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Nevada Irrigation District – Hemphill Diversion Structure

Conceptual Design Report
Draft

Revision No. 0

November 2021

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Table of Contents

List of Tables

List of Figures

Appendices

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Revision Log

Revision No.	Date	Revision Description
0	November 2021	Draft Conceptual Design Report

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1.0 Introduction

Section 1 presents a summary of the overall project including authorization, purpose, background, project understanding, and the Conceptual Design Report organization.

1.1 Authorization

McMillen Jacobs Associates (McMillen Jacobs) was retained by Nevada Irrigation District (NID) to provide engineering services for the removal of the existing Hemphill Diversion Structure and replacement with a roughened channel (rough-rock ramp), fish screen on Hemphill Canal, Hemphill Canal modifications, and stabilization and erosion control within Auburn Ravine. The contract was authorized on September 23, 2021.

1.2 Purpose

The purpose of this Conceptual Design Report is to present the design criteria, succinctly describe potential concepts, and provide recommendations to be further developed and evaluated. The selected alternative advanced through the Conceptual Design Report will be taken through a more rigorous and site-specific engineering development. The evaluation will be based on criteria covering biological efficiency, constructability, environmental considerations, operation, design approach, and cost estimate.

1.3 Project Understanding

NID is planning to remove the existing Hemphill Diversion structure which is a barrier to upstream passage of anadromous and local fish species. The Hemphill Diversion is located approximately 3 miles east of Lincoln, CA on the Auburn Ravine. The existing facility (the Facility) includes a channel-spanning irrigation diversion structure and an irrigation intake headgate that feeds the Hemphill Canal. The diversion structure is a 64-foot-wide channel-spanning concrete structure with a crest elevation of 197.4 feet (ft; NAVD88). During irrigation season, the wooden flashboards are assembled on the concrete structure to increase the crest elevation to 200.4 ft (NAVD88).

It is our understanding that the Project will include design and construction of a modernized irrigation diversion and headworks structure with the following attributes:

1. Provide for passage for anadromous fish at Hemphill Diversion Structure through elimination or modification of the existing structure.
2. Provide for a project that limits operational and maintenance activities within Auburn Ravine.
3. Maintain NID's water rights (pre- and post-1914) within Auburn Ravine.
4. Continue to provide raw water deliveries via the Hemphill Canal.
5. Minimize or eliminate fish passage into Hemphill Canal.
6. Provide for a project that reduces the risk of further upstream erosion.
7. Provide a project that is economically feasible to implement, operate, and maintain.
8. Provides value and cost benefit to the owner and operator.

1.4 Background

The Hemphill Diversion structure diverts water from Auburn Ravine into the Hemphill Canal located south of the ravine for delivery to NID raw water customers. The Hemphill Diversion structure is an approximately 8-foot-tall concrete structure that has been utilized by NID since its purchase of the facility in 1933.

Auburn Ravine is identified as Salmon and Steelhead (*Oncorhynchus mykiss)* habitat and the Hemphill Diversion structure has been identified as a barrier within Auburn Ravine.

Figure 1-1 presents the location map of the Project and Figure 1-2 shows the existing diversion and irrigation canal.

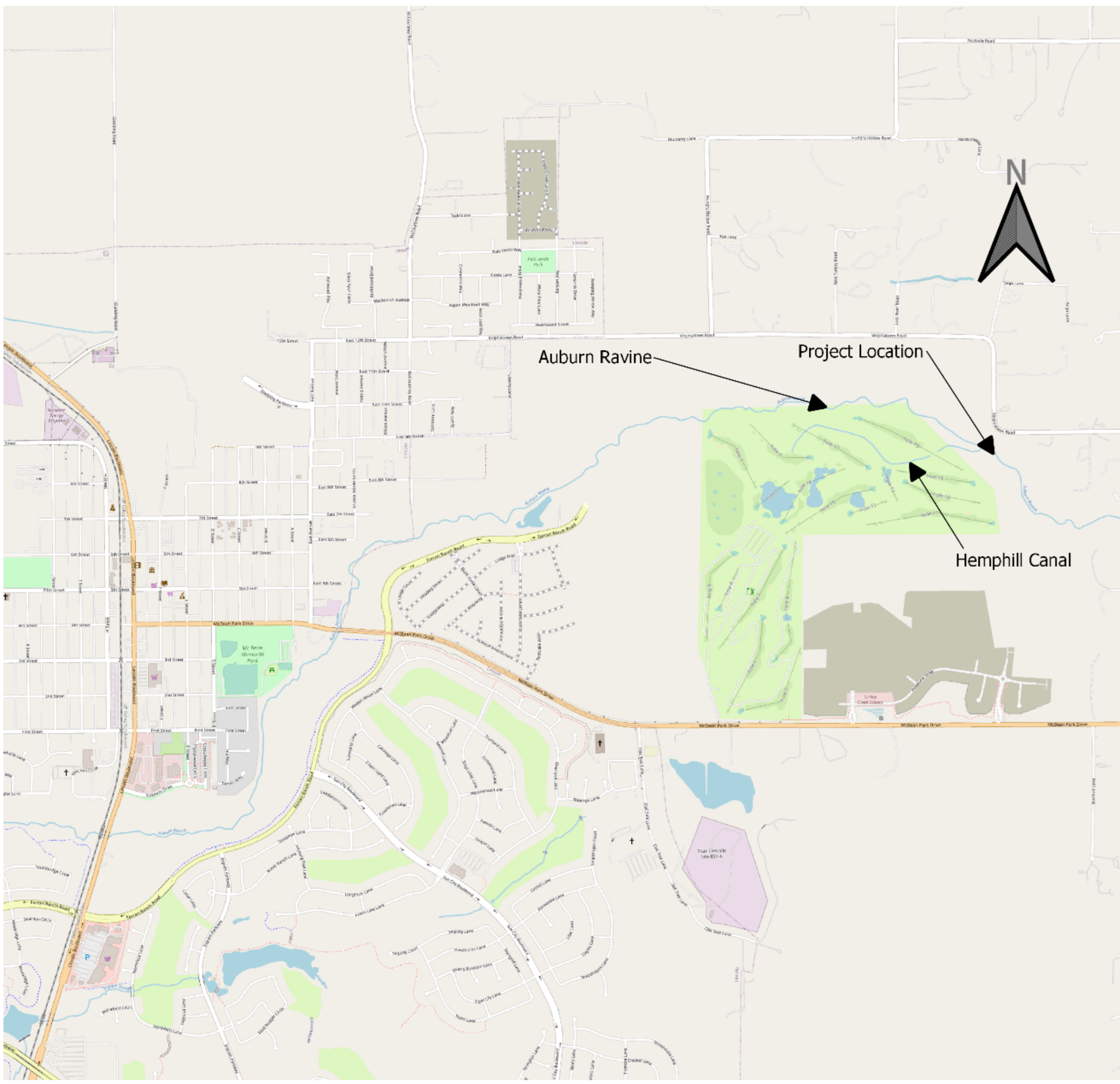

Figure 1-1. Location Map

Figure 1-2. Existing Diversion and Irrigation Canal

1.5 Report Organization

The overall organization of the Conceptual Design Report is summarized in Table 1-1.

Table 1-1. Report Organization

Section	Description	Purpose
1	Introduction	Summarizes the project authorization, purpose, background, project understanding, and report organization.
2	Design Criteria	Presents the pertinent data and design criteria which will be used in the analysis and alternatives development.
3	Alternatives Development	Outlines the approach to developing the conceptual alternatives and presents a succinct description of each alternative.
4	Conclusions and Recommendations	Presents a summary of the conclusions of the conceptual design development and recommendation of alternative for advancement to 50% design.
5	References	Documents the references used in developing the conceptual design report.
Appendices		
A	Conceptual Design Drawings	

2.0 Design Criteria

This section presents the design criteria in a series of tables. A brief description of the contents of each table is as follows:

- **Table 2-1. Biological Criteria:** Includes fish species, size, swimming abilities, passage timing, and expected numbers.
- **Table 2-2. Hydraulic and Hydrologic Criteria:** Includes mean daily flow, maximum daily flow, exceedance flows during the Fish Passage Window, ordinary high-water mark, and the 100-year flow event.
- **Table 2-3. Operation and Maintenance Criteria:** Presents the operation and maintenance criteria which are critical for NID and the Stakeholders.
- **Table 2-4. Canal and Diversion Criteria:** Presents the requirements of the canal and diversion. This will inform construction sequencing and project operation.
- **Table 2-5. Screen Hydraulic Criteria:** Presents the design requirements for the fish screen(s).
- **Table 2-6. Fish Return Bypass Criteria:** In the event that a pipe is used instead of an open channel flume, fish return criteria related to pipes are presented in this table.
- **Table 2-7. Fishway Criteria:** Presents the design requirements for the roughened rock fishway
- **Table 2-8. Monitoring Criteria:** Presents the data and information that need to be collected and monitored and the frequency of the monitoring and reporting.
- **Table 2-9. Structural engineering codes and standards:** Provides the codes and standards that will serve as the general structural design criteria for the design of the exclusion barrier.
- **Table 2-10. Mechanical engineering codes and standards:** Provides the codes and standards that will serve as the general mechanical design criteria for the design of the exclusion barrier.
- **Table 2-11. Civil engineering codes and standards:** Provides the codes and standards that will serve as the general civil design criteria for the design of the exclusion barrier.

Table 2-1. Biological Criteria

Criteria	Units	Value	Comments
Species			
Target Species			
Central Valley Fall Run Chinook Salmon	-	Juvenile/Adult	*Oncorhynchus tshawytscha* PCCP Covered Species; Federal Species of Concern; California Species of Special Concern.
California Central Valley DPS Steelhead	-	Juvenile/Adult	*Oncorhynchus mykiss;* PCCP Covered Species; federal threatened species.
Other Species			
Pacific Lamprey	-	Juvenile/Adult	*Entosphenus tridentatus* (California Species of Special Concern).
Fish size			
Total Length			
Central Valley Fall Run Chinook Salmon	mm	30-50 (Juveniles) 750-1400 (Adults)	Fork length (Moyle P. B., 2002)

Criteria	Units	Value	Comments
California Central Valley DPS Steelhead	mm	100-250 Juveniles 350-800 (Adults)	Fork length (Moyle P. B., 2002); (Moyle, Williams, & Wikramanayake, 1989)
Pacific Lamprey	mm	140-160 (Juveniles) 300-760 (Adults)	(Moyle P. B., 2002)
Average Fish Weight			
Central Valley Fall Run Chinook Salmon	lbs.	10-35	(Bell, 1991)
California Central Valley DPS Steelhead	lbs.	1-12 3-12	(Bell, 1991) Adults (Moyle P. B., 2002)
Pacific Lamprey	lbs.	0.5 - 0.8	Adults
Swimming Capabilities			
Burst Speed			
Central Valley Fall Run Chinook Salmon	fps	16	(Bell, 1991)
California Central Valley DPS Steelhead	fps	20	(Bell, 1991)
Pacific Lamprey	fps	7	(Bell, 1991)
Sustained Speed			
Central Valley Fall Run Chinook Salmon	fps	8	(Bell, 1991)
California Central Valley DPS Steelhead	fps	10	(Bell, 1991)
Pacific Lamprey	fps	3	(Bell, 1991)
Maximum Jump Height		Calculated	The calculated jumping height is equal to (burst speed)^2 / 2 * G.
Central Valley Fall Run Chinook Salmon	ft	4	
California Central Valley DPS Steelhead	ft	6.2	
Pacific Lamprey	ft	--	Little/no jumping ability, but can ascend steep barriers (e.g., dams) by attaching and moving in intermittent bursts (Moyle P. B., 2002).
Migration Timing			
Central Valley Fall Run Chinook Salmon	MM/DD	10/01 – 12/31 (Adult) 01/01 – 06/15 (Juvenile)	(Moyle P. B., 2002); (CDFW, 2015); (Helix, 2019). Adult immigration period is dependent on sufficient rainfall to create sufficient flows for passage; juvenile peak emigration period is March-April.
California Central Valley DPS Steelhead	MM/DD	10/01 – 03/31 (Adult) 01/01 – 06/30 (Juvenile)	Adult immigration period is subject to same comment as above (Moyle P. B., 2002); (McEwan, 2001) Kelts (post-spawning adults) may move downstream within a month after spawning.

Criteria	Units	Value	Comments
Pacific Lamprey	MM/DD	02/01 – 06/30 (Juvenile) 03/01 – 06/30 (Adult)	(Moyle P. B., 2002)
Fish Passage Window	MM/DD	10/01 – 06/30	Per above migration timing.

Table 2-2. Auburn Ravine Hydraulic and Hydrologic Criteria

Flow Criteria	Flow (cfs)	Comments
5% Exceedance	172.5	Based on analysis of the stream gage located downstream of Hwy 65 (1995-2021).
95% Exceedance	13.3	Based on analysis of the stream gage located downstream of Hwy 65 (1995 – 2021).
50-Year Event [1]	12,882	Used to define flood protection features and operations of the facility.
100-Year Event [1]	15,643	Proposed design shall not cause rise in 100-year floodplain.
Min. Instream Flow	NA	

[1] FEMA FIS 06061CV0001A

Table 2-3. Operation and Maintenance Criteria

Criteria	Units	Value	Comments
Access	-	See Comment	Access to the screen and diversion will be via the existing access road up to 100-year Elevation.
Timing	-	See Comment	Headworks does not need to be operable year-round; a working time period would be from April 1 through October 31.
Cost of Operation	-	See comment	Limit O&M cost.
Debris Management	-	See comment	Debris needs to be able to pass through the fish ladder.
Bedload Management	-	See comment	Enhance passive bedload/sediment management.
Standardization	-	See comment	Gate and operator.
Occupational Safety	-	See comment	Use USBOR design criteria.

Table 2-4. Canal and Diversion Criteria

Criteria	Units	Value	Comments
Canal			
Timing	-	Apr 1 – Oct 31	
Current Min Flow	cfs	3	95% exceedance flow (2011-2021).
Current Max Flow	cfs	9	5% exceedance flow (2011-2021).
Debris, Bedload, and Fish Management	-	See comment	Headgate design will need to address debris management. Screen design will address sediment and fish management.
Diversion Structure/Headworks			

Criteria	Units	Value	Comments
Adjustability	-	See Comment	Need to be able to adjust flows periodically – no need for automated gate.
Control	-	See Comment	Manual control is sufficient.

Table 2-5. Screen Hydraulic Criteria (NMFS, 2011)

Criteria	Units	Value	Comments
Screen Material	-	See Comment	Corrosion resistant - to be determined in design.
Diversion Shut-Off	-	See Comment	Per NMFS 11.6.1.7.9, if inadequate bypass flow exits at any time, a horizontal screen design must include an automated means to shut off the diversion flow, or a means to route all diverted flow back to the originating stream.
Sediment Removal	-	See Comment	Per NMFS 11.6.1.7.10, a horizontal screen design must include means to simply and directly remove sediment accumulations under the screen, without compromising the integrity of the screen while water is being diverted.
Screen Approach Velocity	ft/s	≤0.40 (active) ≤0.20 (passive) ≤0.25 (horizontal)	Approach velocity is calculated by dividing the maximum screened flow amount by the vertical projection of the effective screen area. NMFS 11.6.1.1. It was noted that a passive system would be preferred.
Sweeping Velocity	ft/s	0.8 to 3 2.5 (horizontal)	Screens longer than 6 feet must be angled and must have sweeping velocity greater than approach velocity. For screens longer than 6 feet, sweeping velocity must not decrease along the length of the screen. NMFS 11.6.1.5.
Screen Cleaning	-	See Comment	Per NMFS 11.6.1.7.13, for passive horizontal screens, approach velocity and sweeping velocity must work in tandem to allow self-cleaning of the entire screen face to provide good bypass conditions.
Screen Submergence	%	85 max for rotating drum screens 65% min drum dia.	NMFS 11.6.1.3.
Inclined Screen Face	Degree	45° max	NMFS 11.6.1.6.
Circular Screen Openings	inch	3/32 max	NMFS 11.7.1.1.
Slotted or Rectangular Screen Openings	inch	1/16 max	NMFS 11.7.1.2.

Criteria	Units	Value	Comments
Square Screen Openings	inch	3/32 max	NMFS 11.7.1.3.
Screen Open Area	%	27 min	NMFS 11.7.1.6.
Active Screen Cleaning Frequency	Min	5 minutes, min	Or triggered by a max head differential of 0.1 ft over clean screen conditions. NMFS 11.10.1.2.

Table 2-6. Fish Return Bypass Criteria (NMFS, 2011)

Criteria	Units	Value	Comments
Change in Bypass Channel Velocity	ft/s/ft of travel	0.2 Max	The rate of increase velocity between any two points in the bypass channel should not decrease and should not exceed 0.2 ft/s per foot of travel. NMFS 11.9.1.8.
Bypass Entrance Velocity	-	110% min of the maximum canal velocity upstream of the bypass entrance.	NMFS 11.9.2.2.
Bypass Entrance Dimensions	ft	18 wide for more than 3 cfs 12 wide for less than 3 cfs	NMFS 11.9.2.4.
Bypass Conduit Bends	-	R/D ratio greater than or equal to 5.	NMFS 11.9.3.4. R/D (center line of radius of curvature/pipe diameter).
Access Points	-	None	NMFS 11.9.3.5. Spacing access points are to be provided for bypass length greater than 150 feet.
Pipe Size, min.	inch	10	NMFS 11.9.3.6.
Bypass Flow	%	5% of the total diverted flow amount	NMFS 11.9.3.7.
Bypass Velocity	fps	Between 6 and 12	NMFS 11.9.3.8.
Minimum Depth	%	40	40% of the bypass pipe diameter per NMFS 11.9.3.9.
Bypass Outfall Ambient River Velocity	ft/s	4 min	NMFS 11.9.4.1.
Impact Velocity	fps	< 25	NMFS 1.9.4.2.
Bypass channel	-	See Comment	Minimize distance between barrier and bypass outfall; and minimize attraction.
Materials	-	HDPE	All smooth interior and fittings and smooth welds.

Table 2-7. Fishway Criteria (NMFS, 2011)

Criteria	Units	Value	Comments
Roughened Channel			
Total Length of Passage	ft	<150	NMFS 4.10.2.2.
Maximum Slope	%	6	NMFS 4.10.2.2.
Minimum flow depth	ft	1	NMFS 4.10.2.2.
Transport Velocity	fps	1.5-4	NMFS criteria Section 4.4.2.1. This transport velocity is below the sustained swimming speed to the target fish. Material placement will provide area with varied velocities dependent upon flow.
Minimize Sub-surface Flow	-	See Comment	Guidance on the mixture of fill material is still evolving, but general guidance is provided in Washington Department of Fish and Wildlife (WDFW) 2003.
Material Placement	-	See Comment	Match complexity characteristics of adjacent stream reaches.
Minimize Head-Cutting	-	See Comment	Avoid discrete hydraulic drops across the entire width of the roughed channel.
Bedload Transport	-	See Comment	Demonstrate in the design analysis that any scouring of fines from the constructed channel will be refilled by subsequent bedload transport and aggradations.

Table 2-8. Monitoring Criteria

Criteria	Units	Value	Comments
Screen Flow Monitoring	EA	Manual	Visual staff gage.
Canal Flow Monitoring	EA	Manual and Automatic	Stage discharge curve (currently); ratable structure (e.g., low-head ramp flume in lined section to provide hydraulic flow rating); visual staff gage with pressure transducer or float with automatic upload of canal flow data to the cloud.
Auburn Ravine Flow Monitoring	NA	Automatic	No changes anticipated.
Others	-	*TBD*	

Table 2-9. Structural Engineering Codes and Standards

Code	Standard
2021 IBC	2021 International Building Code
SEI/ASCE 7-10	Minimum Design Loads for Buildings and Other Structures, 2013 Edition
ACI 318-11	Building Code Requirements for Structural Concrete
ACI 350-06	Code Requirements for Environmental Engineering Concrete Structures
ACI 350.4R-04	Design Considerations for Environmental Engineering Concrete Structures

Code	Standard
2020 ADM	Aluminum Design Manual, 2020 Edition
AWS D1.1-04	Structural Welding Code - Steel
AWS D1.2-08	Structural Welding Code - Aluminum

Table 2-10. Mechanical Engineering Codes and Standards

Standard
American Society of Testing and Materials (ASTM)
American National Standards Institute (ANSI)
American Society of Mechanical Engineers (ASME)
American Welding Society (AWS)
National Fire Protection Association International (NFPA)

Table 2-11. Civil Engineering Codes and Standards

Design Class	Standard
Stormwater	California Department of Transportation Construction Manual, 2020 Edition
Erosion Control	California Department of Transportation Construction Manual

3.0 Alternatives Development

3.1 Introduction

Section 3.0 presents the development of the alternatives for the Hemphill Diversion Project. This section presents the initial conceptual design alternatives developed, followed by a screening evaluation that compares each of the alternatives in terms of the evaluation criteria.

3.2 Approach to Alternatives Development

During the past 12 years, a number of engineering studies have been prepared for NID related to the Hemphill Diversion project [(Love, 2009); (Balance, 2020); (NV5, 2020); (NHC, 2021)]. Each of these reports has focused on different aspects of the Project while addressing fish passage. As such, the only fish passage alternatives developed for the concept design are 1) a channel-wide rough-rock ramp and 2) concrete weirs. Fish screening on the Hemphill Canal has not been discussed in many of the previous reports, however, NHC (2021) briefly discussed the need for fish screening and provided a few alternatives.

For the purpose of this concept level design document, two fish passage facilities and three fish screening alternatives were considered. The alternatives include:

- Alternative S-1 - Farmers Horizontal Screen
- Alternative S-2 - Vertical Flat Plate Screen, Passive
- Alternative S-3 - Cone Screen with External Brushes
- Alternative P-1 - Roughened Channel (i.e., mimicking natural stream conditions)
- Alternative P-2 – Full Width Stream Weir

3.3 Alternatives Considered

Alternatives were considered based on the following discrete Project elements (and alternative prefix): Fish screen and bypass (S) and fish passage (P). A brief description of each alternative is presented in the following paragraphs.

3.3.1 Alternative S-1: Farmers Horizontal Screen

The Farmers Conservation Alliance (FCA) patented, NMFS-compliant horizontal flat plate screen is a passive screen that utilizes a tapering screen in conjunction with a control weir to ensure sweeping velocities and approach velocities are maintained over a comparatively broad range of flows (see Figure 3-1). The Farmers Horizontal Screen has seen installations that range from as little as 1.5 cfs of diverted water up to as much as 600 cfs using multiple, modular screen installations. The Farmers Horizontal Screen has no moving parts and does not require power to operate.

Farmers Horizontal Screens require comparatively large footprints. However, in situations where adequate space is available, they perform well, requiring very little hydraulic drop across the screen, and requiring comparatively little bypass flow. They require an inlet flume to train the flow pattern so that water entering the screens does so uniformly. The Farmers Horizontal Screen installation requires excellent compaction and a very level grade under its base, so that the water pouring over the weir wall is uniform across the entire screen length. Like most screens, the Farmers Horizontal Screen will pass sediment in suspension, whereas managing larger sediment should be performed upstream lest the screen clog with larger material. Floating detritus, however, is readily passed through the fish return bypass.

By using multiple modular screens with 10 cfs capacity, one screen could be installed to meet the current demand of 9 cfs and another could be added in the future to deliver up to 20 cfs.

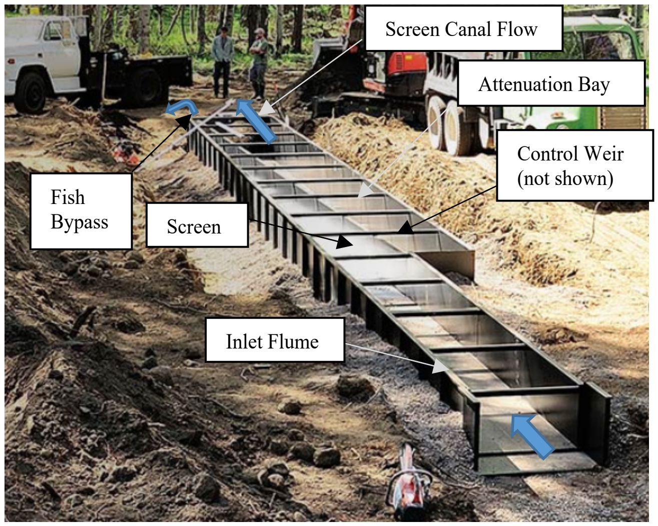

Figure 3-1. Typical Single FCA Screen Installation

3.3.2 Alternative S-2: Vertical Flat Plate Screen, Passive

Passive Vertical Flat Plate Screens (Figure 3-2) are common fish screen applications in rivers across the West. Typical applications include a tilted or vertical screen mounted to a diversion headgate structure. They often include debris racks between the stream and screen to protect the screen from debris impact. Because these screens are usually in-river applications, there is typically no need for a fish bypass. However, one of the main limitations with any vertical screen is the space requirements associated with diverting large amounts of water during the low-flow season. For example, in order to divert 10 cfs in the later summer months with a screen structure that is, say, 25 feet long and still achieve a maximum approach velocity of 0.2 ft/s, the depth of water on the screen would need to be at least 2 feet.

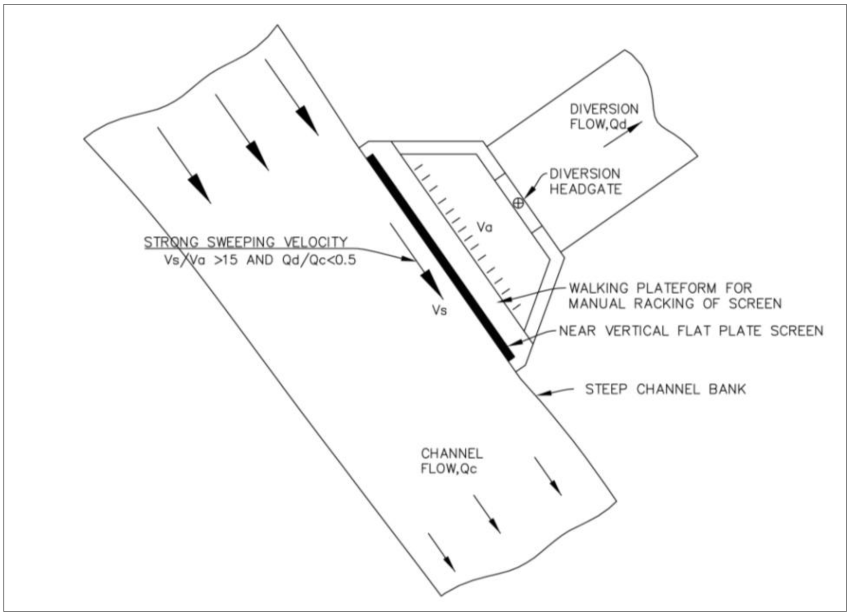

Figure 3-2. Typical Fixed Flat Plate Bank or Wall Screen Application

3.3.3 Alternative S-3: Cone Screen with External Brushes

Cone screens were designed for low-head applications with potentially high sediment and debris loads. Cone screens consist of NMFS-compliant wedge wire screen installed on a cone-shaped frame. The conical shape allows flow separation upstream of the screen to carry debris around the screen, greatly reducing the likelihood of damage from debris impact. The low profile of the cone also allows these screens to divert large quantities of water in relatively shallow depths. The screen is typically set on a concrete pad or a self-supporting intake pipe adjacent to the intake structure. Debris is removed from the screen via mechanical brushes, air burst systems, or both. Cone screens come in a range of sizes and may be installed individually or as an intake manifold system. Cone screen diversion rates range from several cfs to several hundred cfs. Figure 3-3 presents a cone screen intake fabricated by Intake Screens, Inc.

Figure 3-3. Cone Screen with External Brushes

3.3.4 Alternative P-1: Roughened Channel

The Roughened Channel is an engineered "nature like" fishway (Figure 3-4). The streambed material is sized and placed in such a way as to mimic the configuration of natural stream bed. Roughened channels are also referred to as stream or streambed simulation, rock channels, or nature-like fishways. By replicating the natural stream conditions, a wide variety of life stage and species of fish may be able to utilize the roughened channel for passage. NMFS comments that this is a relatively new technology without a developed and proven design methodology. In other words, while this fishway type seems common sense as it replicates nature, the design of a durable fishway is difficult. The slope of the roughened channel ramp would be set at approximately 4.5% and would be approximately 150 feet long. The ramp would be built with a rock skeleton that would provide stability during high flow events. The streambed material could become mobile during some flow conditions and would rely on the river regenerating the streambed material by natural sediment transport.

Figure 3-4. Little Sheep Creek Roughened Channel, Oregon

3.3.5 Alternative P-2: Full Width Stream Weir

The full width stream weir (pool and weir or pool and chute) fish ladder passes the entire flow through successive fishway pools separated by overflow weirs that break the total project head into passable increments (Figure 3-5). Weirs could be constructed with concrete (as shown in Figure 3-5 or boulders or logs). This design allows fish to ascend to a higher elevation by passing over a weir and provides resting zones within each pool. The fish, attracted by the flowing water, move from pool to pool by jumping or swimming (depending on the water depth) until they have cleared the obstruction. Movement between pools usually involves burst speeds. Fish can rest in the pools, if necessary, as they move through the fishway. While simple to construct, the pool and weir is sensitive to fluctuating water levels. When fluctuation of water surface elevation outside of the design elevation occurs, too much or too little flow enters the fishway. When this happens, this flow fluctuation may lead to operation with fishway pools that are excessively turbulent or provide insufficient flow for adequate upstream passage. The water level drop between pools is usually set at 12-inch for adult salmon and 6-inch for adult freshwater fish. Weir fishways usually have a slope of 10%. Pools are sufficiently sized to allow for the flow energy to be nearly fully dissipated in the form of turbulence within each receiving pool. To accommodate tailwater fluctuations, this type of fish ladder is often designed with an adjustable fishway entrance (i.e., adjustable geometry and/or attraction flow) and additional add-in flow diffusers to meet transport channel velocity criterion.

Figure 3-5. Concrete Weir (Pool and Chute) Fishway

3.4 Initial Screening and Evaluation

A series of evaluation criteria were used to evaluate the alternatives. A brief summary of each alternative evaluation criterion is presented in Table 3-1. Table 3-2 was used to determine which alternative should be recommended to proceed to 50% design. The alternatives that are recommended for elimination and removal from further consideration are considered infeasible.

Table 3-1. Description of Major Evaluation Criteria

Criterion	Description
Design Feasibility	This criterion means that the alternative has the potential to meet the design criteria presented in the Basis of Analysis.
Advantages	Lists the advantages of the system.
Disadvantages	Lists the disadvantages of the system.
Cost	Ranks the capital and O&M costs according to low, medium, high, and very high. This is a relative measure of the potential cost associated with each alternative. These criteria are intended to provide a relative comparison between alternatives, not a quantitative cost range.

Table 3-2. Initial Screening and Evaluation

Alt Number	Description	Advantages	Disadvantages	Cost	
				Capital	O&M
S-1	Horizontal Flat Plate, FCA – located in canal downstream of headgate.	• No power needed. • Passive cleaning. • NOAA-NMFS compliant. • Relatively low bypass flows. • Control of approach and sweeping velocities through adjustable weir. • Fish bypassed regardless of location in the water column.	• Larger footprint requiring inlet flumes to train flow. • Requires fish bypass.	Medium	Low
S-2	Vertical Flat Plate Screen, Passive – located in Ravine at headgate.	• Common configuration. • No power needed. • Passive cleaning.	• Susceptible to debris damage. • May require frequent cleaning and other maintenance. • Large footprint depending on diversion flows and required length of screen. • May not be feasible due to required depths on the screen.	Low	High
S-3	Cone Screen with External Brushes– located in Auburn Ravine at headgate.	• Locating the screen in-stream prevents entrainment of fish and debris into the diversion. Fish and debris do not pass through the diversion's flow control structure. • A fish-bypass structure is not required.	• Maintenance access to the screen may be difficult or limited to low flow periods. • Large woody debris carried by high flows may damage in-stream screens. A debris boom in front of the screen may be required. • Power is required for the brush cleaning system • The cone screen is not a passive system.	Medium	Medium
L-1	Roughened Rock Ramp	• Mimics natural stream conditions. • May provide additional benefits to other species such as insects, mollusks, and crustaceans.	• Space requirement dependent on existing stream slope. • Requires annual O&M. • The large boulders would be sized for 100-year flood; however, the smaller material is susceptible to being transported, relying on the natural river sediment transport to be refilled.	Low	Medium
L-2	Pool and Chute	• Common ladder type. • Weir could be made of concrete, boulders, or logs.	• Bigger footprint. • Limited to 9-inch per pool of hydraulic drop. • Requires stable head pool. • No orifice for benthic species.	Medium	Medium

4.0 Conclusions and Recommendations

The Hemphill Diversion structure impedes upstream migration of aquatic species in Auburn Ravine. To restore connectivity and to increase available spawning grounds, NID proposed to provide upstream passage and screening of the diversion to Hemphill Canal. Several reports have been prepared discussing alternatives for both upstream passage and screening. Based on a review of available alternatives analyses, discussions with NID staff and the analysis in this report, we recommend that upstream passage be provided with the removal of the existing Hemphill Diversion structure and the construction of a roughened channel (i.e., natural fishway). For protection from entering the Hemphill Canal for downstream migrating species, we recommend the installation of a Farmers Horizontal Screen in the Hemphill Canal. The conceptual design drawing for this alternative is included in Appendix A.

4.1 Roughened Channel

The proposed roughened channel (i.e., rock ramp) would be installed after the existing concrete diversion structure is removed. The upstream edge of the rock ramp would be defined by either a sheet pile or concrete wall that would extend into the stream bed a sufficient depth to inhibit the passage of water under the rock ramp. This provides stability for the rock ramp and forces all water to flow through the low flow channel. Gradation of the rocks that make up the ramp is a critical design factor that will be addressed in subsequent phases of design. The surface of the ramp must have sufficient roughness to develop turbulence while utilizing smaller rocks, cobbles, and gravel to keep the water on the surface.

A low flow channel will be designed to concentrate low flows. At concept level, this channel is 1.5 feet wide at the bottom with a depth of 1 foot. This low flow channel would maintain a depth of approximately 1 foot at low flow conditions of 13.3 cfs. At higher flows, the low flow channel would remain submerged, and the flow would spread laterally across the ramp. From the low flow channel, the ramp will extend to the existing banks of the channel rising at a slope of approximately 6%. Based on existing survey data, the elevation of the crest of the existing concrete structure is approximately 197.5 feet. The crest of the proposed low flow channel would be set at this same elevation (197.5 feet). The rock ramp would extend approximately 150 feet downstream at a slope of 4.5% to meet the existing streambed. A scour pool would be created at the bottom of the ramp to allow for dissipation of energy and to provide a safe locating for fish returning from the fish screen by-pass. By setting the low point of the proposed crest at the same elevation of the existing structure, sediment that has collected behind the existing structure will remain in place.

Within the rock ramp, large boulders will be placed to help stabilize the rock ramp and provide for diversity of flow. As the hydraulic model is developed and the velocities and shear stresses are analyzed, it is possible that these larger boulders would need to be anchored to withstand higher flow events.

4.2 Horizontal Flat Plate Fish Screen

The Farmers Horizontal Screen is a horizontal flat plate fish screen that was developed by irrigators in Oregon to meet the strict screening requirements of NMFS and ODFW while delivering water to irrigators with minimal head loss. The design of the screen allows for fish and debris to pass over the screen and return to the river while water to be diverted drops through the screen and exits to the irrigation canal.

While historic flows in the canal generally range from 3 cfs to 9 cfs the NID water master plan indicates a potential maximum flow of 18 cfs. This concept design proposes that two screens be used which would allow the district to meet current demand with one screen and provide the opportunity to expand and install a second screen if demand increases in the future.

The Famers Horizontal Screen uses an inlet flume to train (stabilize) flow as it approaches the screen. Once the flow begins to pass over the screen, one wall of the structure slopes in concentrating flow and maintaining velocity while simultaneously water is moving downward through the screen. The amount of water that flows through the screen is controlled by an overflow weir that maintains a set flow depth over the top of the screen. Fish and debris travel over the top of the screen and are returned to the stream through pipe or channel, while irrigation water drops below the screen, passes over the weir, and then continues down the canal.

5.0 References

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Appendix A Conceptual Design Drawings