rack. During these times the fishway must be dewatered for annual maintenance. The procedure for dewatering the fishway is as follows:

1. Close the auxiliary water gate.
2. Close the fishway exit gate slowly. As flow decreases in the ladder, personnel would monitor the transport channel and fish ladder to make sure that fish are not stranded and adjust the closure speed to allow fish to travel downstream.
3. As the exit gate is being closed, close the transport channel gate located at the fish counting station at the same time. The goal is to have a fully watered transport channel after both gates are closed.
4. After all fish have moved to the entrance pool, close the entrance gates.
5. Pump water out of the entrance pool using a portable pump and salvage remaining fish from the entrance pool.

Removing sediment from in front of the fishway exit and canal intake requires opening the roller gate and accelerating the flow down the flushing channel. During this time the water level at the fishway exit will be lowered, and operating the fishway to meet criteria requirements is not possible. The flushing operation takes about two hours. During flushing operations the procedure for dewatering the fishway is similar, except salvage operations in the entrance pool are not required. Shutting down the fishway would be done prior to opening the roller gate for flushing operations. The procedure is as follows:

1. Close the auxiliary water gate.
2. Close the fishway exit gate slowly. As flow decreases in the ladder, personnel would monitor the fish ladder to make sure that fish are not stranded and adjust the closure to allow fish to travel downstream.
3. As the exit gate is being closed close the transport channel gate located at the fish counting station at the same time. The goal is to have a fully watered transport channel after both gates are closed.
4. After all fish have moved to the entrance pool, close the entrance gates. At this point the only part of the fishway that is dewatered is the vertical slot ladder section, and fish can hold in the entrance pool and the transport channel.

4.6.4.2 Fishway Startup

After the fishway has been dewatered the following procedure would be used to put it back into operation:

1. Open the entrance gates as required to accommodate the desired flow.
2. Open the exit gate slowly.
3. At the same time open the transport channel gate to resume flow in the fish ladder.
4. Open the auxiliary water gate to the desired setting.

4.7 AUXILIARY WATER SYSTEM

The operation and maintenance requirements are described from upstream to downstream.

4.7.1 Trash Rack

The new trash rack will not have to pass upstream migrating fish. Therefore, it will have uniform bar spacing. This spacing can be smaller than the present spacing. It will be cleaned with a Duperon trash rake similar to the existing rake. The trash rake will be operated by manual push button, on a timer, or from the PLC triggered by a high head differential across the trash rack. At maximum diversion of auxiliary water and canal flow, the velocity of approach to the trash rack would be about 2.5 fps.

4.7.2 Canal Gate

The AWS canal gate provides flow to the auxiliary water screening facility. This flow consists of 24 cfs fish bypass flow and from 0 to 180 cfs AWS flow. This gate is meant to shut off the AWS screening facility and auxiliary water system. The flow in the AWS is controlled by the AWS water gate located at the end of the AWS pipe near the entrance pool.

4.7.3 Fish Screen

4.7.3.1 Fish Screen Cleaning

The AWS water is screened by two screens. Of the 180 cfs auxiliary water, 132 cfs passes through the primary screens and 48 cfs passes through the secondary screens. An additional 24 cfs passes by all the screens and carries the fish to the bypass.

The AWS water flows evenly through the fish screens. The baffles behind both the primary and secondary fish screens consist of perforated plates with a fixed open area of about 6 percent of the total screen area. This provides an even drop across the baffles of about 1 foot. The high head drop evenly distributes the flow through the screens and baffles. The AWS water then travels through the AWS pipe to the AWS gate near the entrance pool. The gate is automatically adjusted to maintain a set AWS flow into the entrance pool.

The primary fish screen is cleaned with a brush cleaner that is attached to a trolley that moves the length of the screen to sweep the debris to the entrance of the secondary screen section. The main mechanism for cleaning the screens is by the back eddy behind the brush, which lifts debris off the screens and into the transport flow to be carried downstream. The brush cleaner is activated by manual push button, a timer, or by the water level differential across the fish screens. High head differential indicates a clogged condition on the screens.

The secondary fish screens and finishing screens are cleaned by a water backwash system. A pump behind the primary screens pumps water at about 80 psi and delivers the high pressure water to nozzles located behind the screens. The back spray lifts the debris off the screens and into the flow passing by the screens and to the bypass. The transport velocity of flow by the screens of 3 fps carries the debris to the bypass.

4.7.3.2 Sediment Cleaning System

The pumps located behind the fish screens used to clean the secondary screens would also have the capacity to supply high pressure water (100 psig) to nozzles located at the base of the fish screens. The nozzles would discharge high-velocity jets over the floor of the areas in front of and behind the fish screens. These jets would lift up sediment settled on the floor into the water column. The sediment would be carried away into the screened AWS water. The water jets would be directed in front of and behind the screens. This system has been used in fish screening systems located in other high sediment rivers.

4.7.4 Fish Return

At the end of the secondary screen is a weir gate with a flume attached. The weir would be automatically raised and lowered to maintain the 24 cfs bypass flow over a range of water levels in the screen area. The flow is further reduced to 4.4 cfs by finishing screens. Downstream of the secondary screen bypass a transition section would transition from to the finishing screen section. From the finishing screen the primary channel will transition to a fish return pipe routed back to the river. If sampling is required the flowline channel can be changed to route flow to the evaluation station. The fish return pipe would be about partially full to allow floating debris to pass more easily, and the water would be traveling at about 10-12 fps.

4.7.5 Evaluation Station

An evaluation station would serve both the AWS screens and the canal screens. Flow from each screen enters into separate holding ponds that contain screens to retain fish. Continuous screening will allow for the debris to be removed from the water. The screened water would be returned to the fish return pipe. When it is desired to mark fish, the operators would crowd the fish to the end of the tank and manually remove them. The fish would then be moved to a holding tank and a free standing recovery tank after handling. After recovery, they would be released into the bypass flow.

4.7.6 Bypass Outlet

The bypass pipe from the evaluation station would return the fish to the pool located immediately west of the entrance pool. The bypass pipe would be about partially full and the water would be traveling at about 10-12 fps. The fish would fall a maximum of about 8 feet and would enter the pool about 12 feet from the fishway entrances.

4.8 CANAL FACILITIES

4.8.1 Trash Rack and Trash Rake

About 978 cfs would pass through the trash rack and to the canal. This flow consists of 750 cfs for the canal180 cfs for the ladder AWS flow and 24 cfs for the two screen fish bypasses. The approach velocity to the trash rack would be about 2.5 fps including AWS flow. The trash rack openings would be modified to be more efficient at collecting debris, since adult fish do not have to pass through the trash rack.

4.8.2 Canal Gates

There would be three identical canal gates, one existing gate and two new gates. These would be opened to accept the flow from the river. The flow to the canal would be regulated by the head gates located downstream of the canal fish screening facility. The gates are centered on the fish screen to deliver flow straight down the fish screen axis. This provides the necessary hydraulics for evenly distributing the flow through the screens.

4.8.3 Fish Screen

Like the AWS fish screens, the canal screens contain primary and secondary screens. The primary fish screen is shaped in a Vee configuration, with screens located on both sides of the Vee. About 702 cfs pass through the primary screens with an approach velocity of 0.33 fps. Approximately 72 cfs passes the primary screen into the secondary screens where 48 cfs is screened. The remaining 24 cfs passes into the bypass.

The screens are cleaned by brushes like those used in the AWS screens. See Section 4.7.3.1.

Sediment in front of and behind the screens would be lifted into suspension by water jets and carried downstream in the canal. This is the same system employed in the AWS screen facility. See Section 4.7.3.2 for a description of the sediment suspension system.

4.8.4 Fish Return

The bypass for the canal screen facilities is the same as that described above for the AWS screen system. See Section 4.6.3.

4.8.5 Evaluation Station

See Section 4.7.5

4.8.6 Bypass Outlet

This is the same pipe containing the AWS bypass flow. See section 4.7.6 above.

5.0 COST OPINION

An Opinion of Probable Construction Cost (OPCC) was prepared for the work to implement the new facilities described herein. The Total Estimated Cost is $31M including the new ladder, crest gate and new and enlarged canal screens. A summary of cost per major feature is given in Table 5-1.

Table 5-1 OPCC Summary for New Fish Ladder and Canal Facilities

Item	Description	Value
1	General Items/Temporary Works	$540,000
2	Access Road and Sitework	$573,000
3	Care of Water	$1,296,000
4	Crest Gate and Dam Modifications	$1,364,000
5	Fish Ladder Structure	$6,924,000
6	Canal and AWS Screens & Channel	$16,665,000
7	Electrical and Instrumentation	$3,760,000
	Total Estimated Point Value	**$31,122,000**
	Estimated Market Range	**$23M - $39M**
	Mid Point Market Range	**$31M**
	Suggested Project Budget	**$31M**

Additional OPCC details can be found in Appendix A. Please note the following limitations and basis notes:

- Costs are presented in 2018 dollars.
- The current 12-month price index is 137.0 as published in the California Department of Transportation, Price Index for Selected Highway Construction Items, First Quarter ending March 31, 2018.
- No out-year price escalation has been included.
- No indirect costs for administration, engineering, environmental or geotechnical studies are included.

Estimates are based on the information presented consistent with an AACE International Class 4 Cost Estimate. Class 4 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. Typically, engineering is 10%- 40% complete. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Virtually all Class 4 estimates use stochastic estimating methods such as cost curves, capacity factors, and other parametric and modeling techniques. Expected accuracy ranges are from –15% to –30% on the low side and +20% to 50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. As little as 20 hours or less to perhaps more than 300 hours may be spent preparing the estimate depending on the project and estimating methodology (AACE International Recommended Practices and Standards).

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6.0 CONCLUSIONS

6.1 ATTRIBUTES

6.1.1 Meets Fishery Agency Criteria

The proposed fish ladder and fish screens meet all NMFS and CDFW criteria for these types of facilities. The proposed facilities have been built and operated successfully for salmonids in other locations in the western United States.

6.1.2 Operations and Maintenance

All the facilities are located on the left bank of the Santa Clara River at the existing diversion structure. This area has excellent access. This means that facility problems can be repaired quickly without having to wait for flows in the river to subside. This is a benefit to the fish resource, since it means that facility problems affecting the fish can be repaired sooner. The only feature that cannot be accessed during high flows is the Obermeyer inflatable bladder and the steel plates that it supports. These would have to be accessed from downstream during low flows.

6.1.3 Allows for Fish Capture and Evaluation

Fish biologists have many questions about endangered fish, while trying to recover their populations. The proposed facilities allows them to have access to the fish. Both upstream and downstream migrants can be captured and evaluated in the proposed facilities. This allows tagging of fish for population and migration studies. For example, one of the questions is: What is the population of rainbow trout that out-migrates and become steelhead. Capturing downstream migrants allows inspection to see whether they are smolting for migration to salt water or they are resident rainbow trout.

6.2 EXPANDABILITY

UWCD has proposed a fish facility design flow of 1800 cfs. The proposed facilities can be operated with 180 cfs for AWS flow and about 32 cfs ladder flow to attract fish to the entrance. This flow for fish attraction is about 12 percent of the river design flow. If it is determined that a larger attraction flow is required, then the facilities can be expanded to accommodate higher AWS flows. For example, an AWS flow of 360 cfs, double the proposed flow, would require the expanding the following facilities:

- Intake Facility – Increasing the trash rack size would become necessary to reduce the approach velocity to the trash rack necessary to reduce the head loss at the trash rack and provide for easier cleaning. The south wall of the channel from the canal gates to the trash rack would be widened. This widens the trash rack and the channel between the trash rack and canal gates.
- The existing northern canal gate might have to be replaced with a larger one to accept the doubled AWS flow with a reduced head loss across the canal gates.
- The width of the AWS fish screen approach channel would have to be doubled, and the primary fish screen length would be increased from 53 feet to 141 feet. The secondary screens would remain the same, and all of the increased flow would be screened in the primary screens. There is enough room at the existing location to accommodate the increased size of the screen facility.

6.3 PHYSICAL CHALLENGES

There are many challenges to be addressed in the design of fish facilities at the VFDD including sediment and floating debris comprised mainly of large debris at the trash racks and algae within the system at the screens.

6.3.1 Sediment

Sediment has been a major issue encountered in operating the VFDD diversion. The suspended sediment load has caused problems counting fish due to turbidity and depositing sediment in the intake channel. A fish counter has been proposed to get the fish out of the water to identify it by video. Later review of the video by personnel will provide a good count of steelhead and other species. A sediment re-suspension system has been incorporated in the fish screening structures to re-suspend sediment in the water column, where it will move downstream with the flow. In the AWS the sediment would be carried downstream through the entrance pool and back to the river. In the canal screening facility, the re-suspended sediment would travel downstream in the canal.

6.3.2 Algae

At times algae has been a problem at the existing fish screens. The present reciprocating multi-brush system tends to move the material back and forth across the screen. We have found that debris on the screens is better removed by a single brush that travels the length of the screen and back again. This type of screen cleaner has an eddy behind the brush as it moves. This eddy forms a flow back through the screens, which tends to lift debris out into the sweeping flow. The debris then moves with the flow to the bypass. The debris is then moved back to the river in the bypass pipe. If capturing fish is desired, the debris must be removed in the evaluation station. The rotating drum or traveling screens in the evaluation station will remove the debris from the water. The water level difference across fish screens will be measured. If the difference is larger than a value set into the PLC, the screen cleaner will be activated. If the difference reaches a higher set point an alarm will be sent to maintenance personnel. If the difference reaches a critical set point the canal gates will be shut to prevent damage to the screens. This logic will be operated by the PLC.

Another possible solution to this problem is to use vertical screens in the primary and secondary screen area. Algae pinned to the screens will travel up and over the screens and into the screened water flow. The algae will then be carried downstream in the canal or AWS.

6.4 POSSIBLE CHALLENGES FROM AGENCIES

6.4.1 Fishway Exit

In the proposed fishway, the fish would exit into the flushing channel and adjacent to the trash rack. Possible objections raised by fish agencies might be:

- Fish fall back in the flushing channel - This issue is negated by restricting flushing channel activation to sediment removal maintenance and closing the fish ladder while it is being done.
- Fall back through the trash rack – The approach velocity at the trash rack is low, a maximum of 2.5 fps, and the trash rack bars will be smaller restricting adult fish from traveling through them.
- Fall back over the crest gate – The crest gate will cut a channel upstream and probably adjacent to the guide wall for the approach channel. Fish could fall back over the crest gate. The fish would travel up the flushing channel and exit it 200 feet upstream of the crest gate. There would be no appreciable flow to the

crest until the river flow reached 2,000 cfs. It would be good to perform an evaluation to estimate the flow velocity in the channel formed upstream of the crest gate to estimate the flow velocity, where the fish exit the flushing channel.

- Juvenile downstream passage – Within the stated design flows downstream migrating fish including both fry and smolt will have several paths that they could take. Juvenile protection has been considered in all paths. Entrainment to the fish ladder exit will pass fish down through the ladder without encountering any racks or gates. Entrainment through the trash rack to the AWS or Canal screens are designed for fry protection with bypass systems and monitoring facilities. The crest gate and dam have been modified to improve passage for juveniles over the crest gate. The spillway cap and stilling basin modifications are provided to reduce contact injury and concentrate flow to pass fish in a greater depth.

6.4.2 Attraction Flow

The fishery agencies have been asking for maximum flow in the fish passage route(s). We anticipate this will continue. The fish ladder can be operated in flows higher than 1,800 cfs. The AWS canal gate would be opened and the flow in the ladder would be about 55 cfs. Fish can still transit the ladder in these conditions. Under the proposed facilities and mode of operation, there will be a larger holding pool formed at the fishway entrance and at the downstream end of the flushing channel apron.

6.4.3 Fish Attraction from the Stilling Basin Area

After higher flows and uncontrolled flow over the spillway, fish might be trapped in the pool formed in the stilling basin. The design includes an access from the stilling basin to the entrance pool by extending the stilling basin below the crest gate. The floor is at the same elevation as the flushing channel apron and entrance pool floor. This allows flow from the two north entrance gates to project into the stilling basin to attract fish holding in the stilling basin at lower flows.

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7.0 REFERENCES

NMFS Northwest Region, *Anadromous Salmonid Passage Facility Design*, July 2011

NMFS Southwest Region, *Fish Screening Criteria for Anadromous Salmonids*, January 1997

Northwest Hydraulic Consultants, *Sediment Transport and Deposition Assessment of the Freeman Diversion Conveyance System*, January 7, 2015

Vern Freeman Dam Fish Passage Panel, *Vern Freeman Dam Fish Passage Conceptual Design Report*, Final, September 15, 2010

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Appendix A OPINION OF CONSTRUCTION COST (OPCC)

Stantec Consulting | **JL/KC**
Walnut Creek | 7/20/2018

United Water Conservation District (UWCD)
Vern Freeman Diversion Dam, Fish Ladder Feasibility Study
Left Bank Fish Ladder and Expanded Juvenile Screens
(<10% Design)

Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-MARCH 2018 Dollar

Estimated Point Value:	**$31,000,000**	
Estimated Market Range:	**$23M-$39M**	
Mid Point Market Range:	**$31M**	
Suggested Project Budget:	**$31M**	*Pending inclusion of excluded items*

Proj #	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Final Item Total
		LEFT BANK FISH LADDER AND EXPANDED JUVENILE SCREENS	1	LS	$17,515,670	$17,515,670		*$31,122,000*
1.00		GENERAL ITEMS/TEMPORARY WORKS	1	ls	$304,000	$304,000		$540,000
1.01	P	Mobilization and Demobilization	1	ls	$0	see below		
1.02	P	Environmental Protection and Erosion Control	1	ls	$100,000	$100,000		
1.03	P	Temporary Facilities & Field Oversight Staffing	1	ls	$0	see below		
1.04	P	Temporary Utilities	1	ls	$0	see below		
1.05	P	Owner's Field Office	18	mos	$3,000	$54,000	18 months	
1.06	P	Temporary Works	1	ls	$150,000	$150,000		
2.00		ACCESS ROAD AND SITEWORK	1	ls	$322,546	$322,546		$573,000
2.01	P	Grade Access Road and Parking	112,000	sf	$2	$224,000	yard to site 8000 ft x 14ft	
2.02	P	Temporary Crossing Protection	4	ea	$10,000	$40,000	Allowance for placement of fill for crossings	
2.03	P	Develop Construction Access to River US/DS Of Div	1	ls	$25,000	$25,000	Allowance	
2.04	P	Site Fence	800	lf	$23	$18,546	Replace south fence assumption	
2.05	P	Base Rock and Gravel Access Road at Completion	1,000	cys	$15	$15,000	gravel, spread, grade and roll top course	
3.00		CARE OF WATER	1	ls	$729,500	$729,500		$1,296,000
3.01	P	Upstream Diversion (Supersack)	140	cys	$275	$38,500	single row supersack	
3.02	P	Dam Mod Diversion (Sheet Pile R&R)	2,640	sf	$75	$198,000	sheetpile, 80 ft 163' to 130' siltstone	
3.03	P	Downstream Isolation (Supersack)	120	sf	$275	$33,000	single row supersack	
3.04	P	Diversion of River Around Work	1	ls	$50,000	$50,000		
3.05	P	Groundwater Pumping	12	mo	$30,000	$360,000	$1k/dy incl tender, moderate inflow	
3.06	P	Water Quality/Sediment Removal for Dewatering	1	ls	$50,000	$50,000		
4.00		CREST GATE	1	ls	$767,554	$767,554		$1,364,000
4.01	S	Demolition RCC and Reinforced Concrete	141	cys	$300	$42,300	ysp	
4.02	S	Excavation (Common)	210	cys	$20	$4,200	ysp	
4.03	S	Concrete (CIP, Notch, and Dam Cap)	278	cys	$1,700	$472,614	ysp	
4.04	S	Compressor Building & Supports above Flushing Channel	1	ls	$8,000	$8,000		
4.05	S	Crest Gate (35 ft, 1 system)	210	sf	$700	$147,000	ysp	
4.06	S	Compressor Building Strucural/Mech above Flushing Channel	144	sf	$260	$37,440	ysp	
4.07	S	Air Pipe SST	100	lf	$160	$16,000	3ea*120ft @ ysp u/p	
4.08	S	Mechanical Installation	1	ls	$40,000	$40,000		
5.00		FISH LADDER STRUCTURE	1	ls	$3,896,938	$3,896,938		$6,924,000
5.01		Demolition	1	ls	$121,800	$121,800		$216,000
5.01.01		Structure Demolition	531	cys	$150			
5.01.01.01	*P*	*CIP Concrete*	*342*	*cys*	*$150*	*$51,300*		
5.01.01.02	**P**	*RCC*	*189*	*cys*	*$150*	*$28,350*		
5.01.02		Demolition-Mech	1	ls	$5,000		allowance	
5.01.02.01	*P*	*Remove 30-inch HDPE Pipe*	*200*	*lf*	*$150*	*$30,000*		
5.01.02.02	*P*	*Remove 54-inch concrete pipe*	*45*	*lf*	*$270*	*$12,150*		
5.02		Excavation & Backfill	1	ls	$503,104	$503,104		$894,000
5.02.01	P	Rip Rap Removal	1,112	cys	$25	$27,800	Remove eisting rip rap, store it to be placed back	
5.02.02	P	Common Excavation	10,473	cys	$15	$157,095		
5.02.03	P	River Sediment Removal	2,658	cys	$25	$66,450		
5.02.04	*P*	Backfill Structural	2,095	tns	$40	$83,784		
5.02.05	*P*	Backfill - Rip Rap	2,224	tns	$35	$77,840	Place reused rip rap; same quantity as removed	
5.02.06	*P*	Slab-On-Grade Foundation Prep (No Rock)	698	sy	$20	$13,960		
5.02.07	*P*	Aggregate Base Foundation	349	cys	$75	$26,175	Crushed rock under slab	
5.02.08	*P*	Slab Anchors Allowance	1	ls	$50,000	$50,000	allowance	
5.03		CIP Concrete	1	ls	$2,248,828	$2,248,828		$3,996,000
5.03.01		Slab-On-Grade	364	cys	$727			
5.03.01.01	*P*	*Pools 1-22*	*198*	*cys*	*$727*	*$143,946*	Reinforced concrete slab on grade; 8 ft wide	
5.03.01.02	*P*	*Transport Channel (Pool 23)*	*38*	*cys*	*$727*	*$27,626*	Reinforced concrete slab on grade; 3 ft wide + transition	
5.03.01.03	*P*	*Entrance Pool*	*113*	*cys*	*$727*	*$82,151*	Reinforced concrete slab on grade; 40 ft N-S	
5.03.01.04	*P*	*Energy Dissipation Pool*	*15*	*cys*	*$727*	*$10,905*	Reinforced concrete slab on grade; 8 ftE-W	
5.03.02		Walls	1,616	cys	$1,200			
5.03.02.01	*P*	*Ladder*	*755*	*cys*	*$1,200*	*$906,000*		
5.03.02.02	*P*	*Entrance Pool*	*652*	*cys*	*$1,200*	*$782,400*		
5.03.02.03	*P*	*Ladder Baffles*	*99*	*cys*	*$1,200*	*$118,800*	Reinforced Concrete walls; intricate forming	
5.03.02.04	*P*	*Transport Channel*	*110*	*cys*	*$1,200*	*$132,000*	Reinforced Concrete walls; includes transition and exit walls	
5.03.03		Elevated Slabs	30	cys	$1,500			
5.03.03.01	*P*	*Entrance Pool Energy Dissipation Chamber Elevated Slab*	*30*	*cys*	*$1,500*	*$45,000*	Slab under ladder & over entrance pool and dissipation pool	
5.04		Structural Metals	1	ls	$149,276	$149,276		$265,000
5.04.01	P	Grating	528	sf	$92	$48,576		
5.04.02	P	Handrail/Guardrail	390	lf	$130	$50,700		
5.04.03	*P*	Miscellaneous Metals Guides/Embeds	1	ls	$50,000	$50,000		
5.05		Miscellaneous	1	ls	$873,930	$873,930		$1,553,000
5.05.01	S	False Weir & Counting Equipment	1	ls	$20,000	$20,000		
5.05.02	S	AWS Diffuser Panel	192	sf	$100	$19,200		
5.05.03	S	AWS Diffuser Baffles	192	sf	$100	$19,200		
5.05.04	S	AWS Gate	25	sf	$3,750	$93,750		
5.05.05	S	Fish Entrance Gates (4ea - 3'x6')	72	sf	$3,750	$270,000	3 ft by 6 ft sluice gates; 35 foot head sluice gates	
5.05.06	S	False Weir, Camera System, & Shade Roof	1	ls	$35,000	$35,000	15 inch pipe, 15 inch valv, false weir, picket lead	
5.05.07	S	Fish Exit Cut Into Existing Wall	150	sf	$50	$7,500		
5.05.08	S	Exit Gate	24	sf	$3,750	$90,000	3 ft by 8 ft high 30 foot sluice gate	
5.05.09	S	60" Valve	1	ea	$30,000	$30,000	60" knife gate valve with 30' ext. & electric multiturn actuator and controls	
5.05.10	S	Trashracks at U/S End of Fish Ladder	144	sf	$620	$89,280		
5.05.11	S	Installation Crew	50	days	$4,000	$200,000		
6.00		CANAL & AWS SCREENS & CHANNELS	1	ls	$9,378,762	$9,378,762		$16,665,000
6.01		Demolition	1	ls	$49,000	$49,000		$87,000
6.01.01	P	Demolition - Structural	260	cys	$150	$39,000	Both sides of existing canal including fish screens	
6.01.02	P	Demolition - Mechanical	1	ls	$10,000	$10,000		
6.02		Excavation & Backfill	1	ls	$221,880	$221,880		$394,000
6.02.01	P	Slope Excavation & Cut (Common, Access Ramp)	4,800	cys	$15	$72,000	Remove from south of existing canal gates and store	
6.02.02	P	Slope Excavation & Access Fill	4,800	cys	$15	$72,000	Bring back fill and compact against new wall & re-shape access road	
6.02.03	P	Excavation (Common, North of Screens)	1,280	cys	$15	$19,200	Dirt and previous backfill	
6.02.04	P	Excavation (Common, South of Screens)	1,414	cys	$15	$21,210		
6.02.05	P	Excavation (Rock)	-	cys	$25	$0		
6.02.06	P	Backfill Structural	749	cys	$50	$37,470		
6.03		CIP Concrete	1	ls	$1,638,652	$1,638,652		$2,912,000
6.03.01		Canal Screens	1	ls	$1,047,999			
6.03.01.01	*P*	*Headwall*	*34*	*cys*	*$1,000*	*$34,000*		
6.03.01.02	*P*	*Prepare Slab to Meet Future Slab*	*1*	*ls*	*$5,000*	*$5,000*		
6.03.01.03	*P*	*Slab-On-Grade*	*237*	*cys*	*$727*	*$172,299*	Additional slab added to existing slab, includes Fin Screen	

Stantec Consulting JL/KC
Walnut Creek 7/20/2018

United Water Conservation District (UWCD)
Vern Freeman Diversion Dam, Fish Ladder Feasibility Study
Left Bank Fish Ladder and Expanded Juvenile Screens
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Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-MARCH 2018 Dollar

					Estimated Point Value:	$31,000,000		
					Estimated Market Range:	$23M-$39M		
					Mid Point Market Range:	$31M		
6.03.01.04	*P*	*Walls*	*313*	*cys*	*$1,200*	*$375,600*	from canal gates to head gates both sides, includes Fin Screen	
6.03.01.05	*P*	*Canal Sill*	*13*	*cys*	*$1,500*	*$19,500*		
6.03.01.06	*P*	*Pillars*	*38*	*cys*	*$1,200*	*$45,600*		
6.03.01.07	*P*	*Walls, South*	*330*	*cys*	*$1,200*	*$396,000*		
6.03.02		**AWS Screens**	**1**	**ls**	**$230,653**			
6.03.02.01	*P*	*Slab-On-Grade*	*139*	*cys*	*$727*	*$101,053*	*, includes Fin Screen*	
6.03.02.02	*P*	*Walls*	*98*	*cys*	*$1,200*	*$117,600*	*, includes Fin Screen*	
6.03.02.03	*P*	*AWS Sill*	*2*	*cys*	*$1,500*	*$3,000*		
6.03.02.04	*P*	*PIllars*	*6*	*cys*	*$1,500*	*$9,000*		
6.03.03		**Trap Building**	**1**	**ls**	**$360,000**			
6.03.03.01	*P*	*Slab-On-Grade*	*600*	*cys*	*$600*	*$360,000*		
6.04		**Structural Metals**	**1**	**ls**	**$877,680**	**$877,680**		**$1,559,000**
6.04.01		**Canal Screens**	**1**	**ls**	**$733,322**	**$733,322**		
6.04.01.01	*P*	*Grating & Supports*	*6,816*	*sf*	*$92*	*$627,072*	Grating deck including supports between piers on the fish screen	
6.04.01.02	*P*	*Handrail/Guardrail*	*625*	*lf*	*$130*	*$81,250*		
6.04.01.03	*P*	*Miscellaneous Metals Guides/Embeds*	*1*	*ls*	*$25,000*	*$25,000*		
6.04.02		**AWS Screens**	**1**	**ls**	**$144,358**	**$144,358**		
6.04.02.01	*P*	*Grating & Supports*	*954*	*sf*	*$92*	*$87,768*		
6.04.02.02	*P*	*Handrail/Guardrail*	*243*	*lf*	*$130*	*$31,590*		
6.04.02.03	*P*	*Miscellaneous Metals Guides/Embeds*	*1*	*ls*	*$25,000*	*$25,000*		
6.05		**Mechanical**	**1**	**ls**	**$6,104,950**	**$6,104,950**		**$10,848,000**
6.05.01		**Canal Screens**	**1**	**ls**	**$3,247,500**			
6.05.01.01	*P*	*Primary Canal Fish Screen Material and Headwalls*	*3,984*	*sf*	*$350*	*$1,394,400*		
6.05.01.02	*P*	*Secondary Canal Fish Screen Material and Headwalls*	*144*	*sf*	*$350*	*$50,400*		
6.05.01.03	*P*	*Finishing Screen Material and Headwall Framing*	*66*	*sf*	*$350*	*$23,100*		
6.05.01.04	*P*	*Canal Primary Screen Brush Cleaning System*	*2*	*ea*	*$250,000*	*$500,000*		
6.05.01.05	*P*	*Canal Secondary Screen Brush Cleaning System*	*1*	*ea*	*$150,000*	*$150,000*		
6.05.01.06	*P*	*Canal Weir Gate & Ramp*	*1*	*ea*	*$45,000*	*$45,000*		
6.05.01.07	*P*	*Canal Screen Bypass 36" Reducer Pipe Transition*	*1*	*ea*	*$5,000*	*$5,000*		
6.05.01.08	*P*	*Fish Bypass Pipe (24" HDPE or WSP)*	*200*	*lf*	*$200*	*$40,000*	Includes 90° sweeping bend & 70° sweeping bend	
6.05.01.09	*P*	*60" Spiralweld Steel AWS Pipe*	*60*	*lf*	*$720*	*$43,200*		
6.05.01.10	*P*	*Sediment Drain and Fin Screen Drain (24" WSP)*	*105*	*lf*	*$200*	*$21,000*		
6.05.01.11	*P*	*Screened Water Return, Common Pipe(30" WSP)*	*320*	*lf*	*$220*	*$70,400*		
6.05.01.12	*P*	*Screened Water Return, Valves(24",30",Tideflex-30")*	*3*	*ea*	*$25,000*	*$75,000*	*buried worm gear actuator*	
6.05.01.13	*P*	*Canal Sediment Re-Suspension & Secondary Piping*	*1*	*ls*	*$60,000*	*$60,000*	1000lf 4" emb. pipe, 90° elbow, 200ea nozzles, 6ea 4" act. butterfly valves	
6.05.01.14	*P*	*Canal Sediment Re-Suspension & Secondary Pumps*	*1*	*ls*	*$150,000*	*$150,000*	2 vertical 75hp turbine pumps	
6.05.01.15	*P*	*Canal Gates (2-new 9x8)*	*144*	*sf*	*$3,750*	*$540,000*	Additional Canal gates	
6.05.01.16	*P*	*Installation Crew*	*20*	*days*	*$4,000*	*$80,000*		
6.05.02		**AWS Screens**	**1**	**ls**	**$1,117,450**			
6.05.02.01	*P*	*Primary AWS Fish Screen Material and Headwalls*	*717*	*sf*	*$350*	*$250,950*		
6.05.02.02	*P*	*Secondary AWS Fish Screen Material and Headwalls*	*144*	*sf*	*$350*	*$50,400*		
6.05.02.03	*P*	*Finishing Screen Material and Headwall Framing*	*66*	*sf*	*$350*	*$23,100*		
6.05.02.04	*P*	*Brush Cleaning System Primary Screens*	*1*	*ea*	*$250,000*	*$250,000*		
6.05.02.05	*P*	*Back Spray Cleaning System Secondary Screens*	*1*	*ea*	*$150,000*	*$150,000*		
6.05.02.06	*P*	*AWS Weir Gate & Ramp*	*1*	*ea*	*$45,000*	*$45,000*		
6.05.02.07	*P*	*AWS Screen Bypass 36" Reducer Pipe Transition*	*1*	*ea*	*$5,000*	*$5,000*		
6.05.02.08	*P*	*Fish Bypass Pipe (24" HDPE or WSP)*	*65*	*lf*	*$200*	*$13,000*	*Finish Screen plus Eval Building outlet*	
6.05.02.09	*P*	*Sediment Drain and Fin Screen Drain (24" WSP)*	*75*	*lf*	*$200*	*$15,000*		
6.05.02.10	*P*	*Screened Water Return, Valves(24" ecc plug)*	*1*	*ea*	*$25,000*	*$25,000*	*buried worm gear actuator*	
6.05.02.11	*P*	*AWS Sediment Resuspension System Piping*	*1*	*ls*	*$60,000*	*$60,000*	1000lf 4" emb. pipe, 90° elbow, 200ea nozzles, 6ea 4" act. butterfly valves	
6.05.02.12	*P*	*AWS Sediment Resuspension System Pumps*	*1*	*ls*	*$150,000*	*$150,000*	2 vertical 75hp turbine pumps	
6.05.02.13	*P*	*Installation Crew*	*20*	*days*	*$4,000*	*$80,000*		
6.05.03	**P**	**Trash Rack Replacement**	**6**	**ea**	**$150,000**	**$900,000**		
6.05.04		**Trap Holding Pond**	**1**	**ls**	**$840,000**			
6.05.04.01	*P*	*Trap Holding Pond Swing Gates*	*-*	*ea*	*$77,275*	*$0*	*Removed from Eval Building, now in Finish Scrn*	
6.05.04.02	*P*	*Trap Holding Pond Belt Screens*	*2*	*ea*	*$75,000*	*$150,000*		
6.05.04.03	*P*	*TrapHolding Pond Crowder (hand)*	*2*	*ea*	*$10,000*	*$20,000*		
6.05.04.04	*P*	*Trap Holding Pond Size Sorting Panels*	*2*	*ls*	*$10,000*	*$20,000*		
6.05.04.05	*P*	*Trap Hoppers/Brail*	*2*	*ea*	*$40,000*	*$80,000*		
6.05.04.06	*P*	*Trap Building Hoist System (davit, elec)*	*2*	*ls*	*$25,000*	*$50,000*		
6.05.04.07	*P*	*Loose Tanks, anesthetic, Tabels*	*1*	*ls*	*$40,000*	*$40,000*		
6.05.04.08	*P*	*Sed System-Pumps*	*2*	*ea*	*$75,000*	*$150,000*		
6.05.04.09	*P*	*Sed System-Pipe, Valves, Nozzles, System*	*1*	*ls*	*$250,000*	*$250,000*		
6.05.04.10	*P*	*Installation Crew*	*20*	*days*	*$4,000*	*$80,000*		
6.06		**Miscellaneous**	**1**	**ls**	**$486,600**	**$486,600**		**$865,000**
6.06.01	**S**	**Evaluation Station**	**600**	**sf**	**$250**	**$150,000**	20'x30'	
6.06.02	**S**	**Remove Control Building**	**1**	**ea**	**$12,000**	**$12,000**	existing 20'x30'	
6.06.03	**S**	**Build New Control Building**	**600**	**sf**	**$325**	**$195,000**	20'x30', cmu wall w/ wall and roof insulation	
6.06.04	**S**	**Remove Out Building**	**1**	**ea**	**$9,600**	**$9,600**	20x24=480 sf (exist ~300sf), no domestic water/sewer	
6.06.05	**S**	**Build New Out Bulding**	**480**	**sf**	**$250**	**$120,000**	20x24=480 sf (exist ~300sf), no domestic water/sewer	
7.00		**ELECTRICAL & I&C**	**1**	**ls**	**$2,116,370**	**$2,116,370**		**$3,760,000**
7.01	**S**	**Temporary Power and Control Relocate**	**1**	**ls**	**$50,000**	**$50,000**		
7.02	**S**	**500kW Genset**	**1**	**ea**	**$200,000**	**$200,000**		
7.03	**S**	**Electrical/Instrumentation Installation**	**1**	**ls**	**1,866,370**	**$1,866,370**	25% Mechanical Items	
8.00		**ANCILLARY SUPPORT FACILITIES**	**1**	**ls**	**$0**	**$0**		**$0**
8.01	**S**	**TBD**	**1**	**ls**	**$0**	**$0**	allowance	**$0**
					Running Subtotal:	**$17,515,670**		
A		**Startup/Commission/Owner Training**	1	ls		**$87,578**		
1	P	Pre-Commissioning	584	hrs	$150	**$87,578**		
2	S	Vendor Support	-	ls	$0	**$0**	Covered above	
3	P	Final Commissioning	-	hrs	$150	**$0**	Covered above	
4	P	Owner Training	-	hrs	$100	**$0**	Covered above	
5	P	Startup Expendables	-	ls	$0	**$0**	Covered above	
6		Spare Parts	-	ls	$0	**$0**	Covered above	
					Running Subtotal:	**$17,603,248**		

Stantec Consulting JL/KC
Walnut Creek 7/20/2018

United Water Conservation District (UWCD)
Vern Freeman Diversion Dam, Fish Ladder Feasibility Study
Left Bank Fish Ladder and Expanded Juvenile Screens
(<10% Design)

Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-MARCH 2018 Dollar

					Estimated Point Value:	$31,000,000		
					Estimated Market Range:	$23M-$39M		
					Mid Point Market Range:	$31M		
B		Construction Allowances	1	ls		$131,368		
1	P	Submittals/Procurement/POs/Resource Coordinatioi	1	ls	$0	$0	Covered below	
2	S	Establish Survey Controls	1	ls	$0	$0	Covered below	
3	S	Alignment Layout Survey/Final As-Built	-	hr	$325	$0	Covered below	
4	P	Initial Equipment Mobilizatior	-	lds	$0	$0	Covered below	
5	P	Initial Labor Mobilizatior	1	ls	$0	$0	Covered below	
1	P	Contractor Quality Contro	1	ls	$131,368	$131,368	at .75%	
5	P	Crew / Mgt Perdiems	1	ls	$0	$0	Excluded	
6	P	Labor Overtime	1	ls	$0	$0	"	
7	P	Liquated Damages	1	ls	$0	$0	"	
					Running Subtotal:	**$17,734,616**		
			Markup Factor	1.0125				
6	P	**Estimating Accuracy, Unlisted Items Allowance**	1	ls	5.0%	$886,731	to offset estimating methodology on provided scope	
7	P	**Allowance for Scope Growth**	1	ls	5.0%	$886,731	to offset new undefined new scope	
8	P	**Allowance for Constructability**	1	ls	1.0%	$177,346	to offset undefined constructability issues	
					Running Subtotal:	**$19,685,424**	Direct Construction Costs (DCC)	
			Markup Factor	1.1239				
C		Contractor Markups/Indirect Costs	1	ls		$7,377,641		
1		Prime Contractor General Conditions	1	ls	10.0%	$1,544,097		
2		Subcontractor General Conditions	1	ls	10.0%	$424,500		
3		Market Factor (current market conditions are considered competitive	1	ls	5.0%	$1,082,701	Premium for uncompetitive conditions, complexity, etc	
4		Escalation	1	ls	0.0%	$0	excluded	
5		Construction Phasing Factor (sgl mobe, uninterrupted executioi	1	ls	0.0%	$0	Premium for stages, interface constraints, etc.	
6		Subcontractor Overheads & Markups	1	ls	15%	$636,668	H/O Overheads, Job Fee & Risk	
7		Prime Contractor OH&P on Subs	1	ls	6.5%	$275,890	Oversight + Risk on Subs	
8		Prime Contractor OH&P on Self-Perform	1	ls	10.0%	$2,364,928	Job Fee + Risk	
9		Contractor Insurance Program	1	ls	2.5%	$386,024	Performance/Payments Bonds, Genl Liability	
10		Subcontractor Bonding	1	ls	1.5%	$63,667	Reference Activity Summary for subtotal	
11		State Sales Taxes (CA)	1	ls	8.50%	$585,641		
12		Contractor Furnished Permits	1	ls	0.25%	$13,525	covered above	
					Running Subtotal:	**$27,063,060**	Base Construction Cost (BCC)	
13		Design Scope Market Contingency	1	ls	15.00%	$4,059,460	on running subtotal, unknowns	
					Running Subtotal:	**$31,122,520**	Total Field Cost	*$31,122,000*
				Cost Range:	**$23,000,000**	**$39,000,000**		
			Markup Factor	1.7768				
D		Owner Project Allowances				$0		*$0*
1		Sunk Costs - All	1	ls		$0	Excluded	
2		Construction Change Contingency	1	ls	0.0%	$0	Excluded	
3		Contractor Provide Resident Engineer's Field Office	-	mos	$3,500	$0	Excluded	
4		Land Purchase - Property Value	-	ac	$0	$0	Excluded	
5		Land Purchase - Condemnation Process	1	ls	$0	$0	Excluded	
6		Management Reserve	1	ls	0.0%	$0	Excluded	
			Markup Factor	1.7769				TPC
						$31,123,000	Total Project Costs (TPC)	*$31,122,000*
				Cost Range:	**$23,000,000**	**$39,000,000**	AACEI Criteria	

Assumes the scope is not changed, significant risk events do not occur and project control is excellent.

Notes/Exclusions:

1) Cost estimating team has visited the project site.
2) Any addendum issued to contractors were not available at time of this cost estimate's development.
3) Cost estimate is based on quoted costs for some equipment.
4) Preliminary construction field schedule under development
5) Market Assumption: Desirable local project that should generate contractor interest. (Expecting at least five responsible bidders).
6) Clients are urged to budget towards the high range value pending the final design cost estimate. Suggested construction budget provided above.
7) This OPPC is not intended to be a predictor of lowest bid. Rather the intent is to represent fair market value assuming competitive conditions.
8) Wage decision = CA Prevailing
9) Undefined environmental mitigations/landscaping and slope stability items are excluded.
10) Work areas assumed to be available from 6am to 6pm M-F without constraint to the contractor.
11) P=Prime, S=Subcontractor
12) Unknown outside third party special inspections not included.
13) No escalation included.
14) Pricing assumes competitive market conditions at time of tender (+4 bidders/trade).
15) Assumed contracting strategy: design-bid-build
16) This OPPC is classified as a Class 4 cost estimate per AACE guidelines. Stated accuracy range = -25% to + 25%
17) Pricing level is Q2 2018

OPPC Disclaimer

Stantec has no control over the costs of labor, materials, competitive bidding environments, unidentified field conditions, financial and/or commodity market conditions, or any other factors likely to affect the OPPC of this project, all of which are and will unavoidably remain in a state of change, especially in light of high market volatility attributable to Acts of God and other market forces or events beyond the control of the parties. As such, Client recognizes that this OPPC deliverable is based on normal market conditions, defined by stable resource supply/demand relationships, and does not account for extreme inflationary or deflationary market cycles. Client further acknowledges that this OPPC is a "snapshot in time" and that the reliability of this OPPC will degrade over time. Client agrees that Stantec cannot and does not make any warranty, promise, guarantee or representation, either express or implied that proposals, bids, project construction costs, or cost of O&M functions will not vary significantly from Stantec's good faith **CLASS 4 OPPC**

AACE International CLASS 4 Cost Estimate- Class 4 estimates are generally prepared based on limited information and subsequently have fairly wide accuracy ranges. Typically, engineering is 10% to 40% complete. They are typically used for project screening, determination of feasibility, concept evaluation, and preliminary budget approval. Virtually all Class 4 estimates use stochastic estimating methods such as cost curves, capacity factors, and other parametric and modeling techniques. Expected accuracy ranges are from -15% to -30% on the low side and +20% to 50% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. As little as 20 hours or less to perhaps more than 300 hours may be spent preparing the estimate depending on the project and estimating methodology (AACE International Recommended Practices and Standards).