WARM SPRINGS NATIONAL FISH HATCHERY INTAKE IMPROVEMENTS

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ABSTRACT

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The Warm Springs National Fish Hatchery located in Warm Springs Oregon, is hampered with many issues that impact its effectiveness. In an effort to improve the effectiveness of the hatchery, United States Fish and Wildlife Services (USFWS) has expressed interest in modifying the existing intake to address a number of specific concerns. Five specific objectives have been identified to define the overall project scope. USFWS desires to provide a means to prevent frazil ice from forming on and around the hatchery intake screens, prevent sediment from collecting behind the weir and entering the hatchery intake, provide effective hatchery screening to prevent sediment, debris, and fish from entering the hatchery intake, decrease intake water temperatures during summer months, improve the intake screen cleaning system, and provide a means for effective water quality treatment to limit spikes in turbidity and therefore improving the effectiveness of the existing ultraviolet treatment.

Concept level improvements were developed to address the objectives. Site visits, interviews with hatchery staff, water quality sampling, hydrologic and hydraulic analysis were completed and record construction drawings of the hatchery were reviewed to confirm concept level improvement feasibility.

Three concept level design alternatives were developed to address the first four objectives while only preliminary water quality sampling was conducted so that separate concepts could be developed in the future to address the fifth objective, effectiveness of the existing sand filters. The concepts developed and evaluated included installation of rotary drum screens or vertical fixed plate screens to replace the existing static drum screens. In addition, the concepts included an a la carte of other options that address the objectives. Those a la carte items include; construction of a rock groin structure, weir improvements to provide an adjustable spillway, and miscellaneous utility upgrades.

From this analysis, Concept 3 - relocating the hatchery intake upstream was identified as most likely to address the objectives and is feasible given the site constraints. More analysis is needed before a recommendation can be made including collection of in-stream water temperature data and a quantification of the amount of sediment expected to accumulate near the proposed intake structure. However, it is also recommended that additional and consistent operation and maintenance at the existing intake could also provide significant improvements to address the objectives in the short term.

ACKNOWLEDGEMENTS

Thank you to the professors at HSU who graciously accepted me into the Environmental Resources Engineering Graduate Program. Specifically I owe a great thank you to Dr. Brad Finney for continually encouraging me to be a strong role model to my community, specifically the Native American community, and within the scholastic environment. In addition, his technical support, advice, and guidance were greatly appreciated. Dr. Eileen Cashman has also been a pillar in the completion of this project. Keeping me focused and encouraging me to set personal deadlines and goals. Thank you to Dr. Margaret Lang for being part of my committee and for your technical advice.

Thank you to USFWS staff for providing background information on the hatchery and allowing opportunity to visit the site and discuss the operation with the everyday staff. Thank you to those at KPFF who supported me in preparing this material; my boss, Steve Kingsley, for providing support and guidance while developing concepts, as well as surveyors collecting site information, and drafters supporting my effort in preparation of some of the concept exhibits. The conclusions and recommendations presented in this report are solely those of the author, and do not necessarily represent those of USFWS or KPFF.

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Most importantly, thank you to my family for never doubting my ability. I would not have made it to this point without your support. Thank you to my mom Liz and to my dad Keith, for encouraging me from a young age to always “take more math.”

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INTRODUCTION

Warms Springs National Fish Hatchery (NFH) is located at river mile 10 (rkm 16) of the Warm Springs River. The Warm Springs River is a tributary to the Deschutes River, entering the Deschutes River at river mile 84.4 (rkm 135). The existing Warm Springs NFH and intake are located on the west bank of the Warm Springs River in northern Central Oregon, at approximately 44 51’ 38” N latitude, 121 14‘ 42” W longitude, and an elevation of +1514 (NGVD298) (USFWS, 2006). The intake was surveyed by KPFF in 2014. The survey can be viewed in Appendix A.

Figure 1. Warm Springs National Fish Hatchery, photo taken in 1994 (Google, 2016).

Poor stream channel conditions just above the intake, due to heavy sediment deposition, has impacted the quality of the water entering into the hatchery. This has led to the hatchery experiencing high turbidity and extreme temperature variations in their

water throughout the year. This also negatively impacts the operations of the two hatchery intake fish screens and other components in the hatchery such as the sand filters and their ultraviolet disinfection system. The existing fish screens are both stainless steel Johnson fixed rotary drum screens that are 54 inches in diameter and 8 feet in length. The screens use a compressed air burst system to clean the debris off the screens. The fish screens were installed at Warm Springs NFH in the winter of 2004-05. They have not performed well and have been severely damaged several times primarily due to icing conditions in the forebays where the screens are located (SOW, 2014).

Figure 2. Existing hatchery intake, looking downstream towards weir.

U.S. Fish and Wildlife Service (USFWS) wishes to improve the processes for collection, screening, and treatment of hatchery production water. During a site visit on April 29th, 2014, the following objectives were identified:

1. Formation and collection of ice on the existing fixed cylindrical drum screens.
2. Excessive collection of sediment and debris within the existing intake structure, and insufficient downstream flushing of collected sediment and debris.
3. High water temperatures during summer months.
4. Ineffectiveness of the screen cleaning system for the existing fixed cylindrical drum screens.
5. Ineffectiveness of the existing sand filters.

This report summarizes the objectives and presents three feasible improvement concepts with solutions for the first four objectives. In addition, preliminary water quality sampling was conducted and reported in order to initiate the process of developing concepts to address objective five in the future. In addition, this report provides cost estimates for each of the improvement concepts as well as a cost breakdown for each of the design features presented within the concepts. The design work completed is conceptual and intended for the evaluation of concepts for improvements to the hatchery intake.

METHODS

USFWS wishes to improve the processes for collection, screening, and treatment of hatchery production water. The following goals were identified:

- Perform a comprehensive study on the existing conditions and processes used to collect, screen, and treat production water used in the hatchery fish rearing operations.
- Provide effective hatchery screening to prevent fish, sediment, and debris from entering the hatchery at the water supply intake.
- Prevent frazil ice from forming on and around the hatchery intake screens.
- Provide a means to prevent heavy sediment from collecting behind the weir and entering the hatchery intake.
- Provide a means for effective water quality treatment to limit spikes in turbidity, improving effectiveness of UV treatment.

Additional project criteria were established:

- Develop solutions that are not energy intensive as this hatchery is already very costly to operate.
- Develop solutions with low maintenance requirements.
- Develop solutions with relatively low complexity and relatively low cost.

Objectives

During a site visit on April 29th, 2014, the following objectives were identified:

Objective 1: Formation and collection of ice on the existing fixed cylindrical screen:

During freezing temperatures, the existing fixed cylindrical screens become clogged by the formation of frazil ice. Frazil ice commonly appears as fragments which form near the surfaces of turbulent, open water (Ettema, 1984). At the hatchery, frazil ice particles are carried into the existing intakes and obstruct flow. In addition, ‘anchor’ ice’ forms directly on the submerged intake structures. Anchor ice forms on submerged objects in shallow, open water due to excessive heat radiation, adding to the frazil ice buildup (Ettema, 1984).

Objective 2: Excessive collection of sediment and debris within the existing intake structure and insufficient downstream flushing of collected sediment and debris:

Sediment enters the intake structure and accumulates within the sump of the intake structure, below the intake screens. Each of the two intake screens is located in a separate chamber in the intake structure. The chambers are designed to allow for sediment to be sluiced, or flushed, out of the bottom. However, hatchery staff has indicated that the sediment build up does not exit through the sluice pipe and sluice gates are stuck in an open position.

Objective 3: High water temperatures during summer months:

Water temperature data for Warm Springs River is not currently available at the hatchery location. Hatchery staff has indicated that temperature readings within the hatchery have been measured to be as low as 32˚F (0˚C) in winter and as high as 72˚F

(22˚C) in summer. Water temperatures increasing beyond 55˚F (12˚C) are not desirable for fish rearing (USFWS, 2006). For this reason, the brood stock ponds are plumbed for chilled supply water. Although temperature data for Warm Springs River is not available at the hatchery location, hatchery staff has indicated that high water temperatures during summer months are experienced throughout the watershed.

<u>Objective 4: Ineffectiveness of existing screen cleaning system for the fixed cylindrical drum screens:</u>

The existing screens have been installed with an air burst screen cleaning system. An air burst system is generally an effective method for temporarily removing sediment and debris that naturally collects on the surface of the intake structure due to draw (USBR, 2006). During freezing temperatures however, the air exhausted from the system can become restricted by the buildup of frazil or anchor ice. The built-up ice prevents the air from escaping through the screen and hatchery staff has indicated that this has resulted in the screens disconnecting from their mounting brackets.

<u>Objective 5: Ineffectiveness of the existing sand filters:</u>

Hatchery staff has expressed concern about the effectiveness of three existing sand filters that provide pre-treatment prior to ultraviolet (UV) disinfection. UV disinfection is utilized at the hatchery to eliminate the risk of pathogens infecting the brood stock. UV disinfection uses UV light to disinfect water by disrupting the DNA in cells. When DNA absorbs too much UV light, it becomes damaged and unable to replicate. The major factor affecting the performance of UV disinfection is water quality,

namely turbidity and suspended solids. Particles suspended in the water column can scatter the UV light reducing the effectiveness of disinfection.

Figure 3. Existing sand filter, one of three.

Hydrology

To properly size intake screens and confirm fish screening compliance, concept development began with a hydrologic analysis of stream flows. Fish screening compliance is further described in the Fish Screening Design Criteria section within this report. The results of the hydrologic analysis were used to develop a hydraulic model for typical monthly water surface elevations. Water surface elevations within the hatchery intake pool behind the hatchery weir were determined to provide a basis of design for elements of the project related to fish passage or intake screening.

The Washington Department of Fish and Wildlife (WDFW) 2013 Water Crossing Design Guidelines and Anadromous Salmonid Passage Facility Design (National Marine Fisheries Service (NMFS), July 2011 Ed. were used to establish design criteria for the intake structure. Both manuals define the design low flow for fish passage to be the 95% exceedance (5th percentile) flow for migration months of the fish species of concern. The WDFW Manual defines the high flow as the 10% exceedance flow (90^{th} percentile), the NMFS defines the same criteria as the 5% exceedance flow (95th percentile) for the migration months. The more stringent NMFS criteria for high flow will be used for the design of the project elements related to fish passage. The WDFW Manual identifies the month of January as the migration month for adult salmon and May as the migration month for Trout, but because spring Chinook are also present at the Warm Springs Hatchery, it was assumed adult salmon migration will also occur in April.

There are two continuous stream gage records on the Warm Springs River, one upstream of the NFH near Siminasho and the other downstream of the hatchery near the Kahneeta Hot Springs Resort. The Siminasho gage record provides 31 years of record from 1983 through 2013. The Kahneeta gage record provides 41 years of continuous record, starting in October, 1972 and is still in operation, however only data through September 2013 is currently available on the USGS National Water Information System Web Interface.

The 5th and 95th percentile flows as well as the daily mean flow for both gages were collected. In addition, records from nearby gaging stations including Beaver Creek, Mill Creek, and Shitike Creek, with continuous gage records of 30, 26, and 29 years, respectively, were gathered. Table 1 and Figure 4 summarize the stream gage data and figures within Appendix B provide the entire daily average stream flow data set.

Table 1. Continuous stream gage records within the region.

Stream Gage	USGS Gage #	Drainage Area (sq mi)	Period of Record
Beaver Creek[Ɨ]	14096850	145	Oct 1983 - Sept 2013
Mill Creek	14096300	27	Oct 1983 - Sept 2009
Shitike Creek[Ɨ]	14093000	104	Oct 1911 - Sept 2013
Warm Springs (Kahneeta) [Ɨ]	14097100	526	Oct 1972 – Sept 2013
Warm Springs (Siminasho)	14095500	107	Oct 1949 - Sept 2009

[Ɨ]Stream gage in operation, data past 2013 not currently available on USGS website

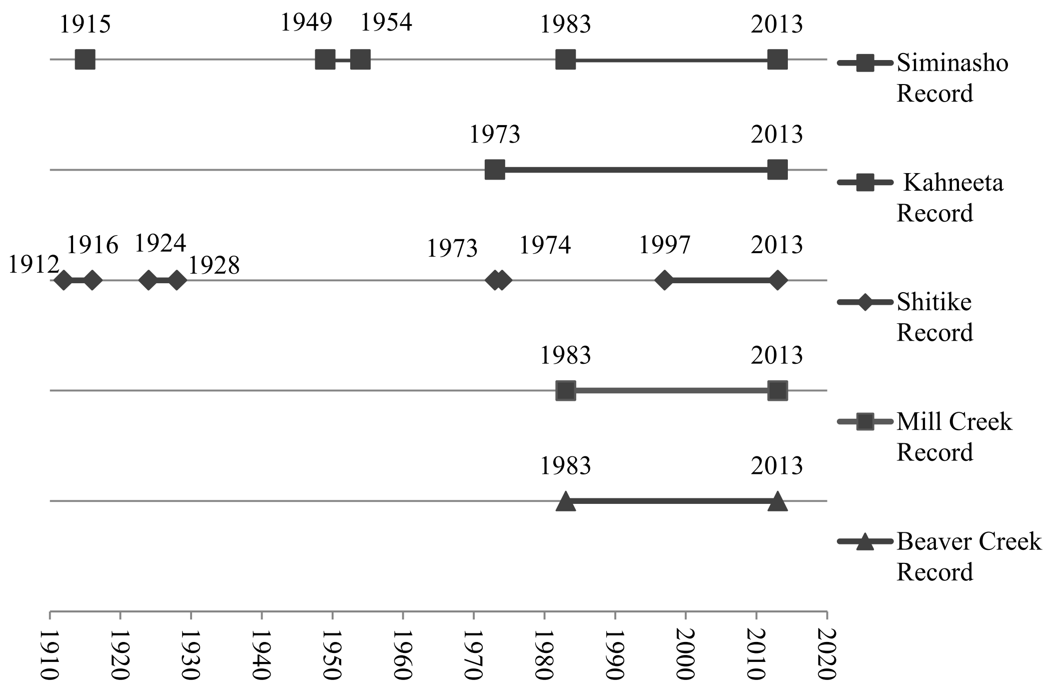

Figure 4. Period of record of available data.

The mean monthly flow per drainage basin area unit for each gage was graphed and compared to the data available for each of the two Warm Springs River gages. Two comparisons were made using the 5th and 95th percentile stream flows. Stream flows for all of Beaver Creek, Mill Creek, and Shitike Creek were collected and compared separately to both the Kahneeta Hot Spring and Siminasho gages. For each stream gage, mean monthly flow per area unit was calculated, multiplied by the respective drainage basin area at Siminasho and Kahneeta creating a synthetic average monthly discharge that was then compared to the actual monthly discharge for the respective gage.

Hydraulic Modelling

A hydraulic model of the project area was created using HEC-RAS version 4.0. The model was created using the hydrologic information described in previous sections as well as the surveyed geometric properties (Tetsuka, 2013) of the Warm Springs River and the observed physical characteristics such as roughness.

Hydraulic Model Geometry

The Warm Springs River geometry was imported into HEC-RAS using the digital survey file prepared in spring 2013 (KPFF, 2013). The survey data collected began at the existing weir and continued upstream approximately a ¼-mile. Once the survey was obtained and imported into HEC-RAS, the model geometry was checked for consistency with known physical conditions. It was apparent that the contour lines reflected in the survey were not accurately reflecting the elevation changes in and around the existing intake structure; therefore, the model was manually updated in this area. In addition, an inline structure was added to reflect the existing weir. The elevation of the existing weir was entered manually based on the survey information and record drawings.

A lateral structure was included in the HEC-RAS model to reflect the existing hatchery intake structure. Fully open gates were utilized in the model to represent the intake structure channels. The gates provided an appropriate way to determine the percentage of flow and water surface elevation within each of the intake structure channels. The flow and water surface elevations were then extracted to perform a more detailed hydraulic analysis for the sizing of the intake screen.

Fish Screening Design

The water source for the hatchery is the Warm Springs River. All water rights on the Warm Springs River are the property of the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWSRO). A business lease with the CTWSRO allows the hatchery to divert up to 100 cubic feet per second (cfs) of water from the Warm Springs River (USFWS, 2006).

Hatchery operational demand has ranged between 20 and 40 cfs. Average daily stream flow during the lowest flow period (July-October) is 264 cfs, meaning a hatchery withdrawal of 40 cfs constitutes around 15% of the total stream flow (USFWS, 2006).

The intake structure and pumps are located at the hatchery site, left bank, just upstream of the existing barrier dam. Water entering the intake structure currently passes through a trash rack, either of the two existing static drum screens, secondary and non-active travelling screens that are no longer in operation before entering the water quality treatment train.

Screen Types

There are many different intake screen types including fixed vertical plate, non-vertical fixed plate (downward or upward sloping), vertical travelling screen (panel and belt type), cylindrical rotating drum, and cylindrical fixed drum. Each screen type has advantages and disadvantages within certain installations. For example, fixed vertical plate screens are relatively simple to construct and are mechanically simple, whereas

travelling and rotary screens are move complex both in construction and mechanical operation.

Screen Design Criteria

The NMFS criteria and guidelines for screens include: approach velocity, sweeping velocity, flow distribution, length, and inclination. The criteria, per section NMFS 11.6, can be summarized as follows:

- Approach velocity must not exceed 0.40 ft/s for active screens, when calculated with the effective screen area.
- Flow distribution must be nearly uniform over the screen surface.
- Sweeping velocity shall be at least 0.8 ft/s and less than 3 ft/s.
- Screens shall not be longer than 6 feet unless angled and unless they have a sweeping velocity greater than the approach velocity. For screens longer than 6 feet, sweeping velocity must not decrease along the length of the screen.
- Vertical screen inclination must be oriented less than 45˚ vertically upstream to downstream.
- Rotary drum screen submergence shall not exceed 85% or be less than 65% of drum diameter.

Approach velocity is the vector component of canal velocity that is perpendicular to and upstream of the vertical projection of the screen face, calculated by dividing the maximum screened flow by the effective screen area (NMFS, 2011). Sweeping velocity, on the other hand, is the vector component of canal velocity that is parallel and adjacent

to the screen and measured as close to the screen face as possible without interfering with the boundary layer turbulence created from flow passing by the screen (NMFS, 2011).

A screen-type evaluation matrix was prepared and used in the selection of the screen type for each concept. The evaluation matrix is included in this report within Appendix C. The matrix describes the different screens that were assessed for concept evaluation, advantages, disadvantages, cleaning concept associated with particular screen, and environmental considerations.

Water Quality Sampling

The primary objective of mechanical filtration at the hatchery is to control pathogens *Ceratonova Shasta* and *Ichthyophthirius multifiliis* (ich). UV irradiation is used to kill these pathogens, as well as other viruses and bacteria in the process water. For UV to be effective however, mechanical filtration upstream of the UV must be able to reduce turbidity and remove suspended particulates which can scatter UV light and therefore decrease its effectiveness. Turbidity is a relative measure of the concentration of colloidal particles within the water column. Total suspended solids (TSS) are operationally defined as the mass retained on a filter per unit volume of water (Qualls, 1983).

TSS absorbs UV radiation and can shield bacteria embedded in the particles. UV disinfection with low-pressure lamps is not as effective when TSS levels are above 30mg/L. Turbid water restricts the transmittal of light, also decreasing effectiveness of UV. Levels over 1 NTU can prevent UV light from penetrating and eliminating micro-organisms.

Water samples were tested for turbidity and total suspended solids. Water samples were taken downstream of each of the three existing sand filters. Samples were taken in 5, 10 and 20 minute increments during and after a routine backwash cycle. A routine backwash cycle lasts 10 minutes, therefore there was a lag of 15 minutes between when an initial control measurement was taken and the treated effluent sample was collected downstream of the filter. Control measurements were collected in the River, just

upstream of the intake structure to provide a baseline for comparison. Table 2 provides an example of the sampling interval for each sand filter:

Table 2. Example of sampling method.

Elapsed Time (min)	Sample Taken?	Description of Sample
0:00	YES	In River
0:05	NO	Backwash Cycle
0:15	YES	Downstream of Filter
0:25	YES	Downstream of Filter
0:35	YES	Downstream of Filter
0:55	YES	Downstream of Filter

Water quality samples were then delivered to the Test America labs in Fife, Washington. Turbidity testing was performed in accordance with the Environmental Protection Agency (EPA) standard method (SM) 2130B and Total Suspended Solids (TSS) in accordance with SM 2540D.

Concepts

Multiple improvement concepts were identified and developed to address the issues, concerns and objectives and satisfy the project objectives. The concepts developed can be described as;

Concept 1: New Rotary Drum Screens in Modified Existing Intake Structure

Concept 2: New Fixed Vertical Plate Screens in Existing Intake Structure

Concept 3: New Rotary Drum Screens in New Intake Structure Located Upstream

In addition to the concepts developed and presented in this report, several other improvement concepts were considered but not carried forward because they did not satisfy the project objectives. These ideas include lowering the existing static drum screens, construction of new intake structure located further upstream in the watershed, Concept 2 with an air-burst screen cleaning system, and performing maintenance dredging.

Rock Groin Structure Sizing

To help minimize the amount of sediment in the intake screen, an instream structure, such as a groin, is considered. A rock groin structure typically consists of interlocking rock, and sometimes woody debris. Preliminary sizing of the aggregate required for a rock groin structure within the Warm Springs River was completed using the Lane's relationship. The modified Lane's relationship provides a qualitative method for computing the D_{50} rock size adequate for the structure.

The Lane's relation application is commonly used in alluvial rivers morphology assuming equilibrium conditions. Natural rivers stay in equilibrium conditions if in a long period of time flow parameters, such as even longitudinal river decline, average channel width and depth, and bedload granulation's characteristics remain constant, which is originally described by Lane as the following (Kiraga and Popek, 2016):

Q_s x d ~ Q_w x S

where:

Q_s - bedload's transport discharge,

d - particle diameter,

Q_w - water discharge,

S - energy grade line slope

Lane's relation is not applicable for the real-world description of the bedload's conditions due to the lack of consistency of parameters on the left and right side of the

equation. Lane's relation has been modified to replace the bedload design grain size with dimensionless grain parameter (Kiraga and Popek, 2016):

$D^* = d_{50} \times [(s-1)g/v2]^{1/3}$

Where:

d_{50} - median grain diameter for 50% of sieve curve,

s - specific density of solid particles;

s = ρs/ρw,

where: ρs—bed material specific density,

ρw—water specific density,

g, acceleration of gravity,

v, kinematic viscosity parameter

The modified Lane's equation can be reworked to determine the d50 - median grain diameter for 50% of sieve curve.

Cost Estimating

Rough order of magnitude cost of construction and preliminary operation and maintenance estimates were prepared for each of the three concepts that met the project objectives. Cost estimates were developed by identifying what materials were needed for construction and performing quantity takeoffs for each concept. Once all line items were identified, unit costs were researched. Unit costs were developed by researching and comparing historical values for similar line items, bid tabulations from recently awarded construction projects of similar scope, RS Means construction cost estimating data reference books, and expert opinion.

Hatchery operation costs depend on energy costs associated with heating, chilling, pumping, and treatment, all of which take place at the Warm Springs NFH. The Warm Springs NFH likely carries a high operational cost due to the complexity of the pumping system and water treatment facilities implemented to address water quality and temperature issues.

Hatchery staff salary and benefits have been assumed for this cost estimate. It was assumed that hatchery staff hourly salary wage is $25.50/hr and hourly benefit wage is $15.50/hr. The cost estimate assumes visual inspections on a consistent basis as well as mechanical and electrical maintenance associated with each of the concepts. For each concept, estimates related to goods and services were also included.

Concept 1 will likely require weekly visual inspection of the intake basin to ensure that basin is clear of floating debris and sediment buildup within the chamber.

Inspection shall be paired with maintenance and any debris and sediment observed shall be removed from the basin to keep the intake screen clean and operational. On a monthly basis the proposed rotary drum screen seals shall be inspected. Seal maintenance and replacement is estimated to occur once every year, therefore an allowance of $200/screen is included. Although unlikely to be necessary every year, an annual allowance for mechanical and electrical maintenance is included of $2,500. To operate the rotary drum screen, the ¼-HP motor will run 24 hours a day, using 2,628 kWh/year. Based on electricity bills provided by the Hatchery staff, a cost of $0.33/kWh was applied.

Concept 2 will also require weekly visual inspection and maintenance of the intake basin to ensure that the basin is clear of debris and sediment. Since the vertical screen plates do not have mechanical seals, the likelihood of seal failure is much less common and replacement will likely be required on a 5-7 year interval rather than annual. The vertical screen plates will be cleaned by the mechanical brush arms. The motor for the brush arm has been preliminarily sized as ¼-HP and will run for 1 hour/day using 109.5 kWh/year.

Concept 3 will require the same operation and maintenance costs of Concept 1 with additional electrical draw for site lighting at the new intake location.

RESULTS

Hydrology

When comparing the regional stream gage records to the Warm Springs River gages (Kahneeta Hot Spring and Siminasho gage), it was determined that the Mill Creek drainage basin streamflow is much higher than the other gages within the region (Figure 5).

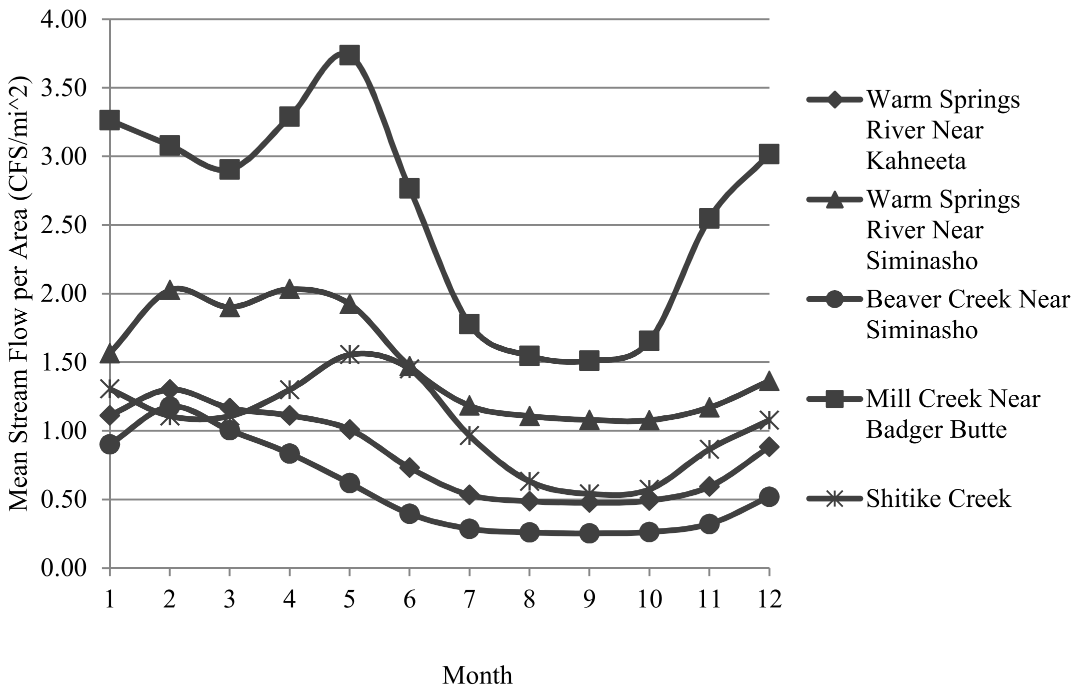

Figure 5. Mean monthly stream flow comparison.

Furthermore, it was determined that the synthetic mean monthly average was much higher than actual measured 5th and 95th percentile flows at the Warm Springs River gage near Kahneeta (Figure 6 and Figure 7).

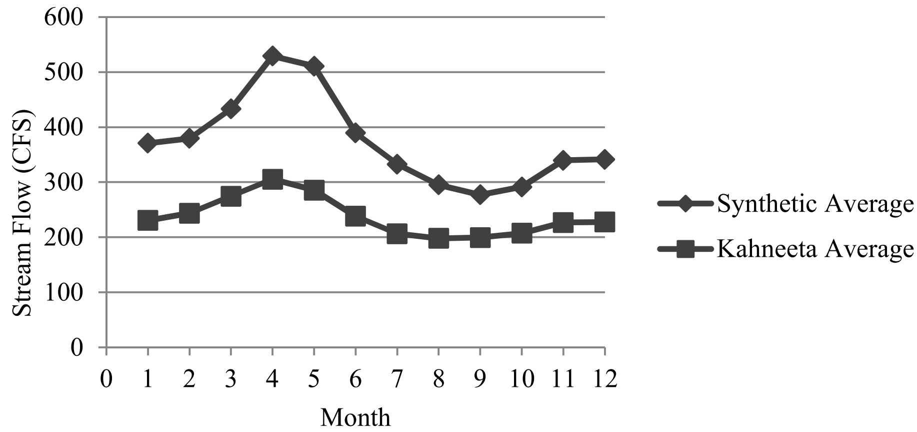

Figure 6. 5th percentile synthetic average streamflow comparison. Synthetic average generated from Mill, Beaver, and Shitike.

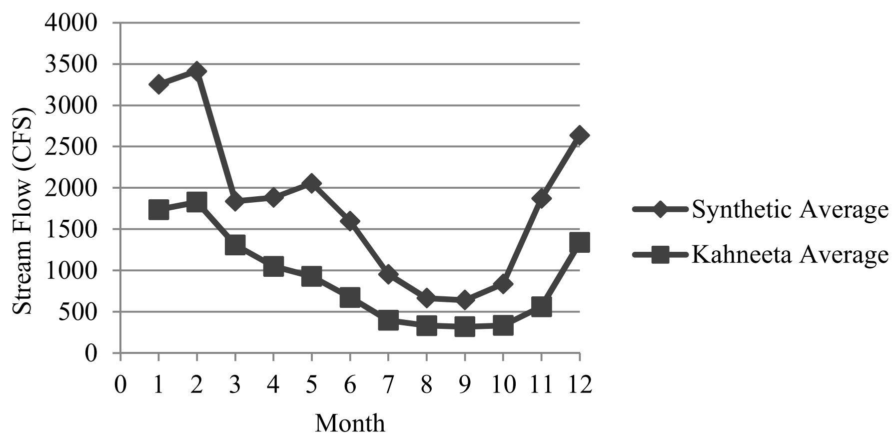

Figure 7. 95th percentile synthetic average streamflow comparison. Synthetic average generated from Mill, Beaver, and Shitike compared to Kahneeta.

For the Warm Springs River gage near Siminasho, the synthetic average more closely resembled the actual measured average and in particular for the 95th percentile flows (Figure 8 and Figure 9).

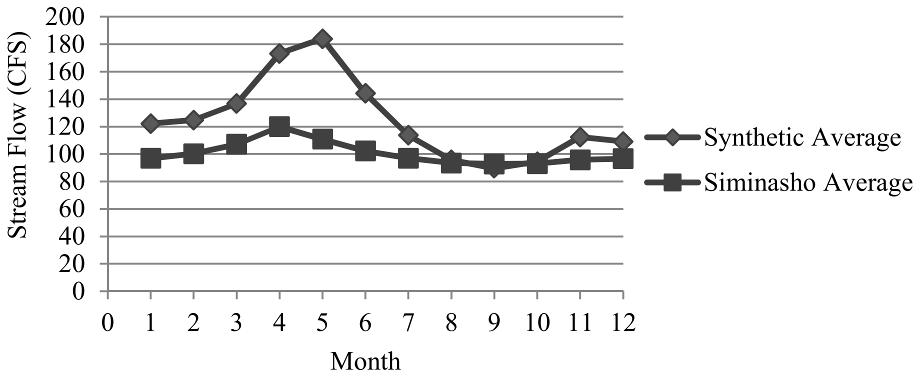

Figure 8. 5th percentile synthetic average streamflow comparison. Synthetic average generated from Mill, Beaver, and Shitike compared to Siminasho.

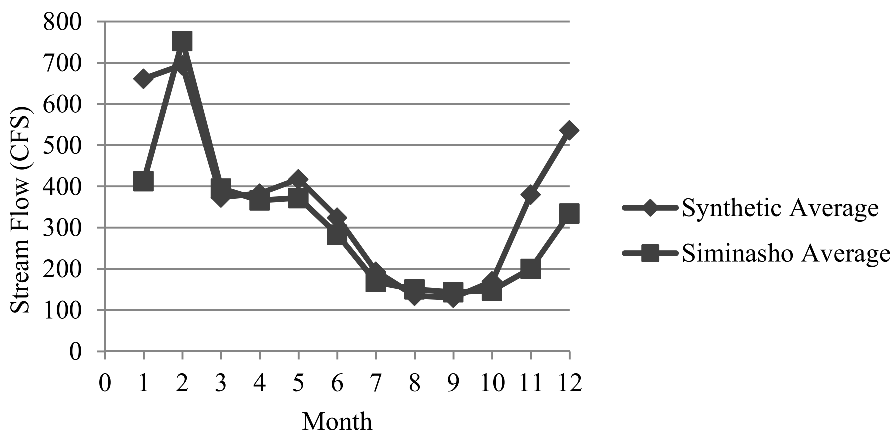

Figure 9. 95th percentile synthetic average streamflow comparison. Synthetic generated from Mill, Beaver, and Shitike compared to Siminasho.

Eliminating the Mill Creek drainage basin from the data set, the synthetic and actual average curves more closely aligned at both Kahneeta and Siminasho. For the 5th percentile, the synthetic average is lower than actual average recordings at Kahneeta and for the 95th percentile, the synthetic average is higher than actual average recordings at

Kahneeta. Using the synthetic average flows for design of improvements is slightly more conservative than the actual Kahneeta or Siminasho data alone. In addition, the developed synthetic average flows capture variability over the longest available record at Shitike Creek, (Figure 10 and Figure 11).

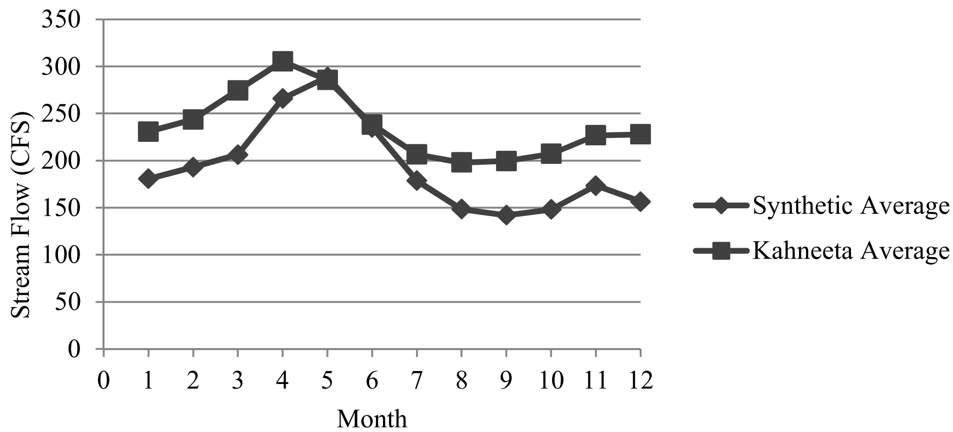

Figure 10. 5th percentile synthetic average streamflow comparison. Synthetic generated from Beaver, and Shitike compared to Kahneeta.

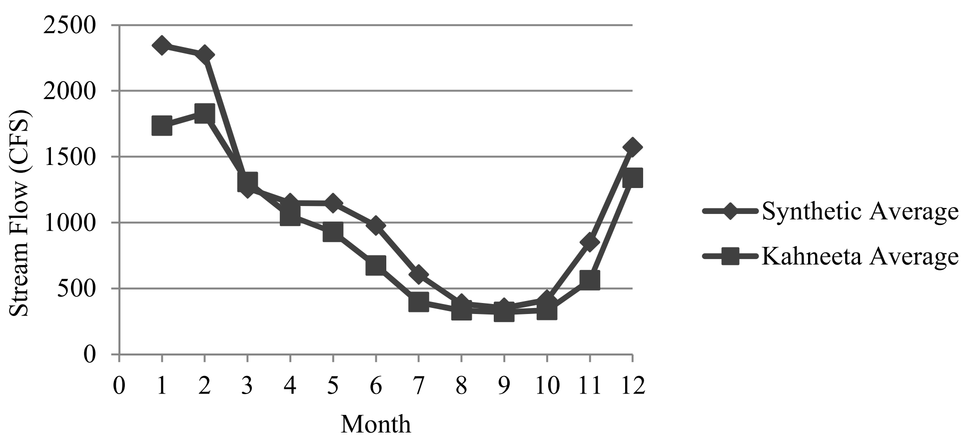

Figure 11. 95th percentile synthetic average streamflow comparison. Synthetic generated from Beaver and Shitike compared to Kahneeta.

The values listed in Table 3 were used as the design flows for the Warm Springs River at the hatchery. Values for the months of January, April, and May are of specific importance because fish are likely to be present. A summary of the synthetic analysis results is included as Appendix D.

Table 3. Design flow summary (cfs).

Month	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
5th Percentile	180	193	206	265	288	235	178	148	142	148	173	156
95th Percentile	2343	2274	1259	1147	1146	976	604	383	351	412	851	1571

Water Quality Sampling

The water quality results indicate that the sand filters are providing some level of pre-treatment, however the backwash cycle frequency is negatively impacting the effectiveness due to an indicated average turbidity of 3.4 NTU and TSS of 15 mg/L. After a backwash cycle, all three sand filters experience a spike in both turbidity and TSS for at least the first 8 minutes. Sand Filter 2 experienced the most extreme spike in both turbidity and TSS reaching levels of 15 NTU and 42 mg/L, respectively. Representing a 180% and 341% increase relative to average river samples. Sand filter water quality spikes are common after backwash cycles, so a 'purge' releases backwash water before bringing the filter back on line. The other two sand filters experienced spikes that are summarized in Table 4.

Table 4. Percent increase in effluent turbidity compared to river effluent.

Filter	TSS	Turbidity
1	113%	253%
2	180%	341%
3	87%	194%

Figure 12 and Figure 13 summarize the water quality testing results. The testing lab ran studies per the methods indicated to determine the lowest compound presence level that can be detected with accuracy and deemed that the 'reporting limit.' Results are labeled 'not detected'; for any value lower than the reporting limit for that analyte. Four

of the samples measured resulted in no detection of the analyte of interest. The figures show the baseline; measurements taken in the river prior to sampling downstream of filters.

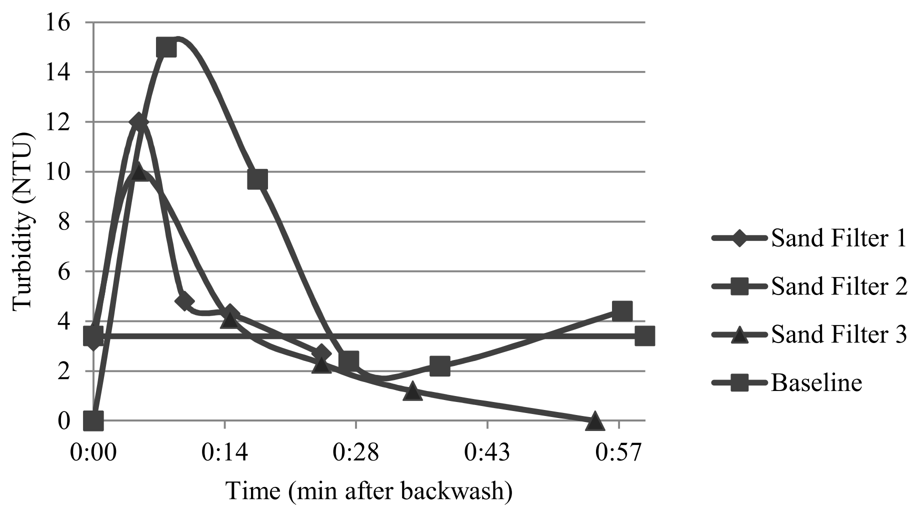

Figure 12. Turbidity sampling results.

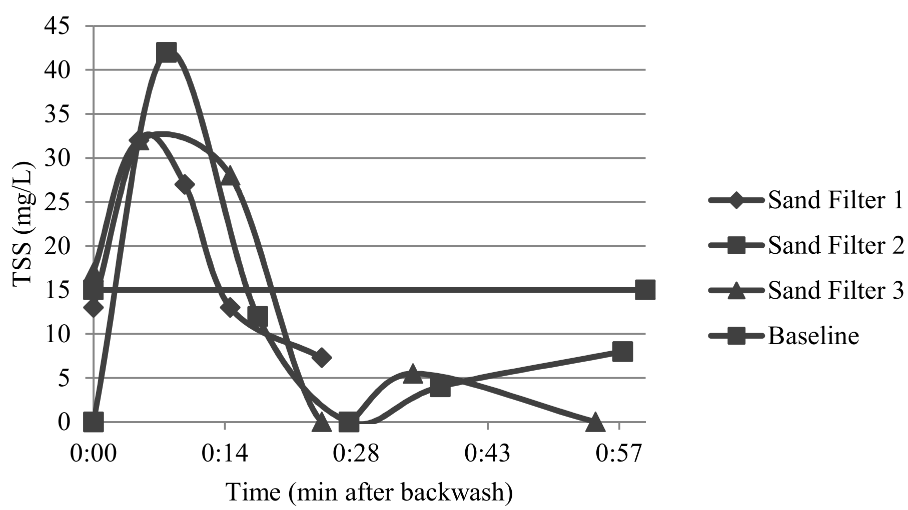

Figure 13. Total suspended solids sampling results.

Additional testing throughout the year would be necessary to determine whether turbidity or TSS spikes occur following high flow events or rain events, however based on the limited testing completed the water near the hatchery intake, in general, has a fairly low level of turbidity and TSS.

The results indicate that the sand filters are not providing consistent and effective removal of TSS and turbidity. Although all three sand filters are producing water quality results that are eventually under the baseline levels of the river, the water quality is not significantly improved by the existing sand filters, which impacts the effectiveness of the downstream UV disinfection system. Currently, the automatic backwash cycle appears to be backwashing each filter every 60 minutes. Typically a backwash cycle results in a spike in turbidity and overall water quality for several minutes following the backwash. With the current frequency of backwash and the lack of filter material maintenance, the spike in poor water quality is being introduced into the system for a significant portion of time.

Concepts

The primary distinction between the three developed concepts are in the types of intake screens used, the methods used to clean the screens, the location of the intakes and screens, and the improvements identified to reduce summer water temperatures and the deposition of sediment near the intake (Table 5).

Table 5. Summary of concepts.

Concept	Location	Screen Type	Cleaning Type
1	Existing Intake	Rotating Drum	Continuous rotation
2	Existing Intake	Fixed Vertical Plate	Mechanical Brush
3	New, Upstream	Rotation Drum	Continuous rotation

Appendix E provides a concept evaluation matrix comparing the improvements, advantages and disadvantages described in the following section.

<u>Concept 1 – New Rotary Drum Screens in Modified Existing Intake Structure</u>

Concept 1 includes modifying the existing intake structure in order to replace the existing fixed static drum screens with rotary drum screens. The rotary drum screens have been preliminarily sized to meet the maximum demand flow of the hatchery of 40 cfs as well as the design criteria for fish screening for both velocity and screen submergence. 40 cfs was used as the target, however it must be noted that 40 cfs can only be drawn into the intake if adequate bypass flow is available; a hatchery operational requirements that this conceptual analysis does not investigate. Drum screens have been sized so that during

high flow conditions submergence does not exceed 85%. Preliminary sizing yields two 88-inch diameter 10-ft 8-inch long rotary drums, Figure 14.

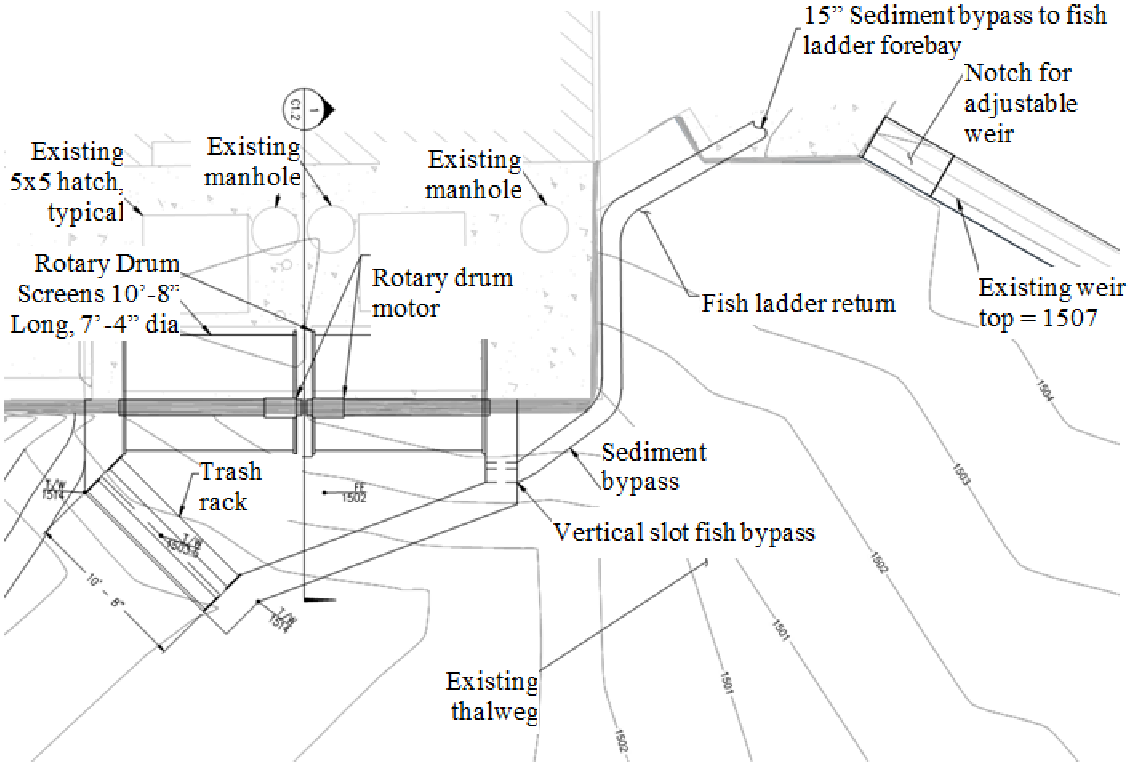

Figure 14. Concept 1 Plan Modified Intake, Rotary Drum Screen (Bennett, 2013).

The rotation of the proposed drums will prevent buildup of ice and clogging of the screen. Although the rotation alone will likely suffice in preventing frazil ice build-up, during low temperatures the mechanical components of the system will slow down. As a preventative feature, a warm water diffuser bar has been incorporated as part of Concept 1. The warm water diffuser bar will be installed downstream of the newly located trash rack and mounted at the low water surface elevation. Warm water would be piped from the existing 3-inch diameter hot water line that is connected into the existing travelling screen bays.

The existing intake structure will be enlarged at the front side of the structure, creating an angled opening that is aligned perpendicular with the existing thalweg. The intake structure opening has been sized so that one of the two existing trash racks can be re-purposed in the new location. The trash rack will be mounted above a 2-ft wide sill similar to that of the existing structure, at elevation 1503.5 ft. The new sill will be at a similar elevation of the modified existing sill at 1503.2 ft. The slab between the sills will have a finish floor elevation of 1502 ft creating a 1.2 ft deep sump. The new structure includes a fish bypass and sediment bypass. The fish bypass is a vertical slot with an invert elevation of 1506 ft. The sediment bypass is conceptually shown as a 15-in diameter opening with an invert elevation of 1502 ft. Refinement of the size and position of this bypass would occur during design to optimize sediment transport past the screen. The sediment bypass invert elevation is set flush with the finish floor of the concrete slab so that any sediment that accumulates within the area in front of the new screens will be sluiced downstream (Figure 14 and Figure 15).

The sluice pipe shall be routed around the outer face of the existing intake structure, across the fishway exit and along the interior wall within the fish ladder, and discharging above the finish floor of the fishway entrance forebay. Periodically, the intake structure should be temporarily closed off with panels so that the structure can be fully drained and allow for sediment that has built up in front of the intake screens to be sluiced out of the intake through a gate valve. The sluicing pipe gate valve can be outfitted with an electric motor operator to allow for automated operation of the valve.

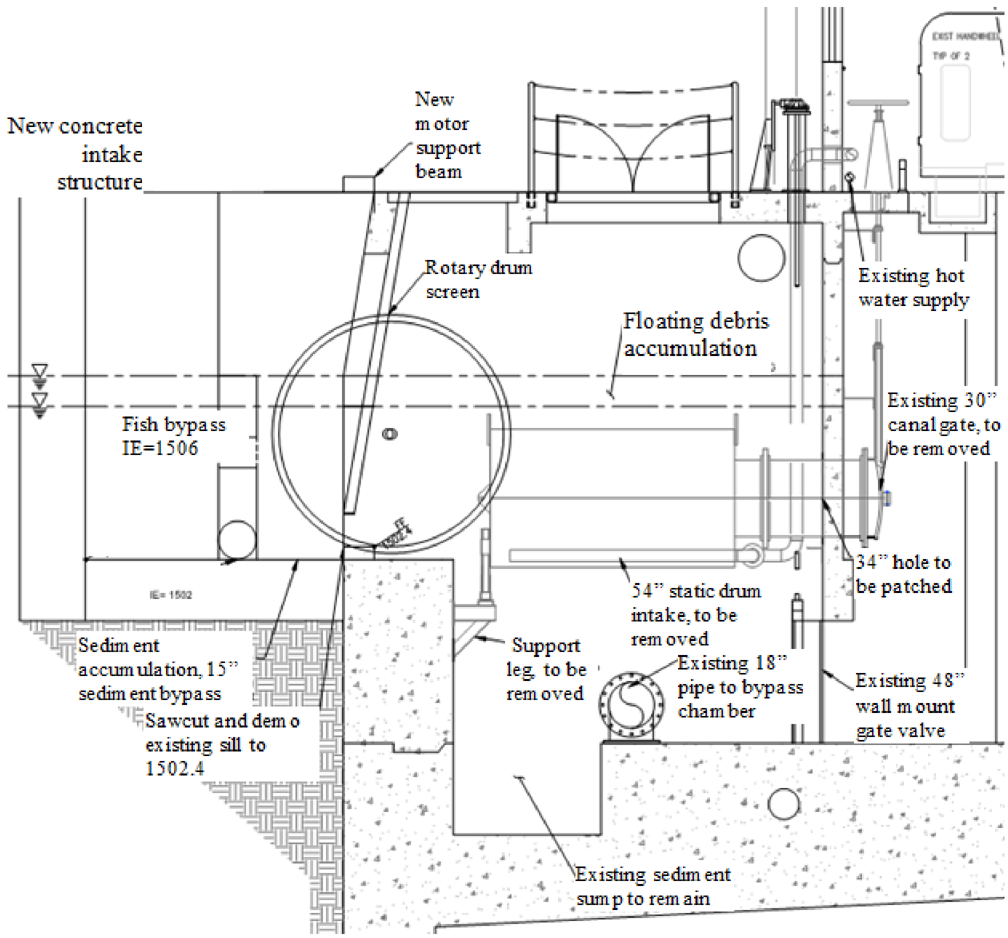

Figure 15. Concept 1 modified intake section (Bennett, 2013).

The existing 36-inch sluice pipes within the intake forebays are intended to release sediment accumulation within the intake sumps. With the reconfiguration of the intake structure, the sediment accumulation within the forebays and existing sump will likely decrease. However, visual inspection of the forebay sediment sump with the use of a dip-stick should occur on a monthly basis to ensure minimal sediment is accumulating within the sump. It is likely that floating debris will accumulate within the forebays due

to the nature of rotary drum screens. The existing separation wall between the forebays and the travelling screen chambers will act as a baffle, preventing the floating debris from entering the hatchery, however visual inspection and routine maintenance to remove the floating debris is recommended on a monthly basis.

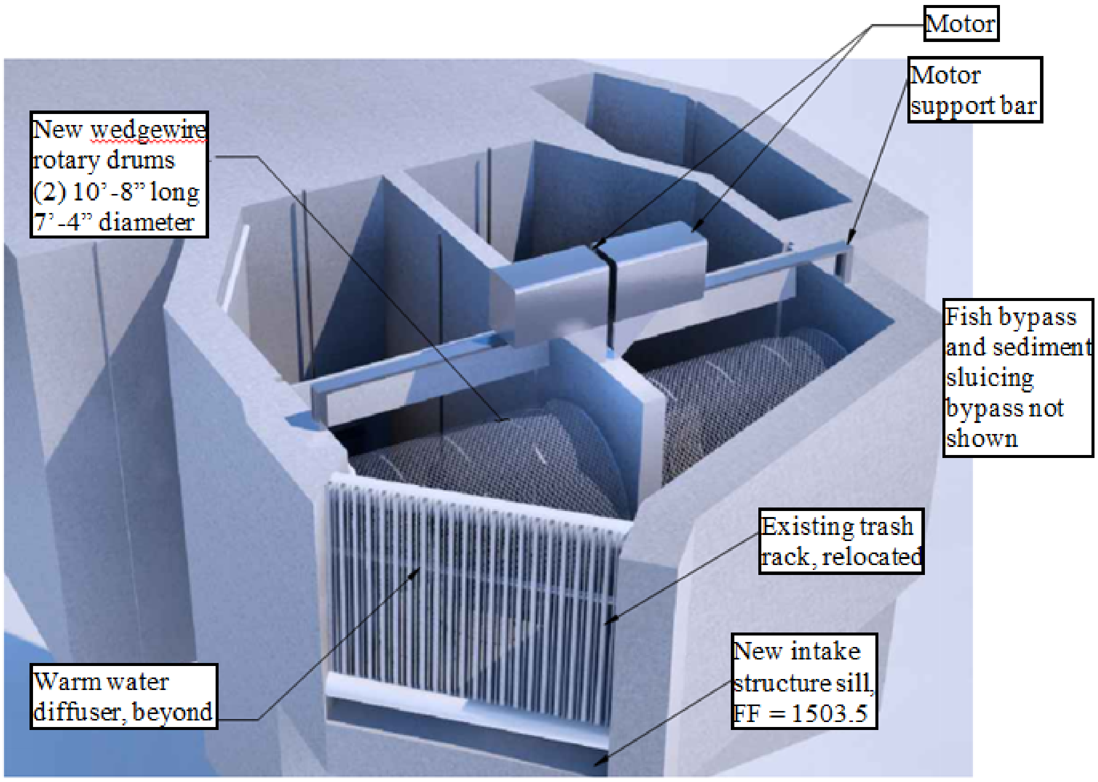

Figure 16. Conceptual view of modified existing intake structure (Carey, G. and Bennett, C., 2013).

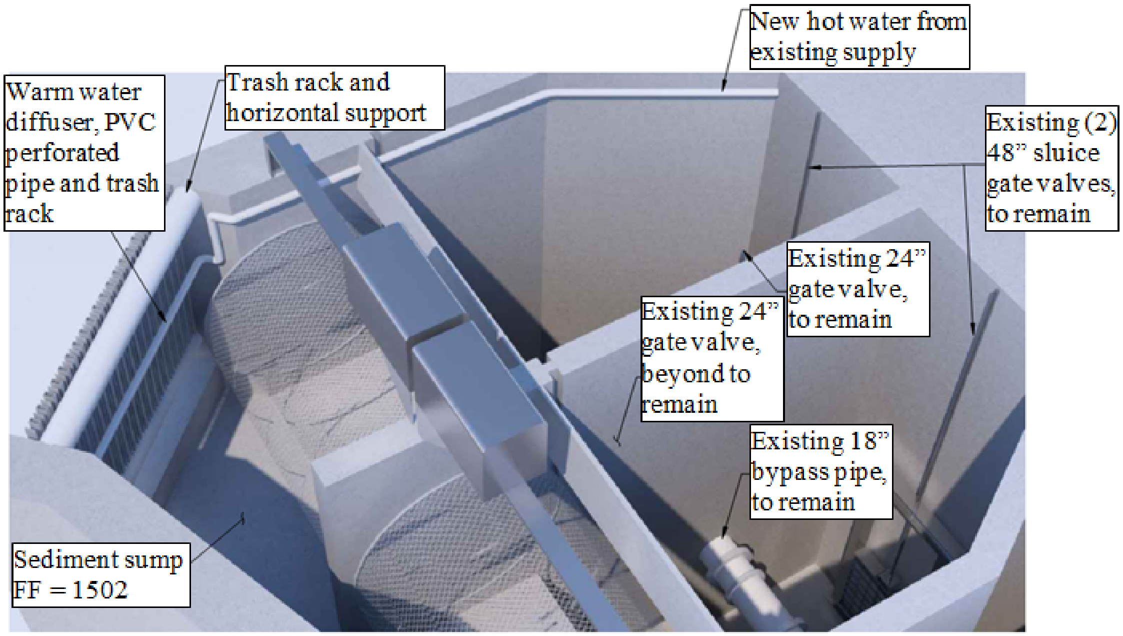

Figure 17. Conceptual view of modified existing intake structure (Carey, G. and Bennett, C., 2013).

In addition, Concept 1 includes retrofitting the existing spillway with an adjustable height weir to improve sediment transport past the hatchery intake. A portion of the existing spillway will be notched and replaced with an adjustable height weir. From the top of the existing weir to the top of the downstream apron is 3.5-ft, therefore a 3.5-ft adjustable weir would provide the most minimal impact to the existing monolithic concrete structure. The ability to lower the existing weir in this notched area would increase flow past the front of the intake. The most recent survey indicates elevations in front of the existing intake vary from 1504 ft at the furthest upstream corner of the intake to 1501 ft on the most downstream corner of the intake. These elevations indicate that material is depositing near the upstream corner of the structure and entering the intake since the existing intake structure sill is at 1503.5 ft. Lowering the adjustable weir 3.5-ft

periodically, will likely prevent sediment build up in excess of 1503.5 ft. A more effective adjustable weir height would be 5-ft, however this would require substantially more retrofitting of the weir and existing apron (Figure 18 and Figure 19).

From record drawing review it was determined that a 12-inch condenser water return pipe was incorporated within the weir. To create the notch necessary for a 3.5-ft or 5-ft adjustable weir would require that the return pipe be terminated and capped making it unavailable for future use. Hatchery staff has indicated that the pipe is currently not utilized and not effective in its original intent.

From discussion with hatchery staff, it has been determined that a future installation of a lamprey fish passage structure is planned. If a lamprey fish passage structure is planned, the location of the adjustable weir should be installed further east so that lamprey are drawn towards the passage structure due to the attraction flow. However, the adjustable weir installed further east might not be as effective as it will be further away from the intake and fishway exit, the primary area of sedimentation concern.

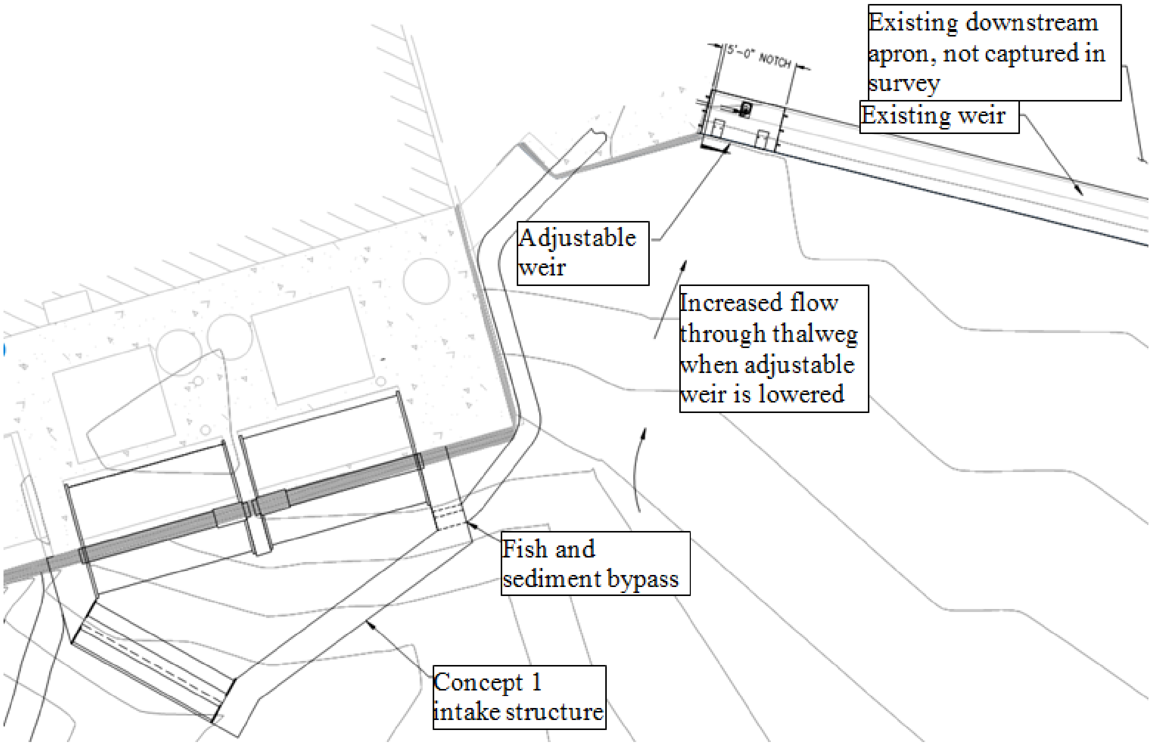

Figure 18. Concept 1 intake structure with adjustable weir (Bennett, C., 2013).

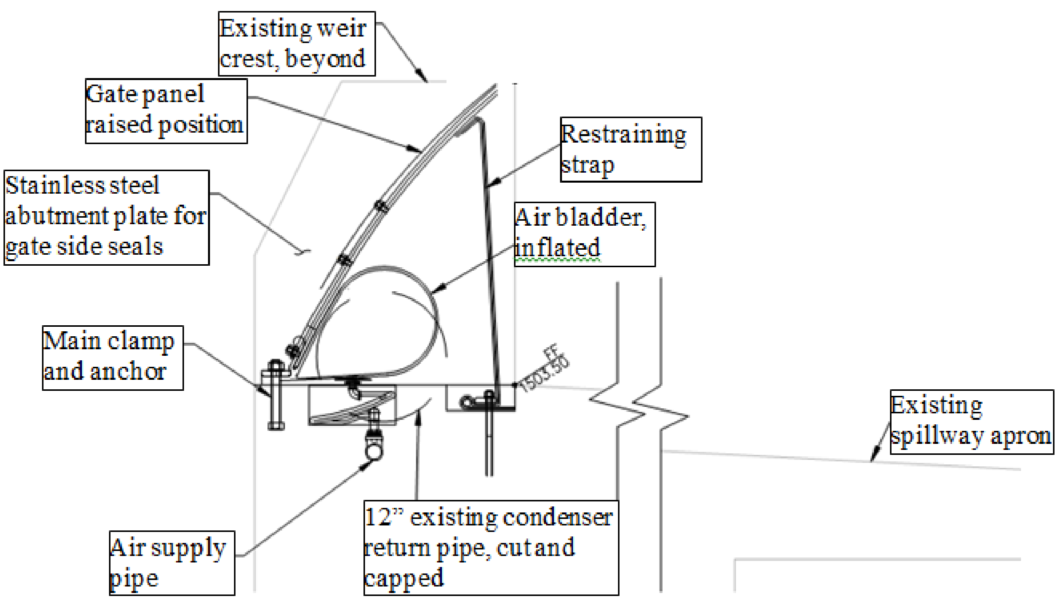

Figure 19. 3.5 ft adjustable weir section view (Bennett, C., 2013).

Concept 2 – New Fixed Vertical Plate Screens in Existing Intake Structure

Concept 2 includes replacement of the existing static drums with fixed vertical plate screens. Fixed vertical plate screens have been selected as an appropriate alternative to the static drums due to their proven effectiveness in environmental conditions similar to those at the Warm Springs NFH. Each static drum screen would be replaced with three 10-foot wide x 3.25-feet tall vertical screens, providing 100 square feet of screen area in each intake forebay and 200 square feet of submerged screen area in total, see Figure 20.

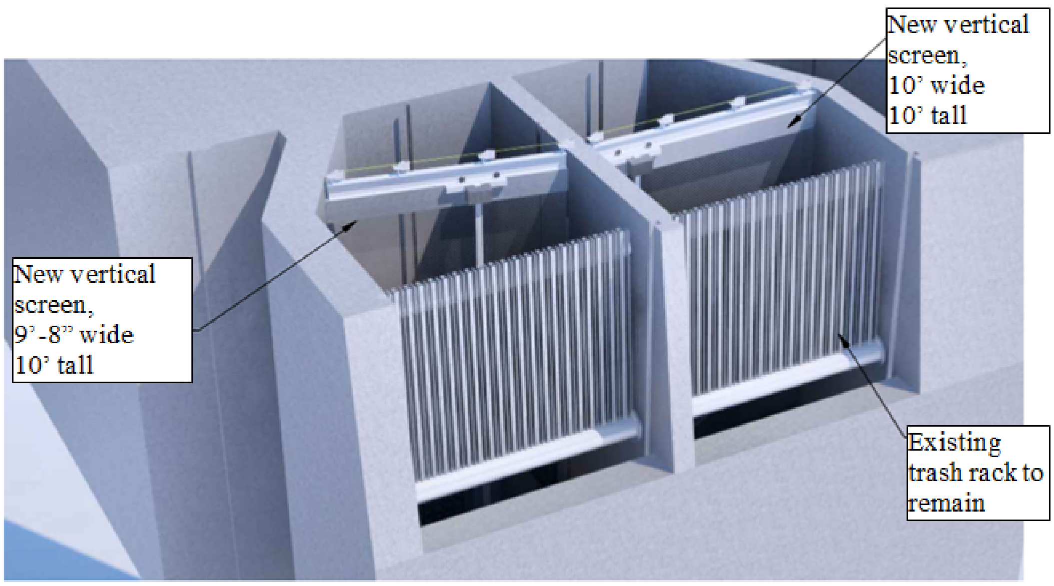

Figure 20. Concept 2 existing structure with fixed vertical plate screens (Carey, G. and Bennett, C., 2013)

Fixed vertical plate screens will fit in the existing intake structure when installed on top of the existing 'shelf' above the sediment sump. Within forebay #1, a vertical plate screen and screen cleaning system will fit with no conflict with the appurtenances within the intake structure other than the existing manhole ladder shifting to the wall separating

forebay #2 and travelling screen forebay #2. Within forebay #2, the screen will fit at an angle of 55 degrees with minimal conflict. In forebay #2 the screen will actually be 11 feet- 1/2-inch wide and will require the relocation of the existing 24-inch sluice gate valve and therefore the associated 18-inch bypass piping. The sluice gate valve and piping will need to be shifted northwest and the manhole ladder relocated as in forebay #1 (Figure 21 and Figure 22).

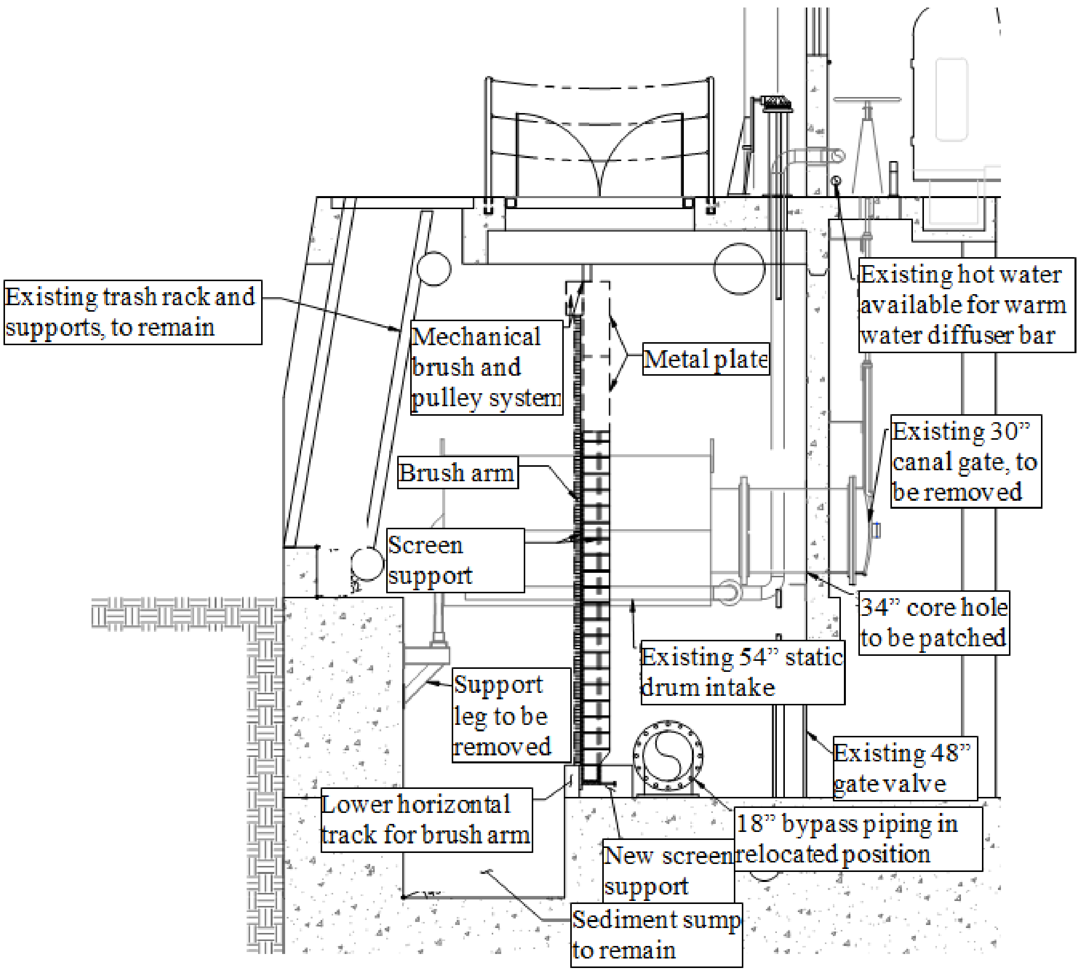

Figure 21. Concept 2 modified intake section (Bennett, C., 2013).

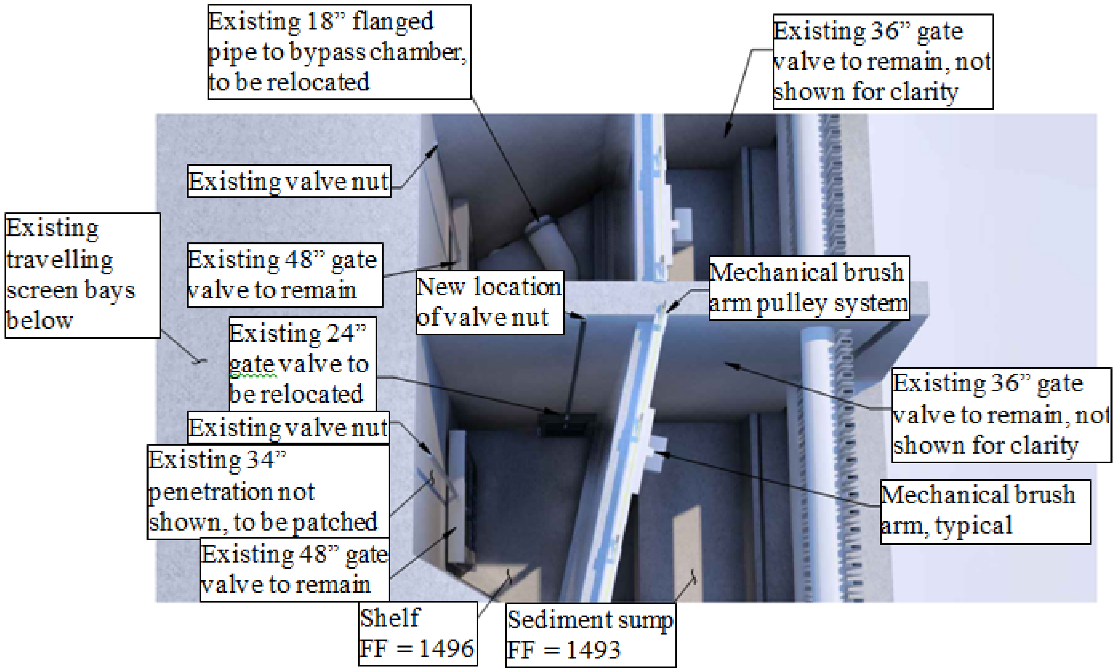

Figure 22. Concept 2 24-inch gate valve relocation (Carey, G. and Bennett, C., 2013).

A fixed vertical plate screen is mechanically simple, easy to seal, and can be cleaned by either a mechanical brush arm on the front side of the screen or an air-burst system on the backside of the screen. Due to the frazil ice conditions experienced at this location, a warm water diffuser similar to that described in Concept 1 would be required. The warm water would ensure that the mechanical arm maintains functionality during freezing conditions by preventing frazil ice from forming on the screen and brush. Although an air burst system could be utilized instead of the mechanical arm, the mechanical arm was selected for this design since it is in a protected location and based on user feedback from other hatchery operators (Figure 23).

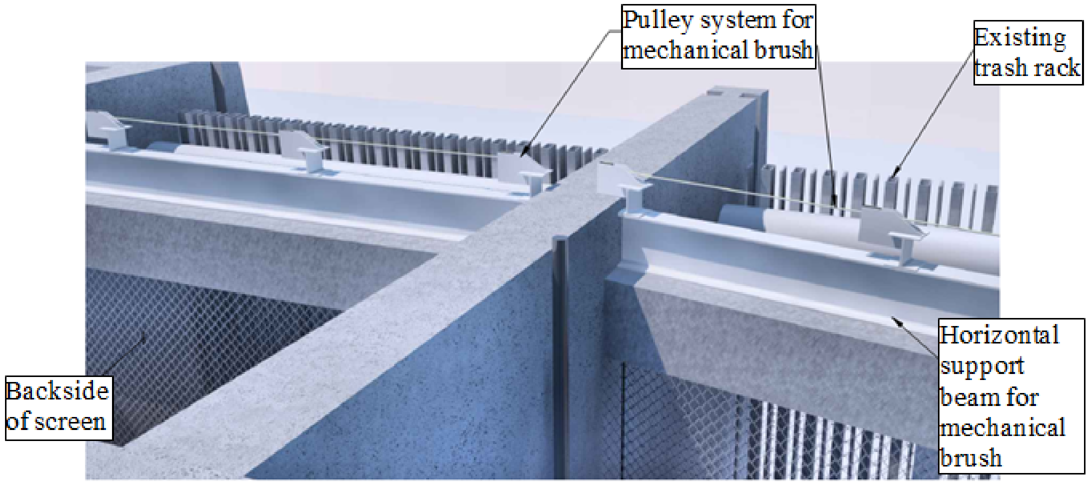

Figure 23. Concept 2 mechanical brush screen cleaning (Carey, G. and Bennett, C., 2013).

Hatchery intake demand varies throughout the year between 20-40 cfs. Screens in both forebays, when operating simultaneously to supply the maximum hatchery demand of 40 cfs, will meet the NMFS approach velocity criteria.

To help minimize the amount of sediment in the intake screen, an instream structure, such as a groin, is considered. The groin will consist of angular, interlocking rock. The functionality of the groin is to redirect flow, encourage sediment deposition behind the structure, create a thalweg in a different location, and a scour hole at approximately the tip/end of the groin (Figure 24).

The groin will be angled at approximately 90 degrees from the bank. The height of the groin will not exceed the bank height but is required to be above the high fish passage flow water surface elevation (95th percentile), which is 1508 in Warm Springs. At this time, the overall height at the tip of the groin will be approximately 5 feet. The

groin will need to be placed far enough upstream of the intake to ensure the sediment that is deposited behind the structure does not have a negative effect on the intake screens. Using the Lane's relationship, it was determined that the D_{50} of the rock will be approximately 0.9 feet in diameter. The precise dimensions and location of the groin will be determined at a later date after further analysis for optimization of the groin.

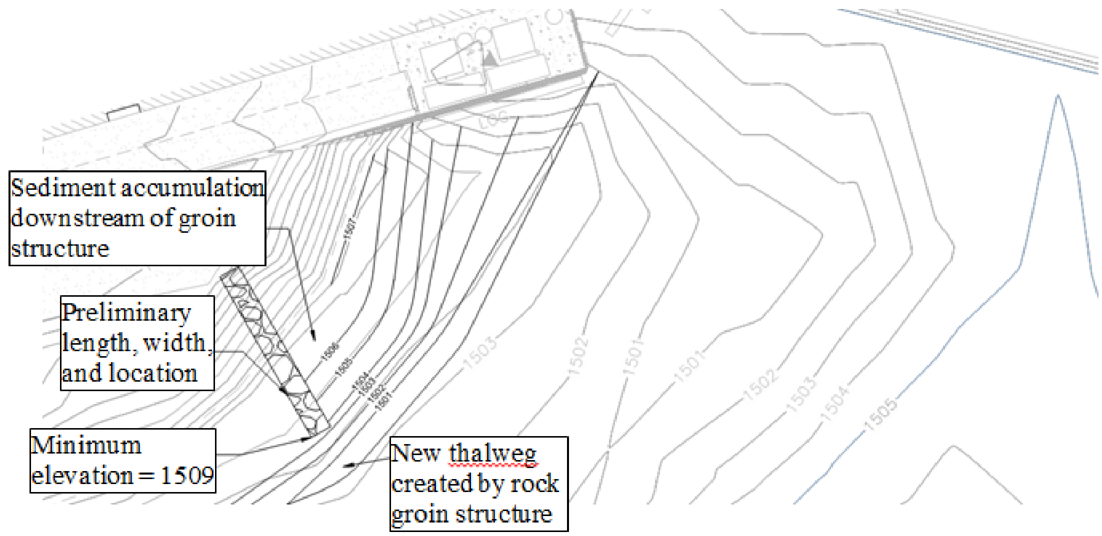

Figure 24. Concept 2 groin structure (Bennett, C., 2013).

Maintenance of the groins consists of potentially having to replace the material if it shifts or is swept away by a high flow events. The replacement of material should be done immediately after a high flow event to reduce the potential for excessive erosion. Also, the groin should be monitored for unreasonable erosion near the bank and evaluated for repair if substantial erosion occurs. Additionally, the groin should be monitored at a minimum of once a year and after each high flow with a return period greater than two-years.

Concept 3 – New Rotary Drum Screens in New Intake Structure Located Upstream

Concept 3 includes a new intake structure, rotary drum intake screens, warm water diffuser, and new hatchery intake pipe. A new intake structure would be located approximately 300 feet upstream of the existing intake structure along the north bank. The intake would be a concrete structure similar in configuration to that of Concept 1 (Figure 25)

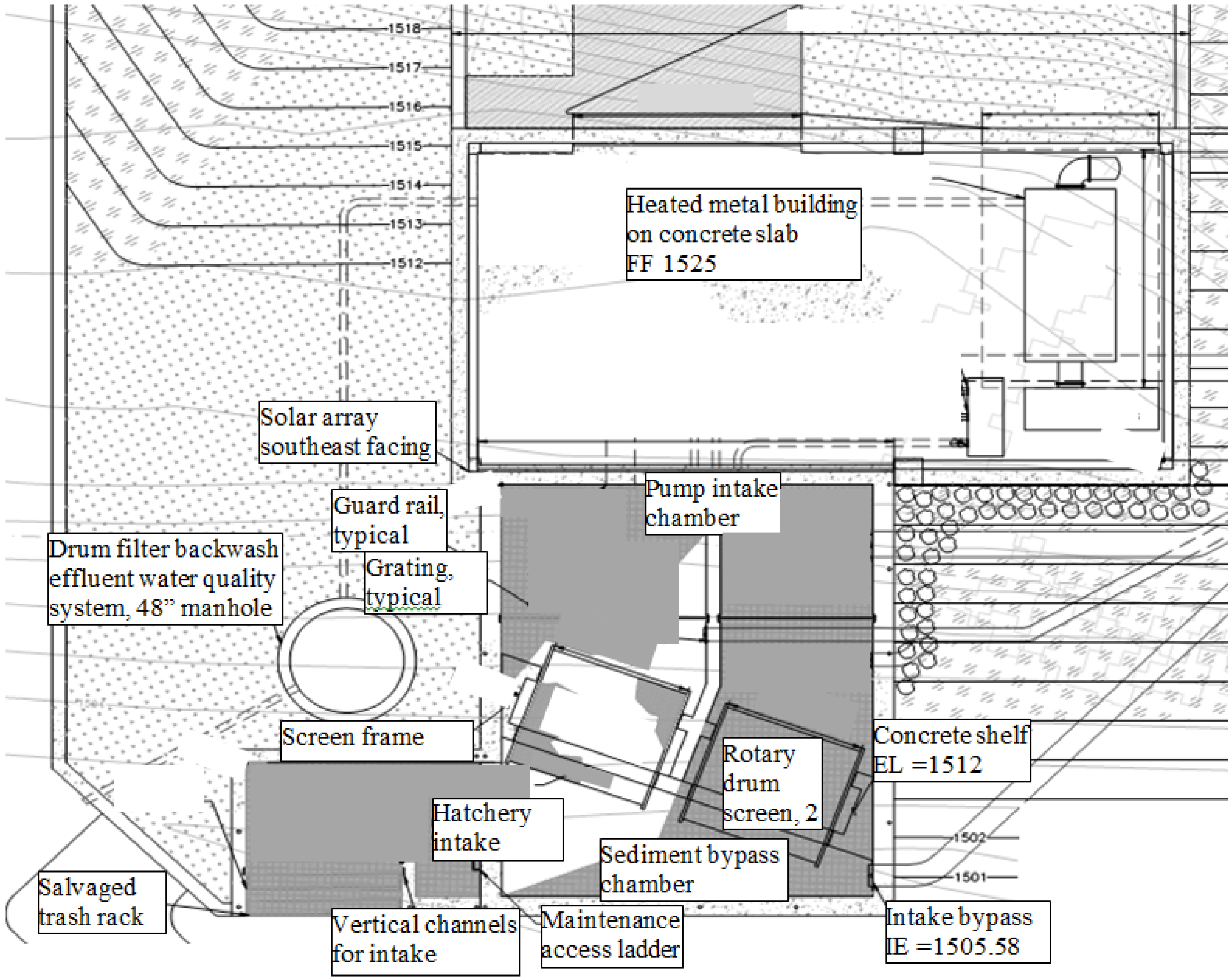

Figure 25. Concept 3 intake site plan at new intake location (Bennett, C. and Kingsley, S., 2013).

The structure configuration will encourage sediment to bypass the intake structure completely or exit the intake structure through the primary 15-inch sediment bypass outlet, refinement of the size and position of this bypass would occur during design to optimize sediment transport past the screen. Additionally, a sediment sump and floating debris accumulation pool has been created behind the intake screens to further decrease the amount of material that makes it to the hatchery. Finally, the existing intake structure will act as a second pre-settling basin (Figure 26, Figure 27, and Figure 28).

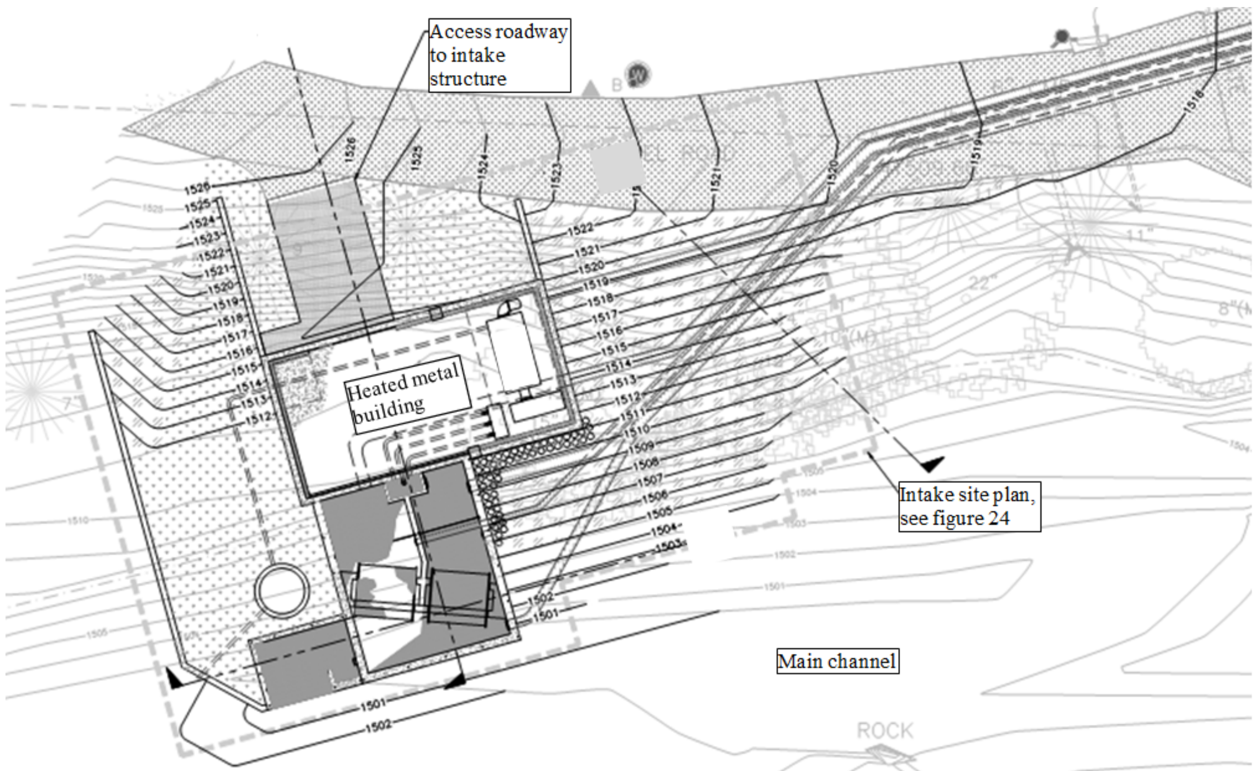

Figure 26. Concept 3 intake site plan at proposed new intake (Bennett, C. and Kingsley, S., 2013).

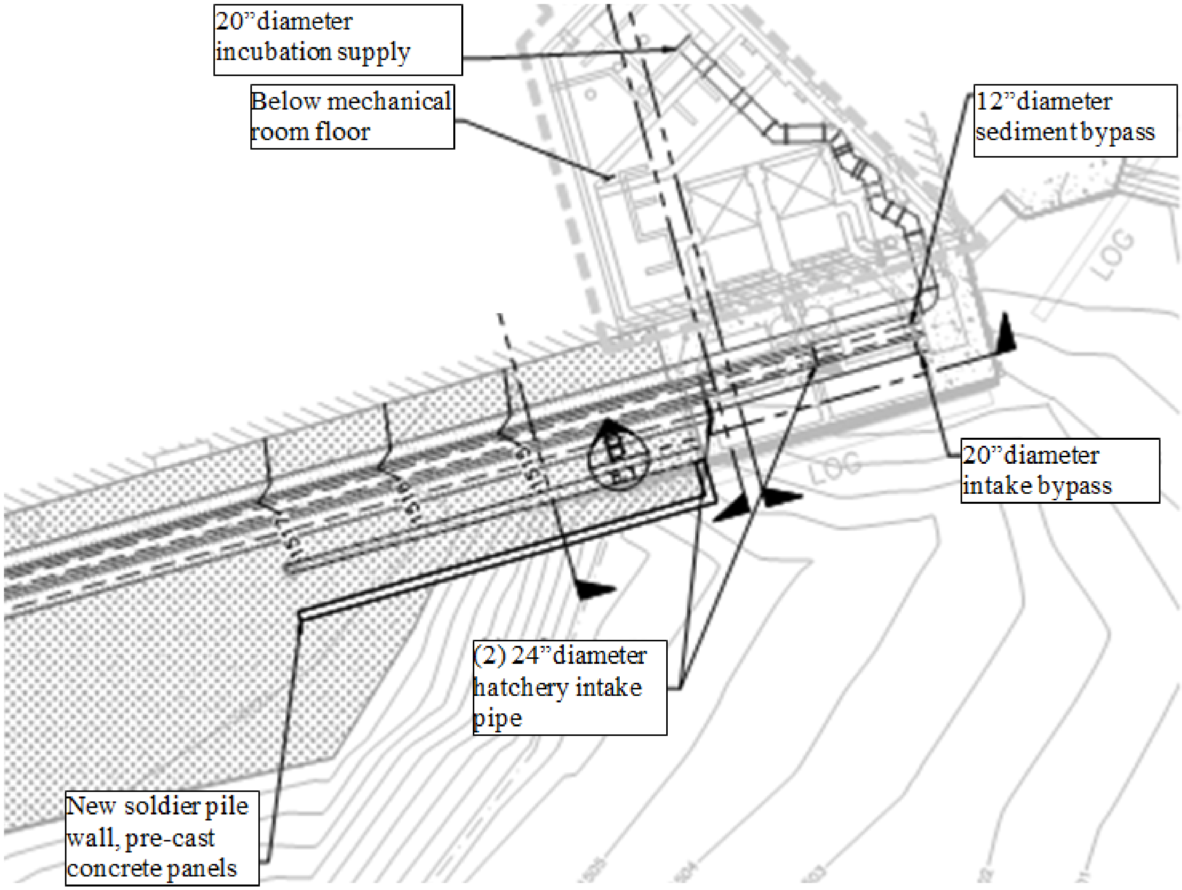

Figure 27. Concept 3 intake site plan at existing intake (Bennett, C. and Kingsley, S., 2013).

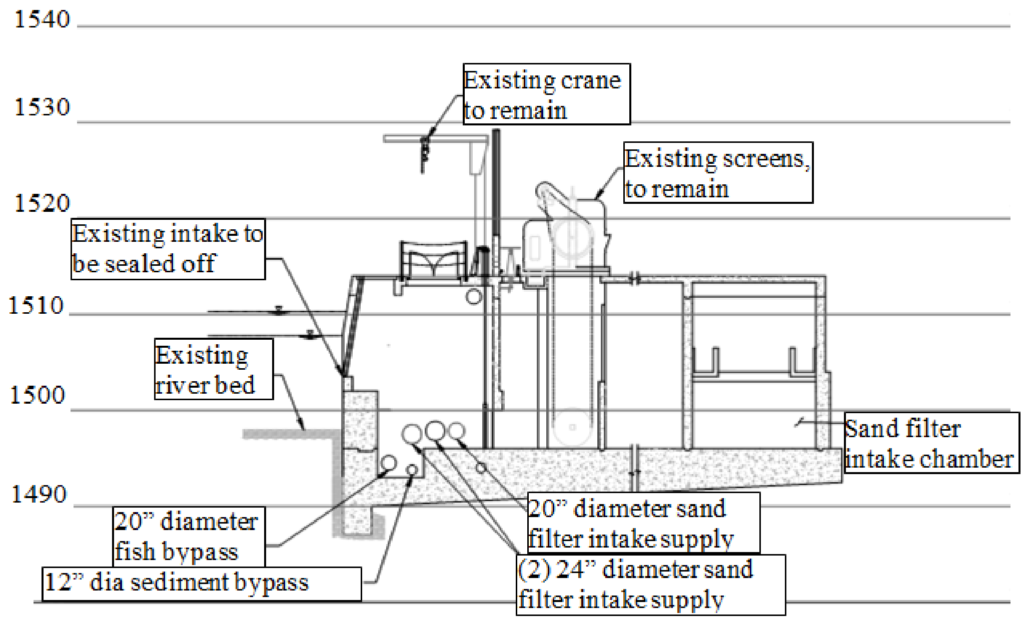

Figure 28. Existing intake section view (Bennett, C., 2013).

Water passing through the screen will be transported to the hatchery via one 24-inch hatchery intake pipe that is outfitted with a sluice gate valve within the new intake structure. The new hatchery intake pipes will run in parallel with the existing stream bank at a depth that varies from approximately 6 to 10 ft. The weir downstream of the intake slows the river down creating a stagnant shallow pool. It is believed that the shallow depths and exposure to summer sun increase water temperatures just outside of the intake. An intake located upstream of the weir will allow for intake water temperatures more consistent with naturally occurring temperatures upstream which are believed to be an improvement over water temperatures just upstream of the weir.

Frazil ice is less likely to occur in turbulent water, therefore moving the intake structure upstream of the stagnant pool will decrease the likelihood of frazil ice accumulating at the intake screen, however a warm water diffuser bar should still be

included as a preventative measure. In addition, Concept 3 includes an enclosed heated structure to house small maintenance equipment items and mechanical components as well as a hoist for removal of screens for maintenance (Figure 29). The enclosed structure is not directly related to preventing frazil ice from forming on the intake screen but provide hatchery staff an enclosed location for routine maintenance, storage of maintenance equipment and future water quality improvement structures.

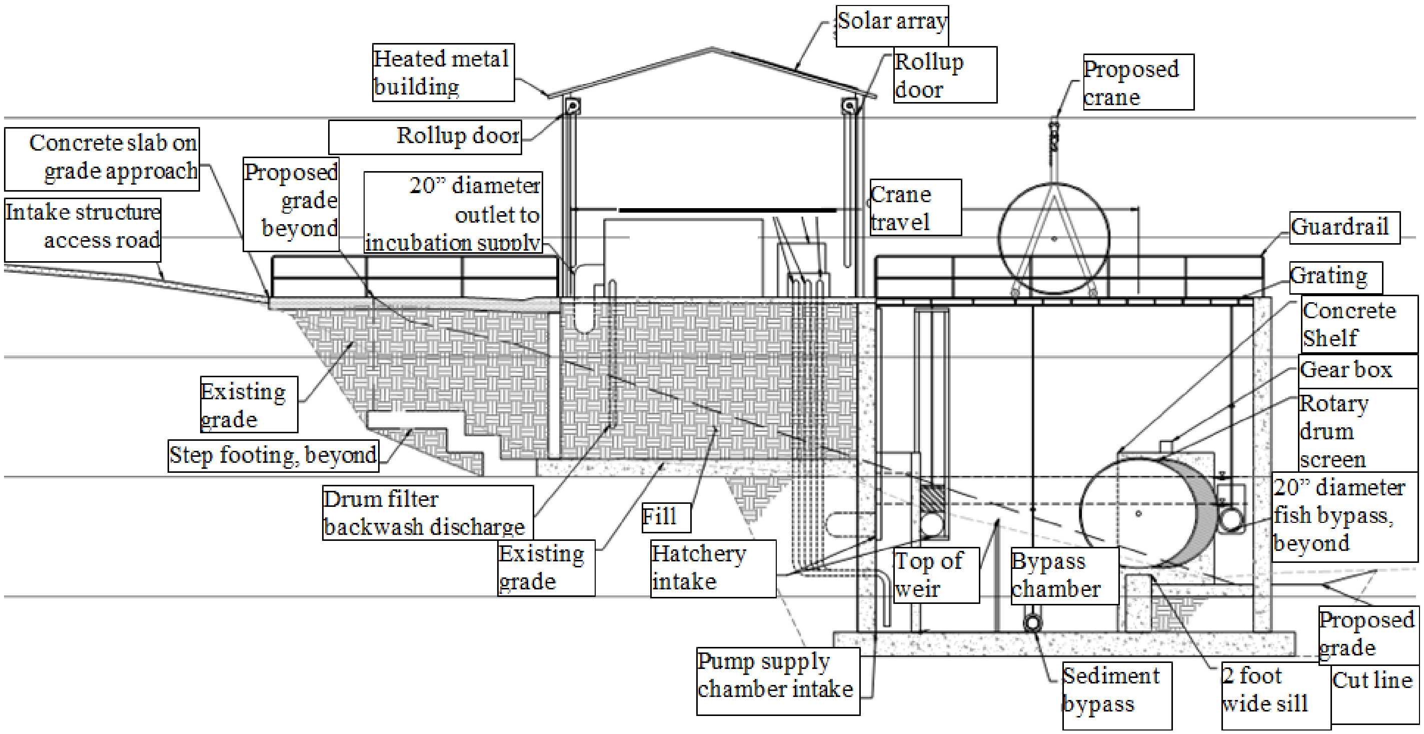

Figure 29. Concept 3 intake section view (Bennett, C. and Kingsley, S., 2013).

One disadvantage is that the new structure is no longer just outside the front door of the hatchery building. With minimal hatchery staff on-site, moving the intake structure upstream makes it more difficult for visual inspection and maintenance, in particular during inclement weather, or nighttime.

Concept 3 could be implemented in a phasing sequence with Concept 1 or Concept 2. With the new structure upstream, the existing structure can be enclosed permanently, enclosed for emergency opening only, or be maintained as a second intake structure if hatchery water demand increased beyond 40 cfs.

Cost Estimates

A rough order of magnitude cost of construction for each concept was developed and the details of the economic analysis are in Appendix F. The analysis shows that Concept 2 has the lowest estimate total of $323,000, followed by Concepts 1 and 3, estimated at $1.1 million and $2.8 million, respectively. The estimated operation and maintenance costs do not vary greatly between the three intake screen concepts; Concept 2 would be the least expensive, $6,700, followed by Concepts 1 and 3, estimated at approximately $7,100.

Concept 1

The cost of a 3.5-ft adjustable weir is roughly $60,000 and $90,000 for a 5-ft weir, which includes a simple mechanical cabinet and compressor. The above cost does not include the retrofitting of the monolithic concrete spillway structure, however, demolition costs for both a 3.5- and 5-ft adjustable weir are included in the cost estimate breakdown within Appendix F.

Concept 2

The cost of a groin depends on its size and ease of access and constructability. At this preliminary level of design, the groin has not been fully designed or located therefore a budgetary allowance of $6,500 is included in this estimate. This budgetary allowance was derived assuming a unit cost of $105/ton for light loose riprap and preliminary sizing.

Concept 3

The cost of Concept 3 is inclusive of civil site work and structural work associated with relocating the intake upstream. There are a number of physical constraints that drive up the cost of construction for this concept including shallow bedrock, shallow fall between proposed intake and existing point of connection, adjacent river bank, and adjacent existing hatchery building structure. There is a fairly narrow area available for pipe trenching therefore construction will likely require temporary shoring. Temporary shoring has been preliminarily designed as timber soldier piling. The work associated with the temporary construction, pipe trenching, pipe installation, and backfilling has been estimated to be $626,000 or 22% of the total estimated cost of construction. The preliminary design and therefore estimate was determined without the benefit of a geotechnical investigation or geotechnical engineer's recommendation.

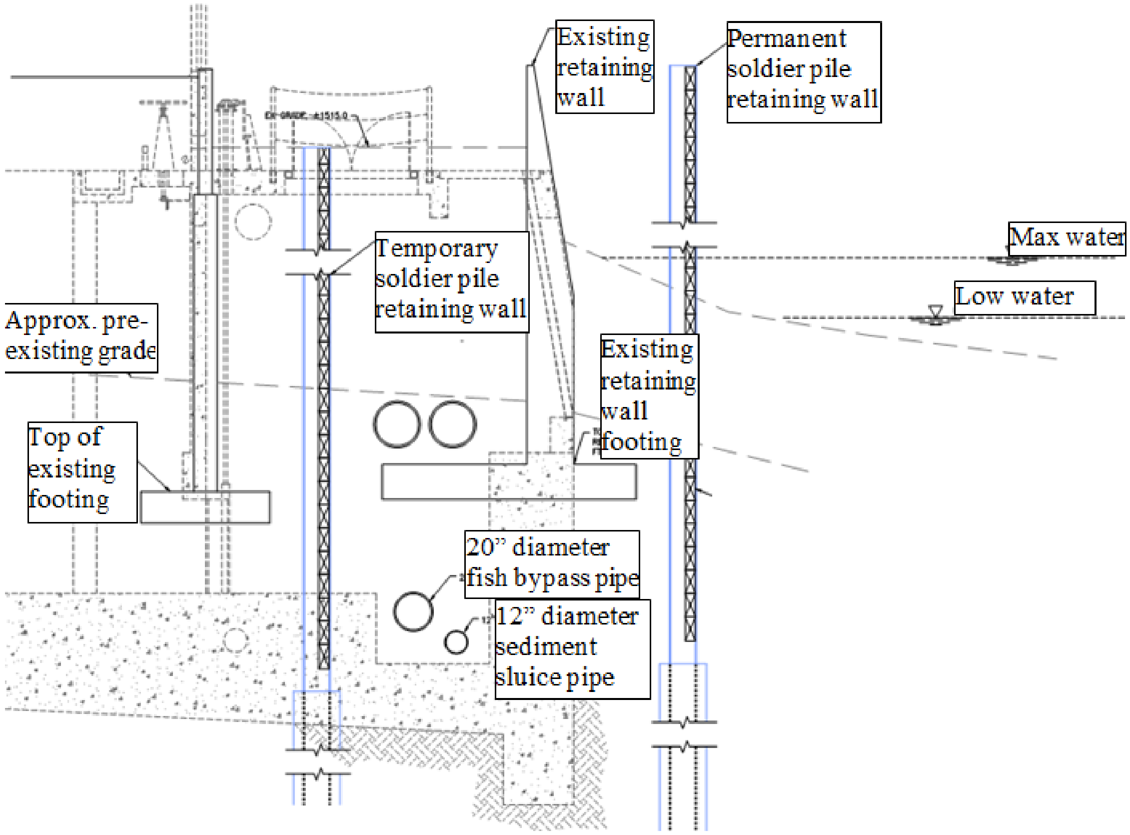

Figure 30. Construction concept for installation of supply pipes, showing site constraints (Bennett, C. and Kingsley, S., 2013).

DISCUSSION

USFWS wishes to improve the processes for collection, screening, and treatment of hatchery production water. In no particular order, USFWS identified five objectives; formation of ice on existing intake screens, sediment and debris collection in intake, high water temperatures, effectiveness of existing screen cleaning, and effectiveness of existing sand filters. Three concepts were developed to address these objectives, however physical and environmental constraints such as high and low temperatures cannot be altered or improved through means of construction. Concepts have been developed so as to provide opportunity for operational flexibility.

By investigating the various intake screen types available and assessing their advantages and disadvantages, it was determined that the existing screen type was not well suited for this particular installation. Research has indicated that cylindrical fixed screens are intended for deep water installation, where a cross directional current can be provided so as to transport debris away from and past the intakes. The existing intake chamber in its current configuration does not provide any cross directional current. In addition, cylindrical fixed screens are known to experience frazil and anchor ice issues when installed in too shallow of depths.

Rotating drum screens are mechanically complex but can be well suited for shallow water installation as long as the seasonal variation of water surface elevation allows the screens to operate within the desirable submergence range. Concept 1 proposed to install rotary drum screens at the location of the existing intake. The

installation of rotary drum screens will require structural modifications to the existing intake. The proposed modifications extend the intake structure out into the stream channel, making the intake structure closer to the thalweg of the channel. By moving the intake close to the thalweg, it is thought that water moving through the trash rack will be faster than it currently is and will therefore reduce the settlement of fine solids out of the water column within the intake chamber. Faster moving water is also an improvement against warm water temperatures. Although the water temperature within the stream cannot be improved within the scope of any of the concepts presented, faster water should theoretically be cooler than stagnant water that has pooled behind the existing weir.

Concept 1 includes the installation of an adjustable weir. The weir is proposed to be adjusted on occasion to flush out the sediment accumulating behind the weir and in particular near the intake. The location of the proposed adjustable weir has been selected to encourage or maintain the thalweg at its current location near the intake structure.

The rotation of the screens will dislodge pinned, leafy debris and keep the screened area clean. The rotation does result in a chamber behind the screens which must be maintained to prevent unmanageable accumulation of floating debris. The continuous rotation is also thought to be an improvement for the frazil ice concern. The proposed warm water diffuser bar will increase the water temperature just upstream of the rotary drums preventing ice from forming within the intake chamber and building up on the intakes. Without the warm water diffuser bar, the turbulence provided by the rotation might prevent ice buildup but it is recommended that the warm water diffuser is always

running during freezing temperatures so that there is added protection against the mechanical components freezing, slowing, or halting entirely.

Vertical fixed panel screens are fairly simple to install and mechanically simple. Concept 2 proposes to install vertical fixed panels in the existing intake chamber. Although it is thought that this screen type is well suited for this location, a cross directional current is needed but will be difficult to maintain due to the configuration of the intake chamber. The cross directional current is desirable to keep debris from building on the screens but also required for necessary fish screening criteria. Concept 2 proposes that a fish bypass pipe provide the current required to meet the fish screening criteria, specifically sweeping velocity. At this preliminary stage of concept development it is not yet confirmed that the necessary sweeping velocity can be achieved across the entire face (depth) of the screen.

Concept 2 includes the installation of a rock groin structure. The groin is hydraulic structure intended to encourage sediment accumulation just behind the rock structure rather than directly in front of the intake structure. A groin structure is not thought to be a better alternative to an adjustable weir, but does represent an opportunity for a similar effect with no impact to the weir structure.

Concept 1 and Concept 3 are very similar, with the exception that Concept 3 proposes to install a new intake upstream of the current intake location and much more civil improvements must be made. Concept 3 proposes to install the intake upstream with the idea that the selected location offers deeper and faster moving water. The existing intake structure has many chambers and baffles that served purposes that seem

unnecessary. A new intake upstream simplifies the intake chamber and ideally will make maintenance easier. Currently, workers must enter confined spaces to clean the existing intake chambers and due to the tight quarters not all of the built up debris is removed.

The relocation of the intake upstream requires the capital investment of a pump station. Although the pump station adds to the mechanical and electrical complexity of the system, the sump pumps act as a new barrier to sediment and provide further protection to the major hatchery mechanical operation.

RECOMMENDATIONS

It is recommended that USFWS consider developing Concept 3 further as this concept has the potential to best address all of the objectives identified yet there are still questions as to the effectiveness of the improvements presented. Formation and collection of frazil ice at the intake screens will likely be reduced by installing the intake within an area of stream with higher current. In stream temperature monitoring is recommended at the proposed intake location and compared with that at the existing intake. The comparison will provide quantitative data for confirming where the intake is best suited. It is recommended that USFWS identify two locations for monitoring in addition to the location recommended in this report. Installing a warm water diffuser bar to maintain the ambient temperature within the intake structure will also reduce buildup of ice on the screens. Increased water temperature can occur with the slowing of channel velocity. Rather than drawing from stagnant water just upstream of the weir, swift channel velocity upstream will likely be slightly cooler during summer months. Locating the intake upstream will likely reduce excessive collection of sediment within the intake structure because weirs are unnatural barriers to stream flow and cause sediment accumulation by decreasing channel velocity. By installing the structure at least 300 feet upstream, the channel velocity is faster and therefore less fine sediment is settling out of the water column at the screen location. It is recommended that water samples be collected and tested for total suspended solids. The sampling locations should correspond to those identified for temperature readings as these represent potential locations for the intake. It

is recommended that additional locations be identified between those that correspond to temperature. The sampling and testing will provide insight into where within the channel solids begin to fall out of the water column, what size solids fall out at what location, and overall what does the trend of solids falling out look like as flow approaches the existing weir.

The effectiveness of the screen cleaning system with Concept 3 is thought to be a significant improvement to the existing system. A trash rack will prevent larger debris from entering the intake chamber and damaging the screens. The rotary drum screens will constantly rotate and therefore remove pinned debris such as dendritic material off the screen face. Hatchery staff will need to visually observe the chamber behind the intake screens and remove floating debris but doing so will be easier than the current intake configuration. A worker will not need to enter a confined space to perform visual observation of debris and/or sediment buildup let alone perform the required maintenance.

At a rough order of magnitude cost of construction of $2.8 million, Concept 3 is the most expensive concept but it is believed to be the most effective improvement. Although all three concepts will continue to have operation and maintenance challenges, Concept 3 with additional design development, represents the best long term solution to addressing the objectives while improving the current operation and maintenance. More analysis is needed before a final recommendation can be made including collection of in-stream water temperature data and a quantification of the amount of sediment expected to accumulate near the proposed intake structure. However, it is also recommended that

additional and consistent operation and maintenance could also provide significant improvements to address the objectives in the short term.

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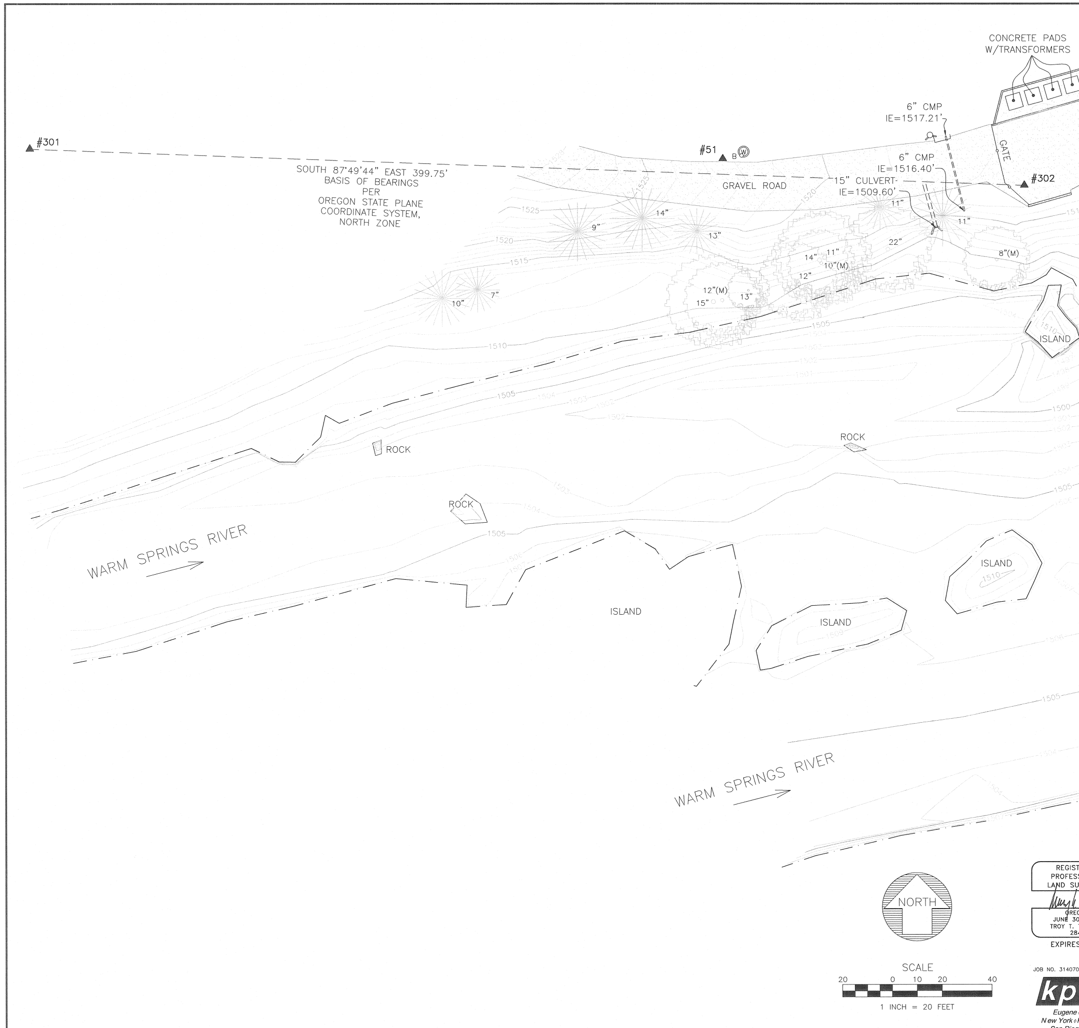
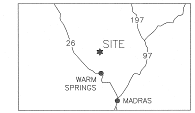
APPENDIX A EXISTING SITE SURVEY



LEGEND:

- BUILDING OUTLINE WITH DOOR
- BUILDING OVERHANG
- CONCRETE SURFACE
- GRAVEL SURFACE
- CONCRETE WALL
- CYCLONE FENCE/GATE
- EDGE OF WATER ON 7/15/2014
- B — BOLLARD
- FIRE HYDRANT
- W — WELL
- DECIDUOUS TREE —PERIMETER REPRESENTS DRIPLINE
- CONIFEROUS TREE —PERIMETER REPRESENTS DRIPLINE
- (M) — SIGNIFIES MULTIPLE TRUNKS
- CMP — CORRUGATED METAL PIPE CULVERT
- MH — UNKNOWN MANHOLE
- V — UNKNOWN VALVE
- 3" BRASS DISK BENCHMARK
- SET CONTROL POINT (SEE TABLE BELOW)

VICINITY MAP



NOTES:

1.) VERTICAL DATUM: NGVD 29
3" BRASS DISK IN TOP OF CONCRETE WALL STAMPED "U.S. DEPT. OF THE INTERIOR, BUREAU OF SPORT FISHERIES AND WILDLIFE 1974, UNLAWFUL TO DISTURB, BM C, 1518.52"
ELEVATION = 1518.52' *

* TO CONVERT THE NGVD 29 VALUES SHOWN HEREON TO NAVD 88 VALUES ADD 3.58 FEET.

2.) HORIZONTAL DATUM FOR THIS SURVEY HAS BEEN ESTABLISHED ON THE OREGON STATE PLANE COORDINATE SYSTEM, NORTH ZONE, INTERNATIONAL FEET UTILIZING SIMULTANEOUS 1 HOUR STATIC GPS OBSERVATIONS ON CONTROL POINTS 301 AND 302.

3.) THIS MAP DOES NOT REPRESENT A BOUNDARY SURVEY.

PROJECT CONTROL:

STATION	DESCRIPTION	NORTHING	EASTING	ELEVATION
50	SCRIBED "X" IN CONCRETE	436142.20	8008901.99	1514.03'
51	5/8" IR W/ RED PLASTIC CAP "KPFF CONTROL"	436100.12	8008662.52	1522.34'
301	MAG NAIL W/ WASHER "KPFF CONTROL"	436104.34	8008384.19	1537.05'
302	5/8" IR W/ RED PLASTIC CAP "KPFF CONTROL"	436089.20	8008783.65	1517.55'

VERIFY SCALE
THIS BAR IS ONE INCH ON ORIGINAL DRAWING
0" —— 1"
ADJUST SCALES ACCORDINGLY, IF NOT ONE INCH ON THIS SHEET

REGISTERED PROFESSIONAL LAND SURVEYOR
OREGON
JUNE 30, 1997
TROY T. TETSUKA
2841
EXPIRES 6/30/16

JOB NO. 314070.02

kpff Consulting Engineers
111 SW Fifth Avenue, Suite 2400, Portland, OR 97204
Tel: 503-227-3251 * Fax: 503-274-4681
Eugene ◊ Everett ◊ Irvine ◊ Lacey ◊ Long Beach ◊ Los Angeles
New York ◊ Pasadena ◊ Phoenix ◊ Portland ◊ St. Louis ◊ Sacramento
San Diego ◊ San Francisco ◊ Seattle ◊ Tacoma ◊ Walnut Creek

REV.	DATE	DESCRIPTION	BY
△			
△			

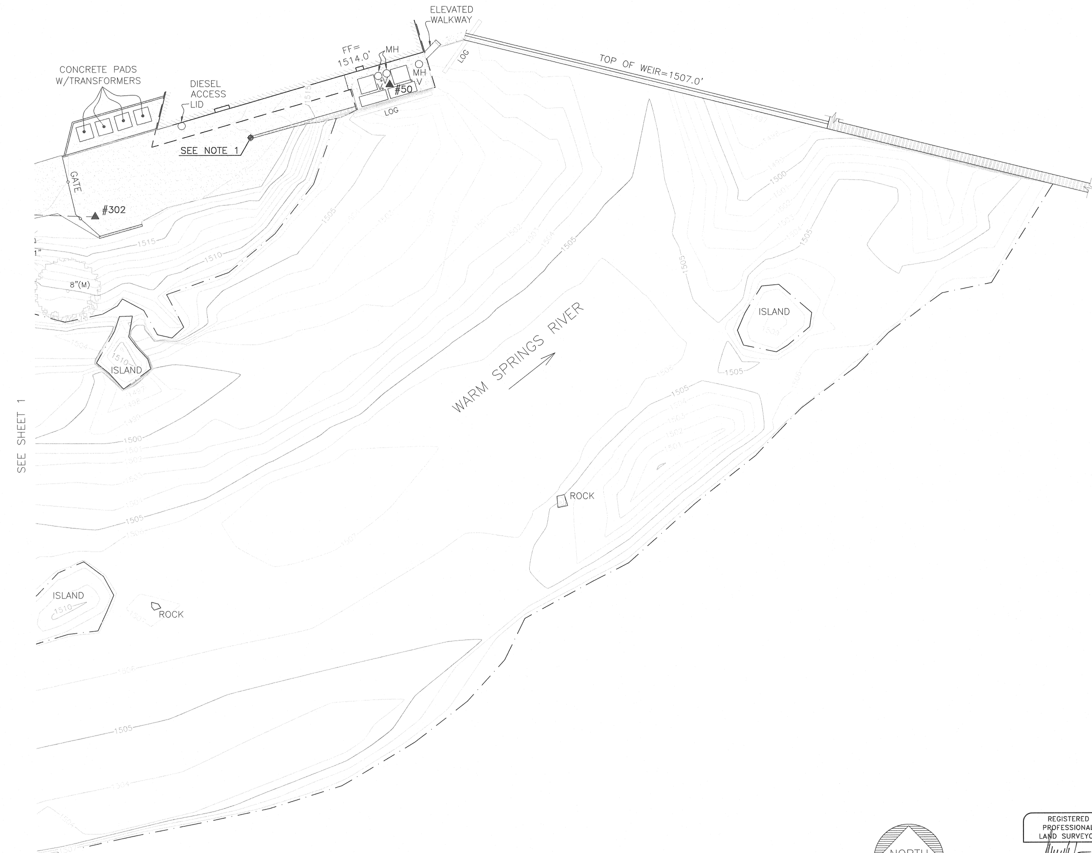
UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1, OFFICE OF ENGINEERING
PORTLAND, OREGON

SUBMITTED BY PROJECT MANAGER
REVIEWED FOR SAFETY COMPLIANCE
REVIEWED FOR ENVIRONMENTAL COMPLIANCE
REVIEWED FOR ADA COMPLIANCE
CERTIFIED 10 CFR 435 COMPLIANCE (ENERGY)
SUBMITTED BY REGIONAL ENGINEER
PROGRAMMATIC REVIEW

WARM SPRINGS FISH HATCHERY
WARM SPRINGS INDIAN RESERVATION
WARM SPRINGS NFH INTAKE IMPROVEMENTS

SURVEYED	DESIGNED	DRAWN	CHECKED
		SJD	TTT

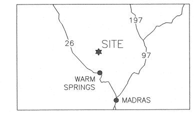
DATE: 7/28/2014
DRAWING NO. 1F-OR-772-264-1-0



LEGEND:

	BUILDING OUTLINE WITH DOOR
	BUILDING OVERHANG
	CONCRETE SURFACE
	GRAVEL SURFACE
	CONCRETE WALL
	CYCLONE FENCE/GATE
	EDGE OF WATER ON 7/15/2014
B	BOLLARD
	FIRE HYDRANT
W	WELL
	DECIDUOUS TREE —PERIMETER REPRESENTS DRIPLINE
	CONIFEROUS TREE —PERIMETER REPRESENTS DRIPLINE
(M)	SIGNIFIES MULTIPLE TRUNKS
CMP	CORRUGATED METAL PIPE CULVERT
MH	UNKNOWN MANHOLE
V	UNKNOWN VALVE
	3" BRASS DISK BENCHMARK
▲	SET CONTROL POINT (SEE TABLE BELOW)

VICINITY MAP



NOTES:

1.) VERTICAL DATUM: NGVD 29
3" BRASS DISK IN TOP OF CONCRETE WALL STAMPED "U.S. DEPT. OF THE INTERIOR, BUREAU OF SPORT FISHERIES AND WILDLIFE 1974, UNLAWFUL TO DISTURB, BM C, 1518.52"
ELEVATION = 1518.52' *

* TO CONVERT THE NGVD 29 VALUES SHOWN HEREON TO NAVD 88 VALUES ADD 3.58 FEET.

2.) HORIZONTAL DATUM FOR THIS SURVEY HAS BEEN ESTABLISHED ON THE OREGON STATE PLANE COORDINATE SYSTEM, NORTH ZONE, INTERNATIONAL FEET UTILIZING SIMULTANEOUS 1 HOUR STATIC GPS OBSERVATIONS ON CONTROL POINTS 301 AND 302.

3.) THIS MAP DOES NOT REPRESENT A BOUNDARY SURVEY.

PROJECT CONTROL:

STATION	DESCRIPTION	NORTHING	EASTING	ELEVATION
50	SCRIBED "X" IN CONCRETE	436142.20	8008901.99	1514.03'
51	5/8" IR W/ RED PLASTIC CAP "KPFF CONTROL"	436100.12	8008662.52	1522.34'
301	MAG NAIL W/ WASHER "KPFF CONTROL"	436104.34	8008384.19	1537.05'
302	5/8" IR W/ RED PLASTIC CAP "KPFF CONTROL"	436089.20	8008783.65	1517.55'

NORTH

SCALE
20 0 10 20 40
1 INCH = 20 FEET

REGISTERED PROFESSIONAL LAND SURVEYOR
OREGON
JUNE 30, 1997
TROY T. TETSUKA
2841
EXPIRES 6/30/16

JOB NO. 314070.02
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Eugene • Everett • Irvine • Lacey • Long Beach • Los Angeles
New York • Pasadena • Phoenix • Portland • St. Louis • Sacramento
San Diego • San Francisco • Seattle • Tacoma • Walnut Creek

VERIFY SCALE
THIS BAR IS ONE INCH ON ORIGINAL DRAWING
0" ——— 1"
ADJUST SCALES ACCORDINGLY, IF NOT ONE INCH ON THIS SHEET

REV.	DATE	DESCRIPTION	BY
△			
△			

UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
REGION 1, OFFICE OF ENGINEERING
PORTLAND, OREGON

SUBMITTED BY PROJECT MANAGER
REVIEWED FOR SAFETY COMPLIANCE
REVIEWED FOR ENVIRONMENTAL COMPLIANCE
REVIEWED FOR ADA COMPLIANCE
CERTIFIED 10 CFR 435 COMPLIANCE (ENERGY)
SUBMITTED BY REGIONAL ENGINEER
PROGRAMMATIC REVIEW

WARM SPRINGS FISH HATCHERY
WARM SPRINGS INDIAN RESERVATION
WARM SPRINGS
NFH INTAKE IMPROVEMENTS

SURVEYED	DESIGNED	DRAWN	CHECKED
		SJD	TTT

DATE	DRAWING NO.
7/28/2014	1F-OR-772-264-2-0

SHEET 2 OF 2

APPENDIX B HYDROLOGIC ANALYSIS DATA

Table 6. 05th percentile of daily mean values for each day for 30 - 30 years of record in, ft3/s (Calculation Period 1983-10-01 -> 2013-09-30) for Beaver Creek gage.

USGS 14096850 Beaver Creek Below Quartz Creek, NR Siminasho, OR
Wasco County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°57'32", Longitude 121°23'35" NAD27
Drainage area 145 square miles
Gage datum 2,260 feet above NGVD29
00060, Discharge, cubic feet per second

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
1	30	40	36	56	50	40	36	32	31	31	35	35
2	25	39	37	55	50	40	35	32	31	31	35	35
3	23	39	40	55	49	39	35	32	32	31	35	34
4	22	40	40	54	50	39	35	32	32	31	35	34
5	21	40	40	53	50	39	35	32	32	31	35	33
6	21	39	40	52	49	41	35	32	31	31	35	34
7	21	39	40	52	48	40	35	32	31	32	35	34
8	24	37	40	53	47	40	34	32	31	32	35	32
9	24	39	41	56	49	39	34	32	31	32	35	29
10	25	39	41	54	49	38	34	32	32	31	35	29
11	30	40	41	54	49	39	34	32	32	32	34	27
12	29	40	41	55	48	38	33	32	31	32	35	26
13	28	40	42	54	47	38	33	32	31	32	35	24
14	29	40	44	53	46	39	33	32	31	32	35	21
15	29	39	44	52	46	39	33	31	31	32	35	22
16	32	39	44	52	46	39	33	31	31	32	35	29
17	37	39	44	52	46	38	33	31	32	32	35	28
18	39	40	44	52	46	38	33	31	32	32	35	25
19	40	40	47	52	48	38	33	31	31	32	34	25
20	42	39	50	54	47	37	33	31	31	32	34	25
21	42	39	50	55	46	36	33	31	31	32	34	27
22	42	39	49	54	46	36	33	31	31	32	34	27
23	42	40	49	55	44	36	33	31	31	32	34	33
24	43	41	48	58	43	36	33	31	32	32	30	36
25	44	40	47	57	43	36	33	31	32	32	32	36

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
26	44	40	47	58	42	36	33	31	31	32	34	34
27	44	39	54	55	41	36	33	32	31	33	35	28
28	43	38	54	52	41	36	33	31	31	34	35	35
29	42		53	51	41	36	33	31	32	34	34	34
30	43		54	51	41	36	32	31	32	34	35	33
31	42		56		41		32	31		34		35
Avg	**34**	**39**	**45**	**54**	**46**	**38**	**34**	**31**	**31**	**32**	**34**	**30**

	Avg CFS	Flow /m^2
Jan	34	0.23
Feb	39	0.27
Mar	45	0.31
Apr	54	0.37
May	46	0.32
Jun	38	0.26
Jul	34	0.23
Aug	31	0.22
Sep	31	0.22
Oct	32	0.22
Nov	34	0.24
Dec	30	0.21

Table 7. 05th percentile of daily mean values for each day for 41 - 41 years of record in, ft3/s (Calculation Period 1972-10-01 -> 2013-09-30) for Kahneeta gage. Calculation period restricted by USGS staff due to special conditions at/near site.

USGS 14097100 Warm Springs River Near Kahneeta Hot Springs, OR
Wasco County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°51'24", Longitude 121°08'55" NAD27
Drainage area 526 square miles
Gage datum 1,394.96 feet above NGVD29
00060, Discharge, cubic feet per second

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
1	234	227	259	283	304	255	216	198	199	208	221	235
2	240	224	260	284	299	258	215	199	199	212	222	243
3	230	222	263	281	295	254	215	197	200	214	224	234
4	228	229	271	281	305	249	214	197	201	209	224	238
5	226	221	269	282	307	246	213	198	200	206	224	234
6	220	256	269	285	297	255	212	197	199	205	222	240
7	222	259	275	286	304	253	214	198	198	205	223	237
8	231	254	291	288	305	250	213	198	198	206	228	225
9	222	247	298	321	302	249	215	198	197	206	229	192
10	221	244	293	319	300	243	216	198	202	206	225	221
11	222	244	283	312	297	238	214	197	204	206	224	240
12	222	246	279	297	291	237	212	199	201	204	233	195
13	222	252	278	303	286	236	208	197	200	204	231	251
14	232	244	274	305	280	245	207	196	200	204	230	244
15	218	233	272	299	284	245	206	197	200	204	228	238
16	211	234	268	296	288	240	205	196	199	207	226	230
17	236	238	264	300	283	239	204	197	201	207	228	231
18	241	240	265	310	278	242	204	198	200	202	229	229
19	245	246	270	316	286	237	203	199	200	203	225	226
20	257	263	269	307	286	234	201	199	198	206	222	213
21	259	247	267	303	277	234	200	198	198	205	224	216
22	258	243	269	303	286	227	202	199	198	206	224	220
23	257	241	276	326	282	227	201	198	198	204	228	208
24	260	262	272	327	272	224	199	199	198	203	217	231
25	233	249	268	330	268	224	199	198	199	202	235	235

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
26	223	240	264	335	268	223	200	198	198	202	234	237
27	240	250	281	335	271	221	200	198	197	206	234	233
28	222	267	293	324	269	221	199	197	197	212	232	234
29	199		283	315	265	220	198	197	204	217	225	216
30	209		276	310	259	219	199	200	204	221	234	211
31	212		288		255		198	200		221		224
Avg	**231**	**244**	**274**	**305**	**285**	**238**	**207**	**198**	**200**	**207**	**227**	**228**

	Avg CFS	Flow/m^2
Jan	231	0.44
Feb	244	0.46
Mar	274	0.52
Apr	305	0.58
May	285	0.54
Jun	238	0.45
Jul	207	0.39
Aug	198	0.38
Sep	200	0.38
Oct	207	0.39
Nov	227	0.43
Dec	228	0.43

Table 8. 05th percentile of daily mean values for each day for 25 - 26 years of record in, ft3/s (Calculation Period 1983-10-01 -> 2009-09-30) for Mill Creek gage.

USGS 14096300 MILL CREEK NR BADGER BUTTE, NR WARM SPRINGS, OR

Wasco County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°51'42", Longitude 121°37'35" NAD27
Drainage area 26.80 square miles
Gage datum 3,380 feet above NGVD29
00060, Discharge, cubic feet per second

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
1	33	42	36	47	56	38	35	30	29	28	31	37
2	37	41	36	47	56	38	34	30	29	28	30	35
3	36	38	41	46	56	38	34	30	29	29	29	35
4	35	37	43	48	54	37	35	31	29	29	29	36
5	35	36	43	50	53	36	35	31	29	29	31	33
6	35	39	43	53	54	38	35	31	29	29	33	32
7	35	38	44	51	56	37	35	31	29	29	35	36
8	34	36	45	51	56	37	34	31	29	29	34	42
9	34	40	45	58	54	35	35	30	29	28	33	42
10	35	40	44	57	53	35	34	31	29	28	33	43
11	36	40	44	57	54	35	33	30	28	29	34	43
12	36	39	46	57	52	35	33	30	28	29	37	41
13	35	39	46	56	52	36	33	30	28	29	36	40
14	35	39	45	54	50	35	33	31	28	29	37	38
15	35	38	44	52	48	36	32	30	28	29	35	38
16	37	32	44	52	48	36	32	30	27	29	35	35
17	38	37	47	54	47	37	32	31	27	29	35	34
18	38	39	45	55	47	37	32	31	27	30	37	34
19	38	43	46	55	48	36	32	30	27	30	36	35
20	38	43	48	55	48	35	32	30	27	29	35	38
21	39	41	48	54	47	34	32	29	26	30	35	37
22	38	39	49	54	49	34	32	29	26	30	35	31
23	39	38	48	54	46	34	31	30	26	30	35	32
24	44	37	49	54	44	33	31	29	26	29	34	33

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
25	45	37	49	56	43	33	31	29	26	29	35	35
26	45	36	49	59	41	33	31	29	26	30	36	36
27	46	35	48	58	40	34	31	29	29	30	36	35
28	44	35	47	56	40	34	31	29	29	30	36	35
29	44		46	56	40	35	31	29	29	33	35	35
30	44		46	57	38	36	31	30	29	32	35	34
31	43		47		38		30	29		32		34
AVG	**38**	**38**	**45**	**54**	**49**	**36**	**33**	**30**	**28**	**29**	**34**	**36**

Table 9. 05th percentile of daily mean values for each day for 29 - 29 years of record in, ft3/s (Calculation Period 1911-10-01 -> 2013-09-30) for Shitike Creek gage.

USGS 14093000 SHITIKE CREEK NEAR WARM SPRINGS, OR

Jefferson County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°45'52", Longitude 121°14'07" NAD27
Drainage area 104 square miles
Gage datum 1,380.00 feet above NGVD29
00060, Discharge, cubic feet per second

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
1	48	51	44	65	75	80	56	39	34	35	38	44
2	47	51	44	63	73	80	55	37	33	35	40	43
3	42	50	42	63	73	80	55	39	34	34	41	42
4	42	51	43	63	79	74	52	39	33	34	41	39
5	43	53	43	63	78	73	52	39	33	34	43	40
6	46	52	43	63	77	71	52	39	33	34	41	39
7	47	52	43	65	76	69	51	38	33	35	41	28
8	43	51	44	67	74	65	50	38	34	35	40	20
9	46	51	43	65	72	62	48	38	33	36	40	20
10	46	50	43	64	71	64	50	37	34	36	41	22
11	46	50	44	64	74	66	48	37	34	35	42	25
12	45	50	43	65	75	67	47	37	34	36	43	33
13	45	48	44	64	78	67	46	37	33	35	44	33
14	44	47	45	61	84	68	47	35	33	34	43	32
15	43	48	43	60	97	66	47	35	33	35	43	32
16	45	47	43	58	101	65	45	36	33	35	44	43
17	49	48	45	69	95	68	45	36	33	34	48	42
18	52	48	46	69	93	62	45	35	33	33	47	44
19	51	47	49	67	90	63	45	35	34	34	47	48
20	51	47	52	68	89	64	45	35	34	36	46	49
21	49	46	52	64	76	64	45	35	34	39	46	46
22	49	47	52	64	77	63	45	35	34	39	47	46
23	49	45	55	65	86	62	44	35	34	37	46	47
24	49	44	53	65	87	61	44	36	34	37	45	49
25	49	44	53	65	84	61	41	35	35	36	48	47

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
26	50	43	53	69	82	61	41	34	34	36	47	47
27	49	42	62	77	80	58	41	34	34	36	47	47
28	49	43	61	80	81	57	41	33	34	37	46	49
29	51		65	80	81	56	40	33	34	38	46	51
30	51		67	79	79	56	40	34	34	36	45	49
31	52		67		77		40	34		36		48

Table 10. 05th percentile of daily mean values for each day for 30 - 31 years of record in, ft3/s (Calculation Period 1949-10-01 -> 2008-09-30) for Siminasho gage. Calculation period restricted by USGS staff due to special conditions at/near site.

USGS 14095500 Warm Springs River Siminasho, OR
Wasco County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°58'02.1", Longitude 121°28'05.6" NAD27
Drainage area 107 square miles
Gage datum 2,525.94 feet above NAVD88
00060, Discharge, cubic feet per second

Day of Month	J	F	M	A	M	J	J	A	S	O	N	D
1	99	98	102	122	114	105	99	94	92	96	98	97
2	96	97	102	122	115	104	100	94	92	94	98	96
3	95	98	102	122	113	104	99	95	93	93	100	95
4	95	99	102	123	114	103	99	95	93	92	99	95
5	93	99	101	121	114	105	99	94	92	92	98	95
6	93	100	102	121	114	105	99	94	92	92	98	96
7	94	99	106	123	111	104	99	94	92	92	97	96
8	93	98	105	122	112	103	99	94	93	92	95	99
9	93	101	105	119	117	102	99	94	93	93	95	97
10	93	101	105	117	117	102	98	94	94	92	95	97
11	91	101	103	118	114	102	98	94	94	92	95	96
12	91	101	103	118	112	102	98	94	93	91	98	97
13	91	102	102	117	110	102	98	94	93	91	98	97
14	88	101	102	116	110	103	97	94	93	92	97	92
15	91	99	102	115	113	102	98	94	93	92	94	95
16	97	99	103	116	112	102	98	93	93	92	94	95
17	97	100	105	117	111	106	97	93	94	92	93	95
18	100	101	106	118	114	104	97	94	93	92	94	94
19	100	101	108	121	113	102	97	93	93	93	93	94
20	100	101	107	122	112	102	96	93	93	93	92	95
21	99	100	109	121	112	101	96	93	93	92	92	95
22	99	99	108	120	112	101	97	93	93	93	92	98
23	100	101	107	126	108	100	96	93	93	94	94	99
24	104	102	106	129	107	100	95	93	92	94	94	98
25	103	102	104	126	106	100	95	93	92	94	100	99

Day of Month	J	F	M	A	M	J	J	A	S	O	N	D
26	102	102	106	122	105	100	94	92	92	94	99	99
27	103	102	122	118	105	101	94	92	92	94	97	99
28	103	102	121	116	106	101	94	92	92	96	96	98
29	101		121	115	105	99	94	93	92	95	96	99
30	100		121	114	105	99	94	93	93	94	95	99
31	100		123		105		94	92		95		99
Avg	**97**	**100**	**107**	**120**	**111**	**102**	**97**	**93**	**93**	**93**	**96**	**97**

	Avg CFS	Flow/ m^2
Jan	97	0.91
Feb	100	0.94
Mar	107	1.00
Apr	120	1.12
May	111	1.04
Jun	102	0.96
Jul	97	0.91
Aug	93	0.87
Sep	93	0.87
Oct	93	0.87
Nov	96	0.90
Dec	97	0.90

Table 11. 95th percentile of daily mean values for each day for 30 - 30 years of record in, ft3/s (Calculation Period 1983-10-01 -> 2013-09-30) at Beaver Creek gage.

USGS 14096850 Beaver Creek Below Quartz Creek, NR Siminasho, OR
Wasco County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°57'32", Longitude 121°23'35" NAD27
Drainage area 145 square miles
Gage datum 2,260 feet above NGVD29
00060, Discharge, cubic feet per second

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
1	1,380	962	448	413	179	139	59	46	44	43	82	223
2	1,170	716	406	321	166	130	57	46	44	43	87	207
3	1,100	563	429	288	160	124	56	45	44	44	131	168
4	838	495	419	273	159	122	55	46	44	44	96	235
5	558	421	426	257	320	225	55	49	44	48	74	318
6	460	359	373	234	249	174	55	46	44	47	66	198
7	468	1,970	381	212	246	130	54	46	43	45	69	196
8	408	1,720	402	199	228	115	53	46	43	45	69	305
9	350	1,280	367	211	206	107	57	45	43	46	59	254
10	510	1,070	372	282	189	101	55	45	44	45	81	303
11	762	690	343	222	182	96	52	45	43	44	94	211
12	502	488	318	204	177	92	51	45	43	45	122	291
13	444	534	289	212	174	89	51	45	43	47	116	377
14	738	421	285	267	176	87	50	44	44	47	99	323
15	404	367	269	277	182	85	50	44	44	44	83	336
16	538	349	329	243	189	83	50	44	46	45	84	238
17	709	815	475	215	196	81	49	44	45	43	76	178
18	518	956	490	193	209	78	50	44	45	44	75	148
19	484	598	397	185	221	76	49	45	44	52	79	135
20	389	491	398	204	219	74	48	45	44	46	97	132
21	414	457	380	351	203	72	50	44	44	45	89	131
22	313	1,420	362	275	186	69	49	44	44	45	83	121
23	274	1,570	331	237	173	68	48	44	43	50	92	113
24	491	1,080	338	238	165	67	48	46	44	49	83	148
25	657	814	301	221	167	66	48	45	43	50	89	387

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
26	513	652	251	236	167	64	48	45	43	50	156	503
27	379	617	236	204	162	63	47	44	43	51	107	377
28	296	517	239	251	155	61	47	44	43	58	201	579
29	439		226	214	152	60	47	44	46	52	152	495
30	567		461	191	244	60	46	44	48	55	169	755
31	623		486		151		46	44		63		1,430
Avg	**571**	**800**	**362**	**244**	**192**	**95**	**51**	**45**	**44**	**48**	**99**	**317**

	Avg	Flow/mi^2
Jan	571	3.94
Feb	800	5.52
Mar	362	2.50
Apr	244	1.69
May	192	1.32
Jun	95	0.66
Jul	51	0.35
Aug	45	0.31
Sep	44	0.30
Oct	48	0.33
Nov	99	0.68
Dec	317	2.18

Table 12. 95th percentile of daily mean values for each day for 41 - 41 years of record in, ft3/s (Calculation Period 1972-10-01 -> 2013-09-30) for Kahneeta gage. Calculation period restricted by USGS staff due to special conditions at/near site.

USGS 14097100 Warm Springs River Near Kahneeta Hot Springs, OR
Wasco County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°51'24", Longitude 121°08'55" NAD27
Drainage area 526 square miles
Gage datum 1,394.96 feet above NGVD29
00060, Discharge, cubic feet per second

Day of Mo.	J	F	M	A	M	J	J	A	S	O	N	D
1	2,500	2,750	1,200	1,380	1,020	824	498	349	335	319	641	872
2	1,830	2,680	1,500	1,350	960	803	490	346	331	319	566	1,130
3	1,480	2,080	1,220	1,180	926	828	482	345	327	317	451	981
4	2,230	1,680	1,330	1,090	919	818	456	342	327	316	408	1,060
5	1,460	1,440	1,420	1,030	904	868	452	340	324	316	391	1,300
6	1,930	1,290	1,230	953	892	884	442	338	320	320	380	1,280
7	1,790	1,760	1,100	898	917	780	433	337	320	318	431	1,060
8	2,400	1,120	1,070	874	960	737	427	336	320	317	443	927
9	1,950	1,210	1,270	858	1,010	691	423	334	320	317	427	797
10	1,430	1,570	1,590	867	1,010	663	417	335	319	318	447	1,260
11	1,460	1,240	1,390	899	968	643	410	335	318	323	593	866
12	1,390	1,010	1,360	878	980	634	405	335	317	324	671	1,250
13	1,840	1,640	1,310	978	950	644	398	332	316	325	562	1,690
14	2,500	1,580	1,220	1,060	942	657	393	331	317	325	463	1,320
15	2,330	1,600	1,250	1,040	983	677	385	341	317	321	421	1,910
16	1,650	1,500	1,190	1,030	982	696	384	335	317	320	488	1,670
17	2,870	1,860	1,420	1,000	949	705	386	331	314	319	511	1,110
18	2,140	3,060	1,290	971	927	684	380	331	314	317	435	929
19	1,760	2,790	1,260	921	953	661	378	331	316	330	482	1,210
20	1,540	2,190	1,400	925	948	641	369	331	337	331	485	1,080
21	1,470	1,880	1,520	1,270	858	628	363	329	330	325	572	1,370
22	1,180	3,110	1,380	1,130	812	597	358	327	314	337	545	1,090
23	1,480	2,460	1,330	1,030	829	586	356	328	312	329	529	954
24	1,450	1,990	1,260	1,220	882	588	353	329	312	325	490	833

Day of Mo.	J	F	M	A	M	J	J	A	S	O	N	D
25	2,110	1,680	1,420	1,280	928	607	352	326	313	337	495	1,600
26	1,720	1,480	1,190	1,110	902	592	350	326	315	340	1,240	1,470
27	1,290	1,320	1,090	1,090	889	553	350	326	314	343	929	1,460
28	1,090	1,230	987	1,130	877	526	348	323	315	383	827	1,590
29	975		935	1,090	871	509	350	323	327	384	835	1,260
30	1,070		1,690	977	965	500	351	332	326	461	716	2,110
31	1,510		1,720		852		350	329		396		4,090
Avg	**1,736**	**1,829**	**1,308**	**1,050**	**928**	**674**	**396**	**333**	**320**	**335**	**562**	**1,340**

	Avg	Flow/mi^2
Jan	1736	3.30
Feb	1829	3.48
Mar	1308	2.49
Apr	1050	2.00
May	928	1.76
Jun	674	1.28
Jul	396	0.75
Aug	333	0.63
Sep	320	0.61
Oct	335	0.64
Nov	562	1.07
Dec	1340	2.55

Table 13. 95th percentile of daily mean values for each day for 25 - 26 years of record in, ft3/s. (Calculation Period 1983-10-01 -> 2009-09-30) for Mill Creek gage.

USGS 14096300 MILL CREEK NR BADGER BUTTE, NR WARM SPRINGS, OR

Wasco County, Oregon

Hydrologic Unit Code 17070306

Latitude 44°51'42", Longitude 121°37'35" NAD27

Drainage area 26.80 square miles

Gage datum 3,380 feet above NGVD29

00060, Discharge, cubic feet per second

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
1	481	623	143	123	145	187	124	64	64	69	267	371
2	464	508	131	117	137	177	122	64	61	61	198	277
3	382	309	122	123	141	169	114	62	65	62	151	298
4	290	220	119	133	142	168	106	63	62	69	110	393
5	215	180	109	131	242	155	101	66	61	80	109	296
6	170	308	111	122	255	158	96	68	59	70	96	217
7	203	732	127	115	240	146	95	71	59	67	207	170
8	289	618	150	114	194	142	93	66	59	68	237	156
9	234	510	134	123	171	124	91	63	59	72	144	143
10	371	360	130	157	168	127	88	62	60	66	111	250
11	589	287	125	148	163	120	88	61	61	67	219	170
12	404	228	143	160	170	124	88	61	60	67	183	294
13	331	214	166	198	171	146	87	60	60	67	167	314
14	286	182	150	342	193	148	85	60	62	66	136	370
15	215	165	158	240	211	154	83	60	71	66	113	408
16	190	166	152	185	233	158	80	61	74	64	166	275
17	186	202	164	154	258	165	78	61	73	63	143	202
18	183	269	198	142	292	155	76	62	67	78	159	164
19	163	248	191	133	276	148	74	61	65	87	189	147
20	163	235	189	187	268	145	80	62	62	74	185	141
21	140	197	173	198	243	137	79	62	61	73	192	134
22	133	204	188	183	200	134	74	61	60	65	154	118
23	142	260	205	183	181	137	72	60	59	76	146	131
24	136	224	169	263	169	137	70	65	59	85	123	118
25	132	188	153	187	185	147	69	62	60	83	210	156

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
26	169	171	163	161	187	136	67	61	61	75	514	155
27	249	152	182	198	175	126	66	62	63	181	335	175
28	186	156	202	275	178	121	65	61	61	102	233	366
29	151		146	181	178	120	67	61	60	103	352	283
30	309		124	148	177	123	65	62	60	172	435	307
31	443		110		172		64	63		263		532
AVG	**258**	**290**	**152**	**171**	**197**	**144**	**84**	**63**	**62**	**86**	**199**	**243**

Table 14. 95th percentile of daily mean values for each day for 29 - 29 years of record in, ft3/s (Calculation Period 1911-10-01 -> 2013-09-30) for Shitike Creek gage.

USGS 14093000 SHITIKE CREEK NEAR WARM SPRINGS, OR

Jefferson County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°45'52", Longitude 121°14'07" NAD27
Drainage area 104 square miles
Gage datum 1,380.00 feet above NGVD29
00060, Discharge, cubic feet per second

Day of month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	736	515	215	346	270	330	252	153	110	102	218	287
2	745	422	205	284	222	394	240	151	95	105	180	307
3	559	401	198	271	227	487	228	145	108	103	148	258
4	445	374	181	259	217	454	227	142	106	127	127	500
5	364	347	172	255	307	508	225	146	101	166	185	590
6	318	328	172	273	386	356	217	143	96	127	162	349
7	326	325	177	266	373	324	215	140	94	204	393	253
8	371	334	170	236	308	282	232	135	93	127	265	297
9	319	445	177	208	263	263	223	130	99	125	151	243
10	394	407	207	203	229	274	225	130	92	111	123	197
11	505	341	209	214	230	253	235	134	88	112	112	201
12	366	252	197	227	241	266	233	130	86	101	117	233
13	436	216	217	277	254	323	234	117	84	101	212	486
14	490	193	180	525	274	347	218	114	90	101	154	612
15	1,360	191	173	475	310	367	202	124	84	101	135	562
16	1,340	284	218	370	349	361	229	121	115	117	341	341
17	986	316	253	295	388	334	210	109	117	103	303	255
18	806	385	234	250	470	356	190	111	114	104	268	257
19	683	315	237	212	447	327	172	108	103	160	319	357
20	587	588	278	269	436	297	177	105	92	98	370	407
21	496	405	405	287	388	281	175	123	89	90	277	575
22	383	345	320	266	268	282	171	106	87	86	355	490
23	330	288	288	278	255	297	172	102	82	109	203	345
24	300	251	275	301	274	266	175	101	82	117	287	246
25	344	229	257	288	400	285	241	99	94	103	501	339

Day of month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
26	338	214	261	278	416	271	178	107	81	83	608	317
27	308	202	256	248	362	237	166	97	89	77	376	366
28	272	212	266	236	324	214	154	96	103	136	425	435
29	251		225	226	299	265	157	94	214	192	334	526
30	357		348	230	305	239	153	96	339	258	328	774
31	526		416		296		153	98		355		823
AVG	**517**	**326**	**238**	**278**	**316**	**318**	**203**	**120**	**108**	**129**	**266**	**394**

Table 15. 95th percentile of daily mean values for each day for 30 - 31 years of record in, ft3/s (Calculation Period 1949-10-01 -> 2008-09-30) for Siminasho gage. Calculation period restricted by USGS staff due to special conditions at/near site.

USGS 14095500 Warm Springs River Siminasho, OR
Wasco County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°58'02.1", Longitude 121°28'05.6" NAD27
Drainage area 107 square miles
Gage datum 2,525.94 feet above NAVD88
00060, Discharge, cubic feet per second

Day of Month	J	F	M	A	M	J	J	A	S	O	N	D
1	856	706	516	323	352	354	202	154	148	141	188	302
2	810	614	473	317	336	345	195	153	146	146	247	294
3	768	489	444	315	335	333	193	152	148	145	263	240
4	605	449	434	335	330	330	187	155	146	143	217	264
5	448	394	416	327	328	330	184	157	145	153	189	305
6	380	469	387	311	331	326	180	153	145	149	178	274
7	339	1,620	421	302	335	314	178	157	144	142	169	285
8	326	1,640	424	301	331	304	175	153	144	143	163	283
9	298	1,500	401	312	330	293	173	153	144	143	158	281
10	301	1,090	394	309	334	294	171	153	144	141	164	285
11	476	894	421	305	359	293	169	152	144	141	173	270
12	362	764	396	311	363	298	168	151	144	141	184	326
13	321	664	359	351	356	293	166	152	144	140	178	370
14	362	586	331	453	365	287	166	152	144	140	172	377
15	313	530	314	444	371	285	165	151	145	140	166	420
16	375	478	333	407	374	288	165	150	147	139	171	317
17	384	448	387	377	412	314	164	150	145	140	182	282
18	423	622	387	368	431	295	164	150	144	139	180	262
19	492	617	385	361	436	282	163	150	144	143	210	259
20	439	618	427	399	438	274	164	150	143	141	211	374
21	405	564	431	406	432	268	166	149	143	145	215	317
22	325	823	402	412	431	261	163	148	142	139	209	286
23	310	990	452	403	417	258	161	148	142	156	217	287
24	319	844	454	465	392	249	159	152	141	145	200	268
25	351	817	406	426	396	246	156	149	141	140	214	345

Day of Month	J	F	M	A	M	J	J	A	S	O	N	D
26	366	668	371	401	391	234	156	148	141	143	264	349
27	341	610	367	389	378	223	155	148	142	157	214	343
28	319	574	351	431	375	216	155	147	141	172	238	507
29	313		331	370	369	212	154	147	141	192	211	469
30	291		322	364	358	206	154	148	140	181	284	517
31	387		311		349		154	148		175		625
Avg	**413**	**753**	**395**	**367**	**372**	**284**	**169**	**151**	**144**	**148**	**201**	**335**

	Avg	Flow/mi^2
Jan	413	3.86
Feb	753	7.04
Mar	395	3.69
Apr	367	3.43
May	372	3.48
Jun	284	2.65
Jul	169	1.58
Aug	151	1.41
Sep	144	1.34
Oct	148	1.39
Nov	201	1.88
Dec	335	3.13

Table 16. Mean of daily mean values for each day for 30 - 30 years of record in, ft3/s (Calculation Period 1983-10-01 -> 2013-09-30) for Beaver Creek gage.

USGS 14096850 Beaver Creek Below Quartz Creek, NR Simnasho, OR
Wasco County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°57'32", Longitude 121°23'35" NAD27
Drainage area 145 square miles
Gage datum 2,260 feet above NGVD29
00060, Discharge, cubic feet per second

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
1	166	184	149	144	107	71	46	39	37	37	42	62
2	161	163	147	137	106	69	45	38	37	37	42	65
3	157	145	153	135	105	68	45	38	37	37	46	61
4	134	132	149	131	103	68	45	38	37	37	44	65
5	112	122	146	127	113	76	44	39	37	38	42	70
6	109	119	153	124	106	71	44	38	37	37	42	62
7	116	241	147	122	103	68	43	38	37	37	42	63
8	118	226	147	122	100	65	43	38	36	37	43	69
9	106	196	146	122	96	63	43	38	36	37	42	65
10	125	176	146	129	94	61	43	38	37	37	43	69
11	137	150	144	123	91	60	42	38	36	37	44	63
12	115	136	142	120	90	58	42	38	36	38	46	71
13	119	149	142	121	89	58	41	38	36	38	46	81
14	143	136	141	123	88	57	41	38	36	38	45	97
15	126	138	142	123	87	57	41	37	37	38	43	88
16	133	141	148	120	87	55	41	37	37	38	43	75
17	144	188	157	117	87	54	41	37	37	38	44	69
18	139	192	157	115	88	53	41	37	37	38	44	64
19	139	169	149	113	88	52	41	37	37	38	44	60
20	133	155	148	113	87	52	40	37	37	38	47	57
21	130	154	149	124	85	51	40	37	36	38	48	57
22	113	234	148	118	83	50	40	37	36	38	48	55
23	109	249	148	115	81	50	40	38	36	39	48	56
24	128	213	147	115	80	49	40	37	37	39	48	58
25	141	186	141	113	78	49	39	37	37	39	50	74

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
26	128	169	138	114	77	48	39	37	37	39	55	82
27	116	161	135	110	76	47	39	37	37	40	52	74
28	112	151	132	115	75	47	39	37	36	40	61	101
29	130	175	129	113	76	47	39	37	37	39	55	102
30	152		146	111	81	46	39	37	37	40	57	129
31	159		149		74		39	37		40		174
Avg	**131**	**171**	**146**	**121**	**90**	**57**	**41**	**38**	**37**	**38**	**47**	**75**

	Avg	Flow/mi^2
Jan	131	0.90
Feb	171	1.18
Mar	146	1.00
Apr	121	0.83
May	90	0.62
Jun	57	0.40
Jul	41	0.29
Aug	38	0.26
Sep	37	0.25
Oct	38	0.26
Nov	47	0.32
Dec	75	0.52

Table 17. Mean of daily mean values for each day for 41 - 41 years of record in, ft3/s (Calculation Period 1972-10-01 -> 2013-09-30) for Kahneeta gage. Calculation period restricted by USGS staff due to special conditions at/near site.

USGS 14097100 Warm Springs River Near Kahneeta Hot Springs, OR
Wasco County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°51'24", Longitude 121°08'55" NAD27
Drainage area 526 square miles
Gage datum 1,394.96 feet above NGVD29
00060, Discharge, cubic feet per second

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
1	638	674	628	632	575	460	311	261	252	252	289	386
2	603	628	625	615	573	453	307	260	252	251	290	407
3	563	580	610	602	572	448	304	260	251	251	304	428
4	531	545	609	588	570	446	301	259	251	253	293	434
5	509	518	598	580	581	459	299	261	250	254	286	474
6	511	543	600	575	579	451	296	259	251	253	285	471
7	521	899	600	570	573	441	293	260	250	253	287	443
8	582	832	600	566	563	434	291	260	249	252	295	425
9	542	746	607	567	555	425	289	257	250	252	288	403
10	538	656	613	577	550	413	287	257	251	253	288	410
11	576	607	607	576	540	403	284	256	249	253	294	397
12	538	572	604	571	535	395	282	255	248	255	300	415
13	585	618	608	574	532	394	280	256	248	254	302	471
14	673	602	605	587	530	389	278	255	249	254	300	562
15	706	587	612	589	535	384	276	256	250	255	294	593
16	713	605	623	579	537	378	276	255	250	255	298	512
17	725	706	635	576	536	372	276	255	250	254	303	481
18	684	822	629	574	539	366	277	255	251	253	304	443
19	662	807	624	564	538	361	276	256	251	258	302	457
20	613	755	614	570	532	355	274	256	252	259	310	440
21	579	738	618	592	521	350	272	256	251	259	318	449
22	529	792	612	585	511	344	270	256	250	260	324	427
23	540	835	616	595	505	340	268	256	250	262	322	408
24	585	792	625	608	500	337	267	255	251	262	315	400
25	599	721	620	601	494	333	267	255	252	263	329	469

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
26	579	688	599	594	491	328	265	255	251	266	382	494
27	540	662	595	578	484	323	264	254	251	269	365	466
28	511	650	591	594	484	319	263	252	250	273	371	527
29	514	668	580	585	479	316	262	253	252	270	362	512
30	550		654	578	482	313	262	253	255	273	367	539
31	594		650		469		262	252		282		638
Avg	**585**	**684**	**613**	**585**	**531**	**384**	**280**	**256**	**251**	**258**	**312**	**464**

	Avg	Flow/mi^2
Jan	585	1.11
Feb	684	1.30
Mar	613	1.17
Apr	585	1.11
May	531	1.01
Jun	384	0.73
Jul	280	0.53
Aug	256	0.49
Sep	251	0.48
Oct	258	0.49
Nov	312	0.59
Dec	464	0.88

Table 18. Mean of daily mean values for each day for 25 - 26 years of record in, ft3/s (Calculation Period 1983-10-01 -> 2009-09-30) at Mill Creek gage.

USGS 14096300 MILL CREEK NR BADGER BUTTE, NR WARM SPRINGS, OR

Wasco County, Oregon

Hydrologic Unit Code 17070306

Latitude 44°51'42", Longitude 121°37'35" NAD27

Drainage area 26.80 square miles

Gage datum 3,380 feet above NGVD29

00060, Discharge, cubic feet per second

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
1	103	127	69	79	95	96	57	42	41	42	63	89
2	104	111	67	78	96	94	56	42	40	41	61	83
3	105	95	68	79	97	91	55	42	41	42	59	85
4	95	85	69	79	97	91	54	43	40	42	56	90
5	88	80	69	78	102	91	53	43	40	42	55	86
6	81	85	70	78	102	89	52	43	40	41	56	85
7	85	107	71	79	100	88	51	43	40	41	62	79
8	97	98	73	82	97	86	51	43	40	41	65	75
9	92	92	73	86	97	81	50	42	40	41	58	74
10	102	82	75	89	95	79	49	42	40	41	56	81
11	109	76	75	87	93	76	48	41	40	42	63	77
12	95	74	79	87	94	75	48	41	40	42	62	86
13	91	75	80	91	94	76	48	41	40	42	66	95
14	94	72	78	101	97	75	47	41	41	42	63	101
15	95	70	80	94	104	75	47	41	41	43	59	96
16	87	72	79	90	107	74	46	41	41	43	62	88
17	84	79	78	90	109	72	46	41	41	42	64	82
18	84	82	81	89	114	71	47	41	41	43	63	76
19	82	81	82	87	112	69	46	41	41	44	66	71
20	79	79	82	91	111	67	46	41	41	44	69	68
21	74	77	81	92	107	65	46	41	40	44	72	66
22	71	81	84	91	102	64	45	42	40	45	73	64
23	73	82	87	92	100	63	44	42	40	45	69	66
24	73	79	84	98	99	62	44	41	41	45	70	65
25	73	74	84	91	99	62	44	41	41	44	82	67

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
26	75	71	85	89	97	60	43	41	41	47	100	67
27	78	69	88	92	96	59	43	41	41	53	90	74
28	75	69	86	97	98	58	43	40	41	49	84	88
29	74	70	81	94	99	57	43	40	40	48	88	84
30	88		78	94	99	58	43	41	41	53	92	91
31	106		77		96		42	40		61		106
Avg	**87**	**83**	**78**	**88**	**100**	**74**	**48**	**41**	**41**	**44**	**68**	**81**

	Avg	Flow/mi^2
Jan	87	3.26
Feb	83	3.08
Mar	78	2.90
Apr	88	3.29
May	100	3.74
Jun	74	2.77
Jul	48	1.78
Aug	41	1.55
Sep	41	1.51
Oct	44	1.66
Nov	68	2.55
Dec	81	3.02

Table 19. Mean of daily mean values for each day for 29 - 29 years of record in, ft3/s (Calculation Period 1911-10-01 -> 2013-09-30) at Shitike Creek gage.

USGS 14093000 SHITIKE CREEK NEAR WARM SPRINGS, OR

Jefferson County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°45'52", Longitude 121°14'07" NAD27
Drainage area 104 square miles
Gage datum 1,380.00 feet above NGVD29
00060, Discharge, cubic feet per second,

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
1	151	144	102	144	145	168	127	78	58	56	77	101
2	149	135	102	139	138	177	124	77	57	56	78	105
3	143	128	102	135	139	181	122	76	57	57	73	100
4	128	123	100	132	142	182	119	75	57	59	71	120
5	117	119	99	131	151	186	116	74	56	62	73	129
6	116	121	99	131	156	170	114	72	56	58	74	108
7	114	126	98	129	159	166	113	71	56	63	91	101
8	116	123	98	128	158	159	112	70	56	58	80	98
9	111	126	99	126	153	152	112	69	57	58	70	91
10	114	120	105	127	148	150	112	69	56	57	67	87
11	119	112	107	130	145	144	108	68	55	58	67	87
12	119	104	111	130	149	146	106	67	55	57	70	94
13	133	101	113	133	150	158	104	65	54	56	80	116
14	152	99	112	151	155	159	103	64	55	56	76	127
15	206	97	111	151	167	157	100	65	54	56	78	120
16	202	110	116	142	179	154	101	64	56	59	107	105
17	176	112	117	139	181	149	98	63	56	57	98	105
18	166	117	115	134	185	151	95	63	57	58	90	106
19	161	114	116	129	188	145	94	63	56	62	96	108
20	149	133	121	135	186	140	92	62	56	57	108	109
21	141	120	130	137	179	136	91	64	54	57	105	118
22	129	115	128	134	166	136	89	62	55	56	106	111
23	121	111	128	134	160	137	88	62	55	59	91	103
24	119	106	126	135	160	134	86	61	54	59	100	97
25	122	104	125	133	169	135	90	61	55	57	124	105

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
26	121	103	124	134	169	134	85	62	53	56	130	100
27	119	103	127	135	167	130	83	60	53	57	104	105
28	112	104	127	137	168	128	82	58	54	62	108	124
29	109	111	124	139	170	132	82	57	62	68	103	146
30	128		140	139	169	128	81	57	71	73	103	176
31	143		146		163		80	57		83		170
AVG	**136**	**115**	**115**	**135**	**162**	**151**	**100**	**66**	**56**	**60**	**90**	**112**

	Avg	Flow/mi^2
Jan	136	1.30
Feb	115	1.11
Mar	115	1.11
Apr	135	1.30
May	162	1.56
Jun	151	1.45
Jul	100	0.96
Aug	66	0.63
Sep	56	0.54
Oct	60	0.57
Nov	90	0.86
Dec	112	1.08

Table 20. Mean of daily mean values for each day for 30 - 31 years of record in, ft3/s (Calculation Period 1949-10-01 -> 2008-09-30) at Siminasho gage. Calculation period restricted by USGS staff due to special conditions at/near site.

USGS 14095500 Warm Springs River Siminasho, OR
Wasco County, Oregon
Hydrologic Unit Code 17070306
Latitude 44°58'02.1", Longitude 121°28'05.6" NAD27
Drainage area 107 square miles
Gage datum 2,525.94 feet above NAVD88
00060, Discharge, cubic feet per second,

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
1	193	211	204	203	217	185	135	121	116	115	120	143
2	188	203	199	204	215	181	133	120	116	115	124	142
3	188	199	197	207	214	178	133	120	116	115	125	137
4	175	193	197	207	212	177	133	121	116	115	123	141
5	163	185	194	207	210	177	131	121	116	115	121	143
6	155	195	192	208	208	176	131	120	116	115	121	140
7	154	281	193	208	206	174	130	120	116	114	122	141
8	157	279	195	210	205	170	129	120	115	114	120	139
9	158	263	195	212	204	167	129	119	116	114	119	139
10	166	231	197	213	203	164	129	119	116	114	119	143
11	172	213	199	211	204	162	128	119	116	114	119	139
12	162	203	200	212	205	162	128	119	116	114	121	144
13	158	204	199	215	207	160	127	119	116	114	122	151
14	165	198	197	224	206	158	126	118	116	114	120	156
15	166	194	200	225	206	157	126	118	116	114	118	153
16	167	193	202	223	207	155	126	118	116	114	120	146
17	170	198	206	223	210	156	126	118	116	114	122	143
18	180	209	206	223	213	153	126	118	115	114	122	140
19	180	209	208	223	214	150	125	118	115	116	125	140
20	173	213	210	225	214	148	125	118	115	115	126	147
21	168	209	210	227	211	147	125	118	115	115	127	142
22	161	237	210	225	209	145	124	118	115	115	130	140
23	159	247	216	224	206	144	124	118	115	116	130	138
24	160	238	216	227	204	142	123	118	115	115	129	137
25	163	238	214	223	201	141	123	117	115	115	132	144

Day of month	J	F	M	A	M	J	J	A	S	O	N	D
26	162	224	214	221	201	139	122	117	115	116	135	146
27	159	215	215	223	200	138	122	117	115	118	133	147
28	160	209	212	229	197	138	122	117	115	118	138	161
29	162	195	206	223	195	138	121	117	114	119	134	158
30	166		203	221	191	137	121	117	115	118	138	164
31	183		202		188		121	116		118		181
Average	**168**	**217**	**203**	**218**	**206**	**157**	**127**	**119**	**116**	**115**	**125**	**146**

	Avg	Flow/mi^2
Jan	168	1.57
Feb	217	2.03
Mar	203	1.90
Apr	218	2.03
May	206	1.92
Jun	157	1.47
Jul	127	1.18
Aug	119	1.11
Sep	116	1.08
Oct	115	1.08
Nov	125	1.17
Dec	146	1.36

APPENDIX C SCREEN TYPE EVALUATION MATRIX

Table 21. Intake Screen Evaluation Matrix.

Type of Screen	Advantages	Disadvantages	Cleaning Concepts	Environmental Considerations
Vertical Fixed Plate	• Compact civil work • Easy to seal • Mechanically simple	• Must be cleaned mechanically • Large bypass flows required to meet velocity criteria	• Mechanical brush on front side • Air burst system on back side	• Canal blockage is minimal • Deep installation
Non-Vertical Fixed Plate (downward or upward sloping)	• No moving parts • No additional diversion required • Self-cleaning • Upward sloping allows for uniform flow distribution through screen	• During low flow, risk of injury on screen • Self cleaning may not be reliable • Downward sloping screen does not provide uniform flow distribution without downstream baffle system	• Self cleaning • Upward sloping equipped with automatic cleaning devices such as mechanical brushes or air or water burst system	• Minimum depth of water over entire face of screen dependent on fish species present and size and type of debris to be transported • Downward sloping screens require several feet of head to operate • Upward sloping typically installed for gravity diversion
Vertical Travelling Screen (panel and belt types)	• Compact civil work • Self cleaned by rotation. Jet sprays can provide additional cleaning • Can be installed on river's edge, no bypass needed • Commercially available as standard manufactured product • Panel-type screens can be easily replaced in sections	• Mechanically complex • Seals require maintenance • Debris/fish transport troughs do not preclude sealing between face of screen and front of screen frame • Not designed for fish protection • Mesh screen can deform with flow and therefore not adequately seal to protect fish	• Self cleaning	• Typically used for pumped diversions • Panel-type have individual mesh panels • Belt-type have continuous belt mesh • Belt screen can be installed in deep water

Type of Screen	Advantages	Disadvantages	Cleaning Concepts	Environmental Considerations
Cylindrical Rotating Drum	• Proven Fish protection • Self-cleaning with rotation • Passes debris downstream	• Major civil works are required • Seals require maintenance • Mesh requires periodic replacement • Upstream water surface cannot vary more than 20%	• Self cleaning	• Typically installed in open channel flow • Typically installed in gravity diversions • Submergence level should be 65-85%
Cylindrical Fixed Drum	• Good concept for deep intake • Some commercially available manufactured products meet the NMFS criteria	• Out of sight, out of mind • Need cross directional current to transport debris from screen site • Air burst system doesn't always clean the entire screen	• Air burst or water jet system on inside	• Typically installed at the end of a pump intake in a pressurized system • Deep installation

APPENDIX D HYDROLOGIC AND HYDRAULIC ANALYSIS RESULTS

Table 22. Hydrologic and Hydraulic Analysis Summary Table.

Summary Table

Drainage Basin of Warm Springs River at Kahneeta, mi^2 526

Drainage Basin Beaver Creek

Size, mi^2 145

		Month											
		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
5th Percentile													
	CFS	34	39	45	54	46	38	34	31	31	32	34	30
Flow/Area	CFS/mi^2	0.2	0.3	0.3	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2
at Diversion	CFS	122	143	163	195	167	138	122	114	114	116	125	110
95th Percentile													
	CFS	571	800	362	244	192	95	51	45	44	48	99	317
Flow/Area	CFS/mi^2	3.9	5.5	2.5	1.7	1.3	0.7	0.4	0.3	0.3	0.3	0.7	2.2
Syn Warm Springs	CFS	2071	2901	1314	886	696	346	185	163	159	173	358	1149

Drainage Basin	Mill Creek												
Size, mi^2	26.8												
		Month											
		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
5th Percentile													
	CFS	38	38	45	54	49	36	33	30	28	29	34	36
Flow/Area	CFS/mi^2	1.4	1.4	1.7	2.0	1.8	1.3	1.2	1.1	1.0	1.1	1.3	1.4
Syn Warm Springs	CFS	751	753	887	1055	955	698	641	589	548	578	672	712
95th Percentile													
	CFS	258	290	152	171	197	144	84	63	62	86	199	243
Flow/Area	CFS/mi^2	9.6	10.8	5.7	6.4	7.4	5.4	3.1	2.3	2.3	3.2	7.4	9.1
Syn Warm Springs	CFS	5064	5689	2993	3352	3872	2835	1651	1227	1222	1685	3915	4768

Drainage Basin	Shitike Creek												
Size, mi^2	104												
		Month											
		Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
5th Percentile													
	CFS	47	48	49	66	81	66	47	36	34	36	44	40
Flow/Area	CFS/mi^2	0.5	0.5	0.5	0.6	0.8	0.6	0.4	0.3	0.3	0.3	0.4	0.4
Syn Warm Springs	CFS	240	243	249	336	410	333	235	183	170	180	222	203
95th Percentile													
	CFS	517	326	238	278	316	318	203	120	108	129	266	394
Flow/Area	CFS/mi^2	5.0	3.1	2.3	2.7	3.0	3.1	1.9	1.1	1.0	1.2	2.6	3.8
Syn Warm Springs	CFS	2617	1648	1205	1408	1597	1608	1024	605	544	653	1345	1995

Synthetic
Average

		Month Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
5th Percentile													
Beaver Creek	CFS	122	143	163	195	167	138	122	114	114	116	125	110
Shitike Creek	CFS	240	243	249	336	410	333	235	183	170	180	222	203
Syn Average	CFS	181	193	206	266	289	235	179	148	142	148	173	156
95th Percentile													
Beaver Creek	CFS	2071	2901	1314	886	696	346	185	163	159	173	358	1149
Shitike Creek	CFS	2617	1648	1205	1408	1597	1608	1024	605	544	653	1345	1995
Syn Average	CFS	2344	2275	1259	1147	1147	977	605	384	352	413	851	1572

Actual Average

		Month Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
5th Percentile													
Kahneeta	CFS	231	244	274	305	285	238	207	198	200	207	227	228
95th Percentile													
Kahneeta	CFS	1736	1829	1308	1050	928	674	396	333	320	335	562	1340

APPENDIX E CONCEPT EVALUATION MATRIX

Table 23. Concept evaluation matrix.

Factor	Concept 1	Concept 2	Concept 3
Formation and Collection of Frazil Ice	• Movement of rotary drum will likely prevent fragile ice build up • Warm water diffuser will continuously prevent ice from building up on the intake screen and brush.	• Warm water diffuser will continuously prevent ice from building up on the intake screen and brush. • OR Adjustment of the frequency and time of day brush cleaning system operates will limit fragile ice building up on the screen.	• Movement of rotary drum will likely prevent fragile ice buildup. • In stream velocity upstream of existing intake is faster, decreasing the likelihood of frazil ice buildup at new location. • Warm water diffuser will continuously prevent ice from building up on the intake screen and brush
Excessive Collection of Sediment and Debris in Intake and Hatchery	• Occasional removal of large debris that could accumulate, particularly at hatchery intake and at adjustable weir. • Addition of 15" sediment bypass above the existing intake structure but below the proposed sill. • Adjustable weir notch in existing weir periodically allows for some release of fine sediment built up behind structure and also allows flow and velocity to be focused near the intake during periods of low flow. • Floating debris carried into the forebays by the rotary drum screen still a maintenance issue.	• Occasional removal of large debris that could accumulate, particularly at hatchery intake and at adjustable weir. • Addition of large diameter sluicing pipe between bypass chamber and lower level of fishway will improve circulation through intake forebays, reduce sediment deposition and increase transport of sediment, floating debris and ice out of forebays. • Groin structure to encourage new location of thalweg just outside of intake structure.	• Occasional removal of large debris that could accumulate, particularly at hatchery intake. • Configuration of new intake structure and trash rack discourages sediment from entering the intake. • Intake is located in a position of increased stream flow velocity. • Pre-settling basin behind intake screen allows for sediment removal prior to transport to the hatchery via the hatchery intake pipe.

Factor	Concept 1	Concept 2	Concept 3
High Water Temperatures during Summer Months	• Methods for addressing sediment issues will likely yield lower water temperatures during summer months due to a deeper pool near the intake structure. • Fish and sediment bypass encourage flow to pass by intake screens and out of intake structure, decreasing stagnant water.	• Methods for addressing sediment issues will likely yield lower water temperatures during summer months due to a deeper pool near the intake structure.	• Soil depth is cooler with depth, with a deep intake pipe intake water is likely to maintain its current temperature or decrease slightly between intake and hatchery building. • Upstream water temperatures are less affected by the pooling created by the existing weir.

Factor	Concept 1	Concept 2	Concept 3
Construction Complexity	• Requires the removal of the existing static drum screens and all appurtenances. Static drum screen appurtenances include the adjustable support brackets and pipe supports as well as 4-inch air piping. • Requires the patching of two existing 34-inch diameter concrete cores between the intake forebays and the travelling screen chambers. • Requires minimal demolition to the existing intake structure sill. • Requires dewatering stream between intake structure and fishway, and construction of large diameter bypass or sluicing pipe at elevation 1493+/- . • Requires utility routing and installation at new intake structure. existing weir wall and anchoring of spillway gate 5-feet below the top of weir (1502’). Includes the piping of compressed air to the spillway gate air bladder.	• Requires the removal of the existing static drum screens and all appurtenances while maintaining the two existing 30-inch diameter canal gate valves. Static drum screen appurtenances include the adjustable support brackets and pipe supports as well as 4-inch air piping, unless air-burst system is selected over mechanical brush • Requires the patching of two existing 34-inch diameter concrete cores between the intake forebays and the travelling screen chambers T • The existing 24” sluice gate in forebay #2 and 18” pipe to bypass chamber need to be relocated. Existing access manholes will provide access behind the new fixed vertical plates, however access ladder in forebay #2 to be relocated. • Mechanical arm, brush motor control panel, and brush controls to be installed and incorporated to hatchery automated system. • Requires dewatering stream between intake structure and fishway, and construction of large diameter bypass or sluicing pipe at elevation 1493+/-. • When constructing groins, it is best done during low flow when dewatering is possible and construction will have the least impact on fish. Excavation will be required to key in the groin into the streambed and to place rock near potential scour locations requiring dewatering.	• Requires the removal of the existing static drum screens and all appurtenances. Static drum screen appurtenances include the adjustable support brackets and pipe supports as well as 4-inch air piping. • Includes the construction of a new intake structure upstream of the existing intake structure along the northeast bank. The new intake structure will be constructed with a trash rack, new intake screens, and warm water diffuser. Requires the dewatering of the river around the new intake construction area and deep trench excavation along the shoreline for hatchery intake piping and near the hatchery building. • Includes installation and mounting of two 12-in intake control gate valves. • Requires utility routing and installation at new intake structure. existing weir wall and anchoring of spillway gate 5-feet below the top of weir (1502’). • Secure, patch or install temporary closure to existing intake structure.

Factor	Concept 1	Concept 2	Concept 3
Construction Access	• All work occurs within 50 feet of the existing vehicle access on the northwest bank of the stream.	• All work occurs within 50 feet of the existing vehicle access on the northwest bank of the stream.	• All work occurs within 300 feet of the existing vehicle access on the west bank of the stream. Work extends further west than Concept 1 and 2
Phasing Considerations	• Block intake forebay #1, closing the valves, and draining the intake. • Utilizing the overhead crane to hoist the existing static drum while gate valves are removed and replaced and support bracket and pipe are modified and relocated. • Once items are removed, initiate dewatering plan and provide temporary water supply to hatchery. Tap existing hot water supply from travelling screen bays. Remove existing trash racks, salvaging one for re-use. • Dewater stream in front of intake structure, construct new intake structure, install new rotary drum screens and associated mechanical components. Install salvaged trash rack. • Re-address dewatering plan to maintain hatchery and fishway water supply, install new adjustable weir.	• Once existing screens are removed, relocate 18-inch pipe to bypass chamber. Install fixed vertical plate screen, mechanical arm, and install utilities for mechanical arm and warm water diffuser. • Once complete move to forebay #2, dewater intake structure, relocate 24-inch sluice gate and connect to 18-inch pipe, and relocate manhole access ladder. • Re-address dewatering plan and install groin structure.	• Dewater new intake site, construct new intake structure on the west bank, trench and install new hatchery intake pipes, and utilities. • Dewater existing screen in forebay #1 and remove static drum, open valves to allow new intake structure to discharge to forebay #1, once new intake is on-line and functioning, dewater forebay #2 and remove static drum, open valves to bring forebay #2 on-line. • Finish site work and grading. • The area around the new intake structure can be dewatered using sandbags while maintain continuous flow in the main channel of the stream. Continuous operation of the existing intakes can continue while new structure is constructed.
In-Water Construction Scope	• Improvements, construction dewatering, and phasing would impact approximately 700 square feet of the existing stream channel.	• Improvements, construction dewatering, and phasing would impact approximately 500 square feet of the existing stream channel.	• Improvements, construction dewatering, and phasing would impact approximately 1500 square feet of the existing stream channel.

Factor	Concept 1	Concept 2	Concept 3
Cost	• Rough order of magnitude estimate of probable construction cost $1,101,590	• Rough order of magnitude estimate of probable construction cost $323,130	• Rough order of magnitude estimate of probable construction cost $1,324,200
Advantages	• Compliant with NMFS fish screening criteria. • Decreases likelihood of frazil ice build-up on screen. • Increases effectiveness of screen cleaning functionality and decreases the amount of sediment entering the intake sump. • Less utility work that Concept 3. • Less in-stream work than Concept 3. • Summer water temperatures likely to be cooler due to configuration of structure and sediment transport improvements.	• Compliant with NMFS fish screening criteria. • Requires less utility work than Concept 3, and potentially Concept 1 if air burst system is utilized over mechanical brush arm. • Smallest scope of in-stream work. • Warm water diffuser limits frazil ice formation on fixed vertical screen. • Mechanical brush system is an effective screen cleaning method. • Summer water temperatures likely to be cooler due to configuration of groin structure.	• Compliant with NMFS fish screening criteria. • Provides sediment bypass trough and pre-settling basin to reduce sediment intake to hatchery. • Does not require modification of existing intake structure other than removal of static drums. • Allows for continuous operation of existing intake structures until new structure is completed. • Deeper intake pipe likely to yield cooler water into the hatchery during summer months.

Factor	Concept 1	Concept 2	Concept 3
Dis-advantages	• Requires the removal and disposal of existing static drum screens and appurtenances. • Complex dewatering and work phasing required for construction of intake structure and screens, and adjustable weir. • Requires more concrete and in-water construction than Concept 2. • Requires seals to be inspected and replaced frequently. • Will require continuous maintenance to manage floating debris and sediment issues.	• Requires the removal and disposal of existing static drum screens and appurtenances. • Requires new mechanical brush system. • Will require continuous maintenance to manage sediment issues. • Will not decrease the amount of sediment entering the intake sump.	• Requires the most amount of in-stream work. • Requires the most amount of utility work. • Requires significant excavation adjacent to hatchery building.

APPENDIX F COST ESTIMATING

Table 24. Intake Improvements Cost Estimates for Concepts 1, 2, and 3.

Intake Improvement Concepts
ROM Cost Estimate
Compiled Item Summary

Item No.		Quantity	Unit	Unit Cost	Total Cost
1	**Option 1 & 3 - Demo - See Note 1**	1	ALL	$40,000.00	$40,000
				Subtotal	$40,000
2	**Option 2 - Demo - See Note 2**	1	ALL	$43,000.00	$43,000
				Subtotal	$43,000
3	**Prepare and Maintain Dewatering Plan**	1	LS	$3,500.00	$3,500
				Subtotal	$3,500
4	**Construction Dewatering - See Note 3**	1	LS	$25,000.00	$25,000
				Subtotal	**$25,000**
5	**Concept 1 - Intake Structure Modification**				
	Rotary Drum Screen	2	EA	$175,000.00	$350,000
	Concrete Structure	55	CY	$1,200.00	$66,000
	10" Wall Mount Gate Valve	1	EA	$3,000.00	$3,000
	15" Wall Mount Gate Valve & EMO	1	EA	$23,800.00	$23,800
	Concrete Coring	2	EA	$250.00	$500
	Warm Water Diffuser w/ 2" HDPE Pipe	1	LS	$5,000.00	$5,000
	Site Grading / Dredging	1	LS	$7,000.00	$7,000
	Rocks - Light Loose Riprap	200	TN	$105.00	$21,000
				Subtotal	***$476,300***

6	**Concept 2 - Intake Structure Modification**				
	Vertical Plate Stainless Steel Screens	2	LS	$22,000.00	$44,000
	Warm Water Diffuser w/ 2" HDPE Pipe	1	LS	$5,000.00	$5,000
	Site Grading -- **See Note 4**	1	LS	$0.00	$0
	Mechanical Arm Brush and Motor	2	LS	$30,000.00	$60,000
				Subtotal	***$109,000***

7	**Concept 3 - Intake Structure**				
	Concrete Structure	120	CY	$1,200.00	$144,000
	Rotary Drum Screen - **See Note 5**	2	EA	$175,000.00	$350,000
	Warm Water Diffuser	1	LS	$4,900.00	$4,900
	Warm Water Diffuser 2" HDPE Pipe	300	LF	$18.50	$5,550
	Building 1250 SF	1	LS	$590,000.00	$590,000
	Hoist Crane	1	LS	$35,000.00	$35,000
	2" Raceway and Wiring	600	LF	$11.00	$6,600
	Hatchery Intake Pipe - 24" PVC	300	LF	$52.00	$15,600
	Sediment Bypass Pipe - 15" PVC	300	LF	$40.00	$12,000
	10" Wall Mount Gate Valve	1	EA	$3,000.00	$3,000
	24" Wall Mount Gate Valve	1	EA	$6,000.00	$6,000
	15" Wall Mount Gate Valve & EMO	1	EA	$23,800.00	$23,800
	Trench Excavation and Haul	798	CY	$13.00	$10,400
	Pipe Bedding, Furnish, Place, and Compact	587	CY	$27.96	$16,400

7	**Concept 3 - Intake Structure (continued)**				
	Pipe Backfill, Compact	798	CY	$5.75	$4,600
	Temporary Shoring and Dewatering	1	LS	$318,000.00	$318,000
	Rock Excavation - See Note 11	1	Allow	$40,000.00	$40,000
	Site Grading / Dredging	1	LS	$15,500.00	$15,500
	New Access Roadway- Surfacing Base Course 6 -in	40	CY	$80.50	$3,220
	Rocks - Light Loose Riprap	100	TN	$105.00	$10,500
	Miscellaneous Electrical	1	Allow	$12,500.00	$12,500
	Light Pole and Foundation	1	EA	$4,500.00	$4,500.00
				Subtotal	***$1,632,070***

8	**Rock Groin**				
	Rocks - Light Loose Riprap	84	TN	$105.00	$8,820
	'Fish Mix' Gravel	4	TN	$150.00	$600
				Subtotal	***$9,420***

9	**Weir Improvements - See Note 6**				
	3.5 FT - Adjustable Spillway Gate	1.0	LS	$66,000.00	$66,000
	Air Compressor and Piping	1.0	LS	$10,000.00	$10,000
	Existing Weir Structural Modifications	1.0	LS	$8,200.00	$8,200
				Subtotal	***$84,200***

10	**Weir Improvements - See Note 10**				
	5 FT - Adjustable Spillway Gate	1.0	LS	$98,000.00	$98,000
	Air Compressor and Piping	1.0	LS	$10,000.00	$10,000
	Existing Weir Structural Improvements	1.0	LS	$9,500.00	$9,500
				Subtotal	***$117,500***

11	**Utility Upgrades**				
	Programming Warm Water Diffuser System	1.0	LS	$1,500.00	$1,500
	Adjustable Height Weir Air Supply and Programming	1.0	LS	$2,500.00	$2,500
				Subtotal	***$4,000***

INTAKE CONCEPT 1

Item No.		Quantity	Unit	Unit Cost	Total Cost
	Mobilization & Site Preparation				
	Mobilization (8%)	1	LS	$41,900.00	$41,900
1	Demo	1	ALL	$40,000.00	$40,000
3	Prepare and Maintain Dewatering Plan	1	EA	$3,500.00	$3,500
4	Construction and Dewatering	1	Allowance	$25,000.00	$25,000
	De-Mobilization (5%)	1	LS	$26,190.00	$26,190
				Mobilization & Site Preparation	**$136,590**

	Hatchery Intake Modifications				
5	Intake Structure Modification	1.0	EA	$476,300.00	$476,300
11, 12	Utility Upgrades	1.0	EA	$4,000.00	$4,000
9	Weir Improvements	1.0	EA	$117,500.00	$117,500
				Hatchery Intake Modifications	**$597,800**
				Subtotal - Intake Concept 1	**$734,390**
				Design Contingency (20%)	$146,880
				Construction Contingency (25%)	$220,320
Total					**$1,101,590**

INTAKE CONCEPT 2

Item No.		Quantity	Unit	Unit Cost	Total Cost
	Mobilization & Site Preparation				
	Mobilization (8%)	1	LS	$13,200.00	$13,200
2	Demo	1	ALL	$43,000.00	$43,000
3	Prepare and Maintain Dewatering Plan	1	LS	$3,500.00	$3,500
4	Construction and Dewatering	1	LS	$25,000.00	$25,000
	De-Mobilization (5%)	1	LS	$8,300.00	$8,300
				Mobilization & Site Preparation	**$93,000**

Hatchery Intake Modifications

6	Intake Structure Modification	1.0	EA	$109,000.00	$109,000
11	Utility Upgrades	1.0	EA	$4,000.00	$4,000
8	Rock Groin	1.0	EA	$9,420.00	$9,420
				Hatchery Intake Modifications	**$122,420**
				Subtotal - Intake Concept 2	**$215,420**
				Design Contingency (20%)	$43,080
				Construction Contingency (25%)	$64,630

Total **$323,130**

INTAKE CONCEPT 3

Item No.		Quantity	Unit	Unit Cost	Total Cost
	Mobilization & Site Preparation				
	Mobilization (8%)	1	LS	$133,890.00	$133,890
1	Demo	1	ALL	$40,000.00	$40,000
3	Prepare and Maintain Dewatering Plan	1	LS	$3,500.00	$3,500
	De-Mobilization (5%)	1	LS	$83,680.00	$83,680
				Mobilization & Site Preparation	**$261,070**

Hatchery Intake Modifications

6	Intake Structure Modification	1.0	EA	$1,632,070.00	$1,632,070
11	Utility Upgrades	1.0	EA	$1,500.00	$1,500
				Hatchery Intake Modifications	**$1,633,570**
				Subtotal - Intake Concept 3	**$1,894,600**
				Design Contingency (20%)	$378,920
				Construction Contingency (25%)	$568,380
Total					**$2,841,900**

Notes

1 Demolition for Options 1 and 3 includes removal of existing intake screen rotary drums, support leg, support pipe, 30" dia. gate valve, patching of existing concrete cores, decommissioning of air burst system, and minor hand demolition of existing weir.

2 Demolition of Option 2 includes removal of existing intake screen rotary drums, support legs, support pipe, 30" dia gate valve, patching of concrete cores, decommissioning of air burst system, relocation of existing 18" bypass, and relocation of existing wall mount gate valve.

3 Dewatering requirements vary for each of the three concepts, this cost is estimated as a total allowance for either three concepts. Dewatering for construction is anticipated to include cofferdams, and dewatering pumping system

4 No site grading for Option 2 - grading associated with groin structure in Item No. 11

5 Rotary Drum Screen Cost includes screen unit, electric drive unit, controls, HPU (or VFD), cabinets, and umbilical

6 Includes weir slab, miscellaneous metal imbeds, demolition (notching) of existing weir structure, and $7000 allowance for dewatering

7 Based on 500 gal plastic tank on elevated steel platform, assumes that structural modifications to existing floor and building structure are not required.