Fish Passage at Oneida: Conceptual Design Report

DRAFT

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March 8, 2011

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FIGURES

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1. INTRODUCTION

This report is a draft of a conceptual design report for fish passage facilities at the Oneida Hydroelectric Project (Oneida). Facilities examined in this report are intended to meet the goals of restoring Bonneville Cutthroat Trout (BCT) connectivity upstream and downstream of Oneida. The scope of work for the fish facility design study states:

> *"The long-term goal of the larger multi-year project is to design and build a fish passage facility to reconnect Bonneville Cutthroat Trout stronghold populations upstream and downstream of the reservoir."*

The goals for fish passage at Oneida are also related to the Final 2008 Comprehensive Bonneville Cutthroat Trout Restoration Plan. According to this plan, the overarching goal for the restoration plan is:

> *"To preserve, restore, and protect BCT and their unique ecological and behavioral characteristics within the Bear River Action Area to ensure the long-term viability of the species on a population by population basis."*

The plan recommends actions pertinent to the Oneida project such as; to enhance existing BCT populations, identify passage issues to improve or expand existing BCT range. The plan also recommends actions to reduce impacts of non-native fish species including rainbow trout populations on BCT populations.

1.1 AUTHORIZATION

The funding for this report was provided by Bear River Environmental Coordination Committee Grant Funds, which are funded annually by PacifiCorp. PacifiCorp contracted with R2 Resource Consultants, Inc. (R2) to provide professional experience and engineering expertise with fish passage design to the Environmental Coordination Committee (ECC), and to prepare a draft and final conceptual design report.

1.2 REPORT OBJECTIVES

The goal of the conceptual design report is to evaluate the feasibility of constructing fish passage facilities at Oneida. Various fish passage facilities will be assessed for purposes of reconnecting BCT stronghold populations upstream and downstream of the Oneida project. The primary focus was intended to be on upstream passage; however, based on input during two ECC review meetings, R2 was also asked to address downstream passage alternatives.

R2 first performed a high-level review of potential upstream and downstream fish passage alternatives that could provide the desired fish passage at Oneida. Upstream and downstream passage alternatives considered to be potentially feasible at Oneida, include but are not limited to:

- Fish Ladders
- Constructed Fishway Channels
- Trap-and-Haul Transport Systems
- Intake Screening Systems
- Surface Collectors
- Head of Reservoir Collectors

After discussions with the ECC held during the development of this report, R2 identified and the ECC agreed upon alternatives to present in this report.

This draft report provides a description of each alternative and presents information on estimated biological performance, impacts to project operations, and provides planning level cost estimates to help the ECC compare alternatives and asses the feasibility of implementing the alternatives at the Oneida Project in order to meet the BCT restoration goals.

Based on comments received from the ECC on this draft report, R2 will compile a final report that will also include engineering and biological professional opinions concerning which alternatives are best suited to the site, and provide guidance on how to proceed with additional studies and to select a recommended alternative that will meet the program goals.

1.3 CONCEPTUAL DESIGN REPORT ORGANIZATION AND CONTENTS

This section describes the contents provided in this draft, and to be provided in the final conceptual design report. The project background and criteria section, and an alternatives memorandum were developed separately to facilitate discussions at the ECC meetings and to assist with project development. These documents have been compiled, and are presented here together in the Conceptual Design Report.

Section 2 provides the project background information including a description of the project's physical features.

Section 3 provides the general design considerations and project goals including biological information for the target fish species and life stages, hydrology and design flows, a description of pertinent project operations, relationship of run timing and flows, and a summary of design goals and guidelines.

Section 4 provides a summary of all concepts considered during the study process, along with documentation of alternatives dropped from further consideration and the justification for their elimination.

Section 5 presents the upstream fish passage alternatives that were developed to a functional level of design. Similarly, Section 6 presents the functional designs for the downstream passage alternatives.

Section 7 provides an estimate of the probable construction cost for each alternative developed in Sections 5 and 6, and describes the accuracy and intended use of these planning level estimates.

Section 8 is reserved for use in the final conceptual design report, which will address recommendations for how to proceed based on ECC review comments and discussion. We envision recommendations for data collection, potential studies, and a recommendation on which alternative(s) to pursue. Additionally a process will be identified to help the ECC decide on future actions.

This report is intended for distribution and review by the ECC Work Group in March 2011. Comments received will be compiled with the authors' responses, and will be included in an Appendix to the final Report scheduled for distribution in May 2011. Other comments and any desired ECC meeting notes can be documented in Appendices in the final report.

2. BACKGROUND

2.1 SOURCES OF PROJECT INFORMATION

A basic understanding of the site and the project goals were provided through a field visit, literature review and conversations with PacifiCorp personnel. Initial project information was gathered on a field visit to the site. Glen Anderson of R2 and Mark Stenberg of PacifiCorp visited the Oneida Hydroelectric Project site on August 20, 2010 to take pictures and discuss the project. A second field visit was conducted on January 19, 2011 with Glen Anderson, Mark Stenberg and Dana Postlewait (R2) attending.

The primary source of project background information was provided by PacifiCorp. PacifiCorp provided drawings of the intake, dam, and powerhouse as well as a base GIS map and control information for the site survey. The following is a list of materials that R2 reviewed for information relative to existing conditions at the project:

- Bear River Settlement Agreement 2002.
- Unpublished PacifiCorp Hydrology and Operations data.
- Unpublished PacifiCorp drawings.
- Comprehensive Bonneville Cutthroat Trout Restoration Plan Final 2008
- Management Plan for Conservation of Bonneville Cutthroat Trout in Idaho 2007
- Bear River Narrows FERC Project No. 12486, Twin Lakes Canal Company Plan

2.2 PROJECT UNDERSTANDING

The Bear River Project is owned and operated by PacifiCorp and consists of 4 facilities including Soda, Grace, and Oneida. The Bear River Project is located on the Bear River in Caribou and Franklin Counties, Idaho, and is partially located on United States lands administered by Bureau of Land Management (BLM). The Bear River Project generates approximately 84.5 megawatts of electricity.

There are no fish passage facilities currently installed at the Oneida Project. Currently, upstream passage is not possible in any way, and downstream passage is only possible over the spillway or through the turbines.

The Oneida facility is the most downstream of the 4 hydropower facilities in The Bear River Project. There is however a proposed project to build a new hydroelectric dam downstream of

Oneida. The Twin Lakes Canal Company has filed for a preliminary permit with the Federal Energy Regulatory Commission to build an 85-foot-tall dam in the Oneida Narrows downstream of the Oneida Project, four miles northeast of Riverdale. According to the preliminary application, the dam would store about 22,700 acre-feet of water at a time, and would produce about 7 megawatts of electricity.

2.3 DESCRIPTION OF EXISTING SYSTEM

The Oneida facilities consist of a 111-foot-high and 456-foot-long concrete gravity dam; the Oneida reservoir with an active storage of 10,880 acre-feet and a surface area of 480 acres; a 16-foot-diameter, 2,240-foot-long steel pipe flow line; a surge tank; three 12-foot-diameter, 120-foot-long steel penstocks; the Oneida powerhouse with three Francis turbine units with a total installed capacity of 30 megawatts; and other appurtenances. In addition to the concrete dam there is an earthen dike with a crest length of approximately 1,080 feet. A concrete parapet wall was added to the top of the earthen dike to provide additional freeboard. Figure 2-1 shows the primary components of the project and Figure 2-2 is a photo of the site.

The dam is a concrete gravity dam that spans the Bear River and is anchored into bedrock with post tensioned cables. The dam diverts flow from the Bear River through the intake structure which has a trashrack with clear spacing of 1-5/16 inches. There are two entrance gates and two 16 foot diameter flow lines that pass through the earthen dike, but the western flow line is capped where it emerges from the dike fill and the eastern flow line is the only one that continues on to the powerhouse. Any remaining flow travels over the dam spillway and into the Bear River channel where it flows for approximately 3,800 ft to its confluence with the tailrace flow from the powerhouse. The forebay is generally kept full but has a water level that varies seasonally and with flow. The powerhouse returns flow to the Bear River just downstream of the powerhouse.

Oneida Reservoir is a long and narrow reservoir approximately 4.7 miles long covering 480 surface acres with a usable storage capacity of 11,500 acre-feet. The width of the reservoir varies from about 1400 ft at its widest point on the downstream end to 200 ft at its narrowest, with an average width of about 800 ft. At full pool, the reservoir has an average depth of about 28 feet, with a maximum depth of about 85 feet.

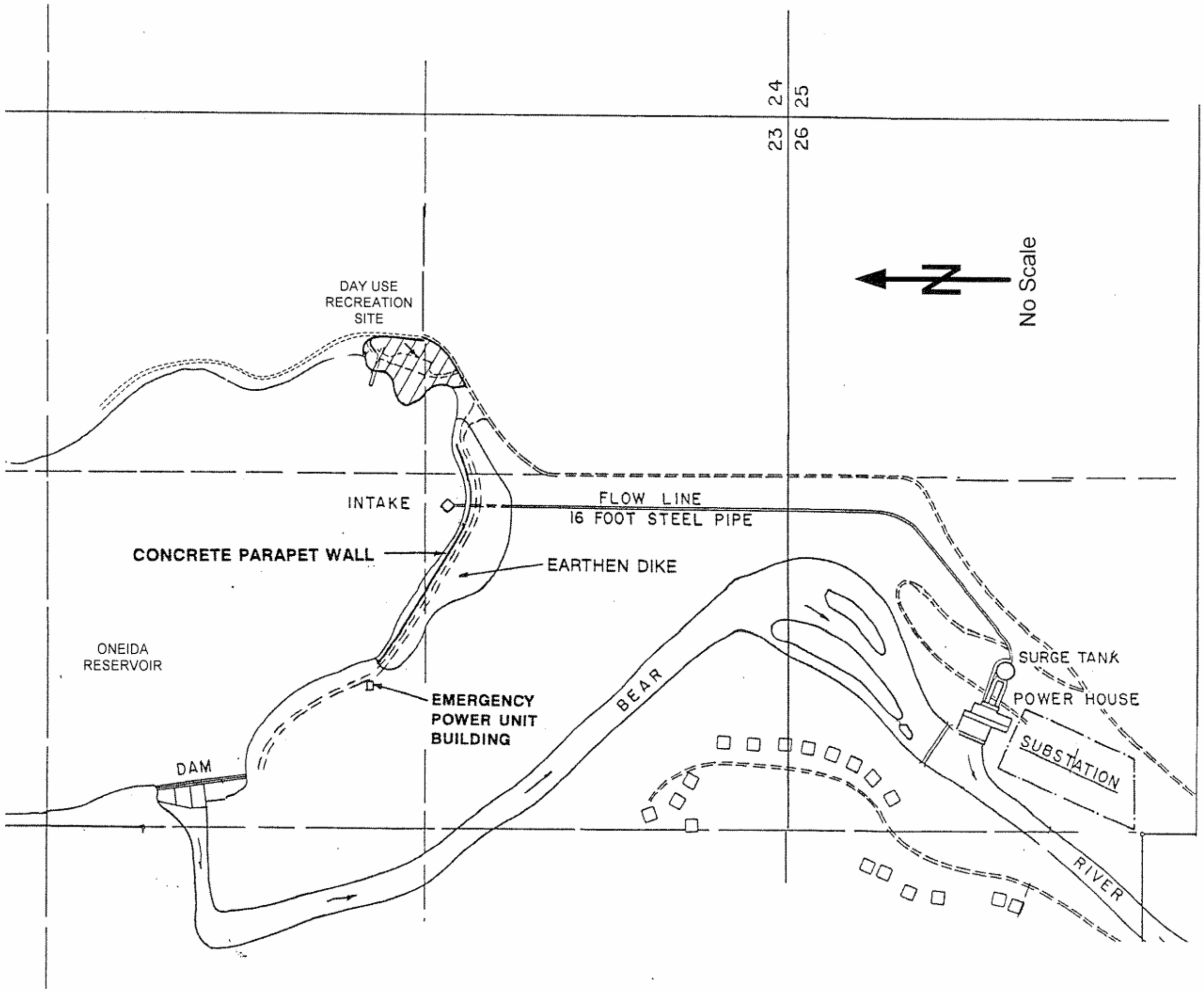


Figure 2-1. Oneida Project schematic showing main Project components (source: PacifiCorp Bear River FERC No. 20).

Figure 2-2. Oneida Project photo site plan (source: PacifiCorp Bear River FERC No. 20).

PacifiCorp studies show that the existing recreational facilities on Oneida Reservoir (Maple Grove Campground and Oneida Day Recreation Site) are popular weekend destinations for camping, fishing, and boating. The recreational facility on the Bear River downstream of the Oneida facility owned by BLM (Redpoint Campground) also is a popular weekend destination where users camp, fish, wade, tube, and kayak the river. At high flows, the river downstream of the Oneida facility is a Class I or II whitewater boating opportunity suitable for beginners. Relicensing studies indicated that the carrying capacity for these recreational facilities is met or exceeded on about one-half of the weekends in summer. PacifiCorp currently supports boating activities with a day time summer flow goal of 900 cfs.

3. GENERAL DESIGN GUIDELINES AND PROJECT GOALS

Fish passage is a multidisciplinary field that demands a variety of areas of expertise. In the development of any successful fish passage project there must be an integration of fish behavior, physiology, and biomechanics with hydraulics, hydrology and engineering. In addition legal, financial and political interests often guide some of the project goals.

The ECC and R2 are developing specific project goals at Oneida in a collaborative manner. As alternatives are identified and further developed the goals become clearer to the team members. Through discussion between R2 and ECC members during the December 8th ECC meeting and conference call, and the January 19th ECC meeting in Pocatello a clearer understanding of project goals was developed by the members.

Some goals may be modified as the project understanding develops and new ideas and information are presented. Key project understanding elements and goals are presented below;

<u>Target Species</u>
Multiple species should be considered, but BCT are the main target species. Other species will certainly use the ladder or enter the trap so their presence should be taken into account for peak run fish numbers. According to email by David Teuscher we should expect Mountain Whitefish, Utah Sucker and Carp among others.

<u>Type of Passage</u>
The main project focus was originally on upstream passage but during the first team meeting it was decided to consider both upstream and downstream passage.

<u>Handling and Sorting</u>
The ECC does not want to include handling and sorting facilities in the conceptual designs at this point.

<u>Operation Window</u>
Consider facilities with constant operation optimized for the BCT spawning season with upstream passage from May-July.

Project Phasing
Building a smaller facility initially to be scaled up in future years is a possibility at the site if it makes sense to the overall project. This could be the first phase of multi phase project (e.g., upstream facility first, followed by downstream facility in subsequent years if necessary)

Source of water
This issue was discussed the need to identify and secure a source of water to avoid any loss in power generation flow. Another possibility is payment for any water lost to power generation due to fish passage facilities (if the Company approves this course of action). Reducing flow taken from the reservoir will be important to any alternative.

Flood Control
Mark Stenberg expressed the concern that any fish passage facility constructed at Oneida cannot increase risk to dam safety.

3.1 TARGET SPECIES AND RUN TIMING

As already mentioned in the introduction the main species of interest for this project is the native Bonneville cutthroat trout (BCT) in the Bear River Hydroelectric Project Action Area. Figure 3-1 shows the native range of the BCT. The Bear River is in the northeastern sector of the range, in parts of Idaho, Wyoming, and Utah.

Other species to consider in design of fish passage include; Mountain Whitefish, Utah Sucker and Carp.

3.1.1 Run Timing and Fish Size

Seasonal timing information for the various life stage activities of the BCT and other species present in the Bear River at Oneida from a variety of sources is presented in the section below.

A variety of sources were used to establish the timing and size of fish expected at the Oneida Project. Another project that dealt with BCT in the Bear River that R2 worked on was the Kackley Springs trap and upstream passage barrier. According to the Kackley Springs guidelines upstream migrating adults are expected to be 14"-22" in length, and run from May to June. For downstream migrating fish the Kackley Springs guidelines state that the migrants are expected to be 122mm-220mm (4.8"-8.7") long.

Figure 3-1. A map of the native range of the Bonneville Cutthroat trout (copied from http://www.nativetroutflyfishing.com/bonnevillecutthroat.htm).

Similar published data was found during a literature search on the subject,

> *"Fluvial BCT reach sizes of 16 to 20 inches. Fluvial fish have been found to be highly mobile; these fish were observed to make long spawning migrations with some individuals traveling over fifty miles. For fluvial and stream resident populations spawn timing varies with altitude, but may occur from April through July. Young of year cutthroat from fluvial populations emerge from the gravel in late summer and studies have shown that they typically drop down to the river to over winter by the end of September" (Trotter 2008).*

In an email on December 14th from David Teuscher a table was included, which lists the species of interest along with an estimate of their size and expected migration periods.

In Table 3-1 below we summarize the species of interest and expected size and run timing to be used for the Conceptual Design for Fish Passage at Oneida. The table will be updated as timing or size information becomes available. At this point the only species timing and size data used to develop conceptual designs are those contained in Table 3-1 below.

Table 3-1. Run timing and life stage sizes for species of interest at the Oneida project (Information source: Kackley Springs criteria document and email David Teuscher).

Species	Spawning Size (mm)	Spawning Timing	Juvenile Size (mm)	Juvenile Migrations
Bonneville cutthroat trout	330-610	May-July	122-220	Sep-October May-June
Mountain Whitefish	300-450	Sep-Nov	(1)	(1)
Utah sucker	350-600	May-July	(1)	May-July (1)

(1) Information not provide at this time on these species. Assume year-round operation of facilities. Facility design tailored to BCT; these species not expected to control the facility design.

Other species expected to be present that are not shown in the table are carp, bass, and walleye. According to the Settlement Agreement the Oneida Reservoir supports a warm water fish population primarily composed of walleye, carp and yellow perch. The nearest known populations of BCT near the project occur in headwater of tributaries such as Cottonwood Creek and Mink Creek. The Bear River from Oneida Dam to Oneida Powerhouse (Oneida Bypass) supports a naturally-reproducing population of brown trout, and the game fish community in the Bear River downstream of powerhouse is dominated by a self-sustaining population of mountain whitefish and stocked brown and rainbow trout.

Figures 3-2 through 3-4 (in Section 3.2 Hydrology) show the Table 3-1 run timing on the percent exceedence graphs.

As stated in the introduction, the main goal of this project is to connect stronghold populations of BCT upstream and downstream of Oneida, so the goals and guidelines of this CDR for fish passage facilities at Oneida will be primarily for BCT passage, with passage of other species a secondary goal.

3.2 HYDROLOGY AND PROJECT OPERATIONS

All hydrology and operations information for the project was provided by PacifiCorp, from their operational records.

3.2.1 Reservoir Elevation and Operation

Recent reservoir elevation readings were received from PacifiCorp. The daily reservoir stage reading from October 1, 2000 to September 30, 2009 was used to generate reservoir water surface elevation exceedence curves. According to PacifiCorp the readings are taken at "end of shift" about 2 pm local time daily. There are no regular diurnal cycles of the reservoir elevation. There is no established rule curve, as the reservoir is operated as a power pool with no major planned seasonal fluctuations except for minor water surface reductions for spring runoff. During the summer reservoir storage is used to balance irrigation deliveries downstream. This is seen in the data during late June through July, depending on the water year.

3.2.2 Downstream River Flow

Daily average flows have been recorded downstream of the project from 1914 to 2009. These data were used to generate the downstream exceedence flows shown in Figure 3-3.

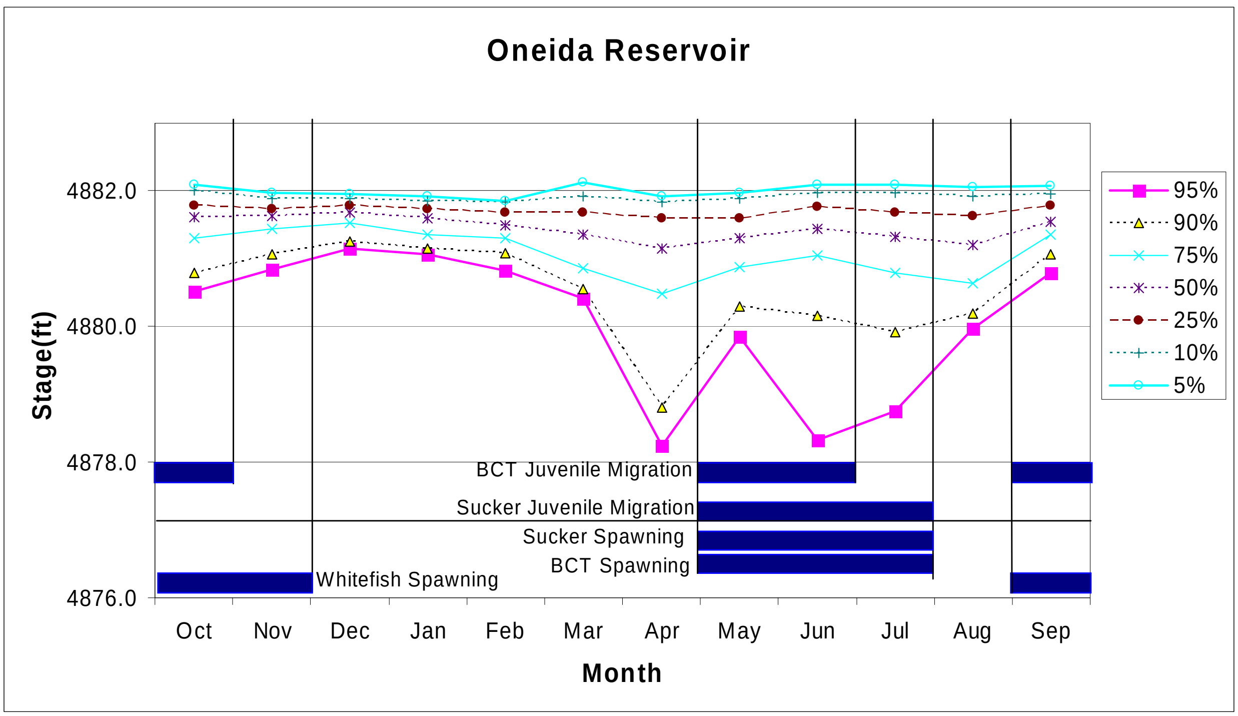


Figure 3-2. Percent exceedence curves for Oneida Reservoir stage readings with fish passage seasons shown (stage reading data source: Unpublished data PacifiCorp 2000-2009).

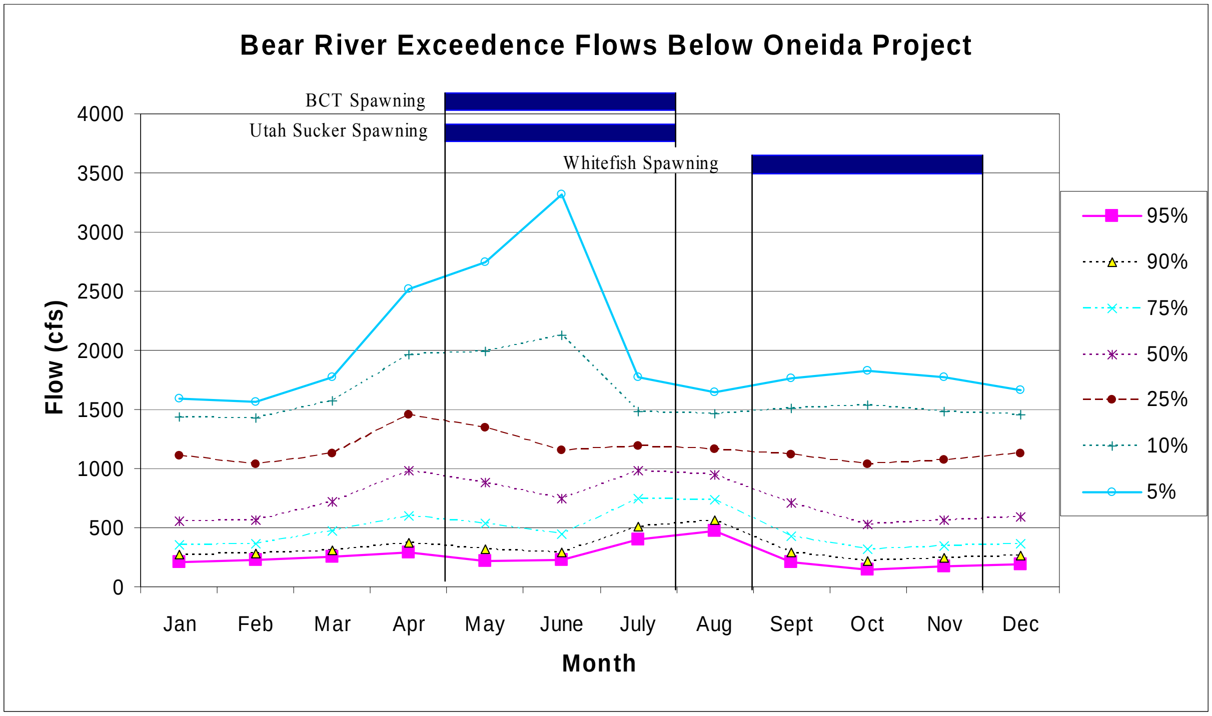


Figure 3-3. Percent exceedence curves for flows below the Oneida Hydroelectric Project with fish passage seasons shown (flow data source: Unpublished data PacifiCorp 1914-2009).

3.2.3 Tailwater Elevations

Tailwater water surface elevation exceedence curves were generated by using the downstream river flows and the stilling well rating curve provided by PacifiCorp. According to PacifiCorp the rating table has changed a little over time, but should not result in large errors. The stilling well elevations reported were converted to the project datum by using the stilling well calibration done by Schiss and Associates in 2008. The elevations in Figure 3-4 show a tailwater elevation variation from the 95% to the 5% exceedence of approximately 4.6 ft during the upstream passage season.

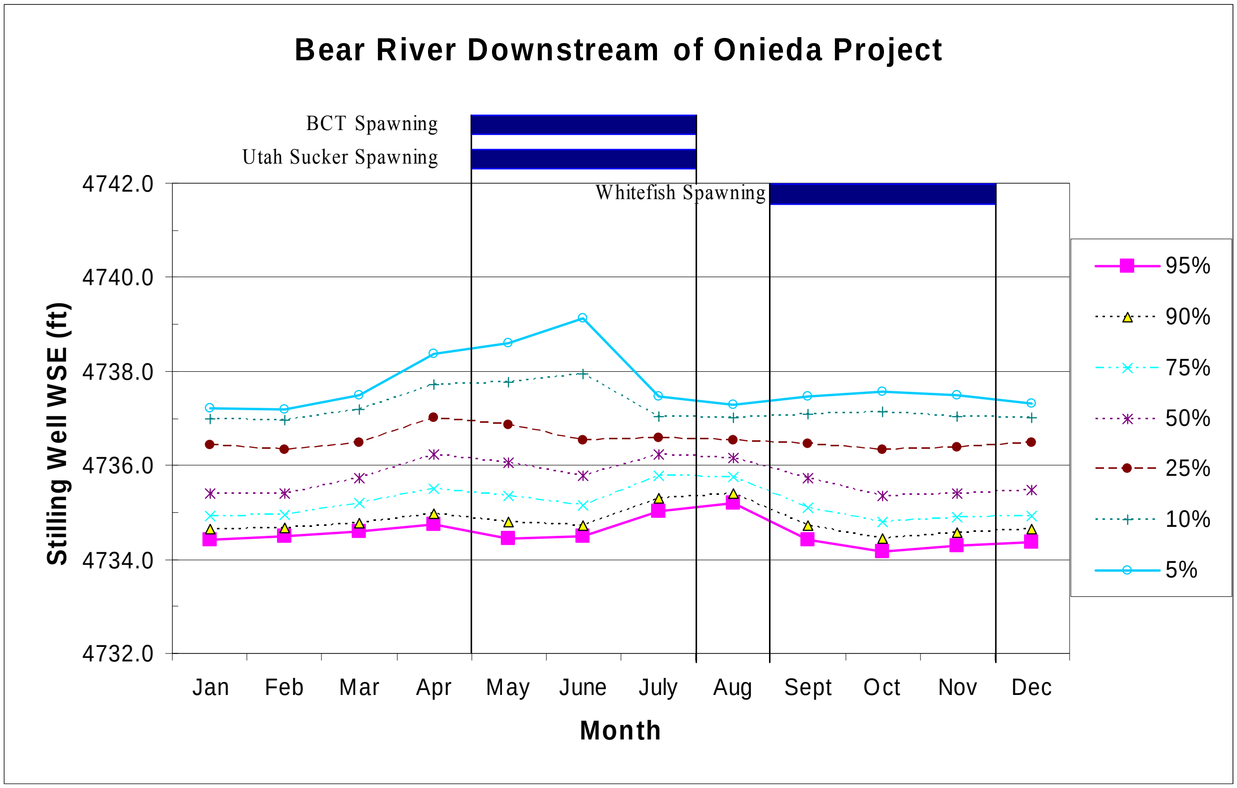


Figure 3-4. Stilling well water surface exceedence elevations below the Oneida Hydroelectric Project with fish passage seasons shown (flow and stilling well rating curve data source: Unpublished data PacifiCorp 1914-2009).

3.3 DESIGN FLOWS AND WATER SURFACE ELEVATIONS

It is standard fisheries engineering practice to design fish passage facilities for all flows between the 5% (high) and 95% (low) exceedence flows in the season of interest. This means that fish passage will be provided 90% of the time during the fish passage season. These flows are calculated based on daily average flows from the period of record during the fish passage season.

We suggest using these exceedence flows as a guideline for the fish passage design flows, keeping in mind that flows must be checked against operational conditions and design constraints at the site. Hydroelectric projects often have specific operations that limit the design flows to be considered, such as the flood control rule curve, and minimum instream flow requirements. There is a minimum instream flow of 250 cfs in the Bear River below the Oneida project, and there is no instream flow requirement in the bypass reach of the Bear River below the Oneida dam. There is no rule curve used at Oneida and the ramping rate below the Oneida project is 3 inches/15 minutes on the descending arm of the hydrograph (Settlement Agreement 2002).

3.4 SUMMARY OF GUIDELINES AND GOALS

Idaho State does not currently have its own criteria developed for fish passage facilities. Idaho does use the National Marine Fisheries Service (NMFS) criteria for juvenile fish screens in those areas where juvenile Salmonids are present. The Bear River does not come under the NMFS review process since it drains to the Great Salt Lake in Utah and not the ocean.

It is our experience that facilities designed to comply with agreed upon criteria are more acceptable and likely to perform well. In the section below we discuss the most relevant fish passage elements to this project and suggest design guidelines for each. On this project we will develop our own project specific design guidelines in coordination with the ECC in order to guide selection of a feasible fish passage facility. These guidelines are developed with the use of relevant reference materials, supplemented with recent project experience. In the following section we provide a discussion of each design element relevant to this project and the suggested design guideline to be followed in development of the conceptual designs.

The most widely used and fully developed fish passage criteria are those developed by National Marine Fisheries Service, Anadromous Salmonid Passage Facility Design 2008. These criteria are not directly applicable to inland fluvial fish species, but because they are the most developed and current criteria for fish passage facility design, they were used, along with other references, as a guide for development of Oneida guidelines.

3.4.1 Guidelines for Upstream Passage

Safe, timely and efficient fish passage is the primary goal of a fish passage facility. In an upstream fish passage facility fish must first be attracted into the facility before they can move upstream, by transport or volitionally through a fishway. Upstream migrating fish are compelled to move upstream, so the upstream passage facility needs to create an environment that allows and encourages the upstream movement. The guidelines that relate mostly to upstream passage are discussed below. These guidelines may in some cases apply to downstream facilities as well, but are more typically associated with upstream passage facilities.

<u>Attraction Flows</u>: In order to attract upstream migrating fish into the facility an attraction flow is needed at the entrance. In order to compete with the receiving water flow and be an attractive entrance that fish can find, flow between 5% and 10% of the receiving water flow is typically used as a design guideline for “attraction flow” at fishway entrances. This attraction flow is the

combination of the upstream ladder flow and any auxiliary water added to the entrance pool for the purpose of increasing attraction to the ladder entrance. Providing an attractive entrance jet and location can increase the effectiveness of the entrance and lower the entrance flow needed to successfully attract fish. Entrance attraction flows can vary widely from project to project. Depending on the hydraulics immediately adjacent to the entrance the attraction flow that is effective can vary from less than 1% of flow to as high as 10%.

<u>Entrance Design</u>: The fishway entrance should be located where fish can easily locate and enter the fishway. In order to attract fish to the entrance the slot should be shaped as close to a square as possible, given site and flow conditions, in order to produce a high energy jet that will propagate as far as possible into the receiving water. The depth and width specified for a fishway entrance is dependent on attraction flow requirements and should be shaped to accommodate site conditions. Typically water depths and widths should be a minimum of 12 inches where adult passage is required.

The entrance should be designed with the target species preferences in mind. Fisheries biologist familiar with the region suggest a full water column slot to accommodate fish that prefer to jump over a weir; and others that prefer orifices.

<u>Pool Energy Dissipation</u>: Energy dissipation in the ladder pools, and entrance pool, should follow the NMFS criteria for fish ladder pools. This guideline assures that turbulence within the fishway pools will not preclude passage. The published pool volume equation is:

$V = (\gamma)(Q)(H)/(EDF)$

Where: V = minimum pool volume, in ft^3

γ = unit weight of water, 62.4 pounds (lb) per ft^3

Q = ladder flow, in ft^3/s

H = energy head of water entering pool, in feet

EDF = energy dissipation factor, 4 ft-lbs/s/ft^3

<u>Head Drops (H)</u>: At any point entering, within, or exiting the fishway where fish are *required* to jump to move upstream, the maximum difference between the upstream and downstream water surface elevations should be a maximum of 1foot. Velocity and energy dissipation guidelines should also be considered at locations with discrete head drops. The ECC may want to consider head drops lower than 1 foot in order to provide passage to more species and life stages. Designs of fishways with drops as small as 0.25 feet per drop have been suggested to successfully passed young 4-6" trout.

Ladder Step Style: The ladder step style should be chosen with the target species preferences in mind, though consultation with fisheries biologists familiar with the target species and the region. Ladder styles including Ice Harbor (and Half Ice Harbor), Vertical Slot and transport channels will be considered.

Diffuser Velocities for Auxiliary Water Supply (AWS): Often fishways are designed with AWS added in the lower most pool (entrance pool), of the fishway to provide sufficient water flow for attraction into the fishway. This water is usually added through diffusers in the walls or floor of the pool. In AWS diffusers the flow should be evenly distributed across the diffuser, diffusers should be oriented to help attract fish upstream, and the following guidelines should be used to limit diffuser velocities: Vertically Oriented Diffusers: 1.0 ft/s
Horizontal Oriented Diffusers: 0.5 ft/s

Holding Criteria: In some cases fish are either attracted or crowded into a pool or tank where they await transport or sorting. In these facilities density of fish becomes a concern due to overcrowding. Overcrowding can be an issue in lift tanks, fish transport trucks, holding tanks for trap and haul facilities, or anywhere fish are held before being able to pass upstream. We suggest using the following fish densities which were developed for the Merwin Hydro Project:

- Lift and Hauling Maximum Loading Density(short term): 0.15 cf/lb of fish
- Pond and Holding Tank Maximum Loading Density(<24hr): 0.25 cf/lb of fish
- Flow through holding facilities: 0.083 gpm/lb of fish

Transport Channel Velocities: In long transport channels the cruising speed of the target species will guide design. Bell Fisheries Handbook reports Cutthroat cruising speed of up to 3 ft/s. If channels are broken up into shorter sections with higher velocities followed by resting pools the sustained speed of the target species will guide design. Bell Fisheries Handbook reports Cutthroat sustained speed of up to 6 ft/s. ODFW suggests limits to velocities in transport channels of between 1.0 ft/s and 2.0 ft/s, and no greater than 5 ft/s in shorter channels like baffled-chute fishways. The ODFW guideline is well with the swimming ability of Cutthroat trout. We suggest using the ODFW limits for the Oneida design guideline.

Fishway Transition Velocities: Transition velocities are the highest velocities through which fish must swim upstream in a fishway. They are the discrete fishway transitions through which fish must swim to move upstream, include but are not limited to slots, orifices and submerged weir crests. The transition velocities need to be high enough to attract fish to move upstream, but not too high as to exceed the swimming ability of the upstream migrant. In transitions, the target species' darting speed, or burst speed will guide design. Bell Fisheries Handbook reports Cutthroat maximum darting speed of up to 14 ft/s. In the ODFW criteria they limit transition velocities to 8 ft/s. The ODFW guidelines are well with the swimming ability of Cutthroat trout, while being high enough to provide attraction upstream. We suggest using the ODFW limits for the Oneida design guideline.

3.4.2 Guidelines for Downstream Passage

Safe, timely and efficient fish passage is the primary goal of a fish passage facility. In a downstream fish passage facility fish must first be attracted into the facility. Downstream migrating fish are compelled to move downstream, so the downstream passage facility needs to create an environment that allows and encourages the downstream movement. The guidelines that relate mostly to downstream passage are discussed below. These guidelines may in some cases apply to an upstream facility as well, but are more typically associated with downstream passage facilities.

3.4.2.1 Screens

One of the most common ways to pass fish downstream of a dam is to guide the downstream migrants into a surface collector using attraction flow, then separating the fish from attraction flow by use of a screen to partially dewater the bypass flow. The flow is accelerated until a capture velocity is achieved and fish cannot swim upstream, then the fish either enter a fish return pipe that returns them to the river downstream of the dam or they are collected and held for transport downstream. Fish friendly design objectives for screens include:

- Guide fish past screens without contacting the screen surface,
- Avoid high velocity areas that could cause impingement,
- Low approach velocities and no gaps between screen and wall to minimize the risk of entrainment,
- High enough sweeping velocity to minimize delay,
- Design screens and bypass to minimize injury or mortality,
- Minimize stress, and
- Minimize opportunities for predation by properly locating the fish return exit.

In order to achieve these objectives a screen must have a relatively uniform approach velocity that does not exceed the fish's ability to swim away from the screen, and a sweeping velocity that carries the fish past the screens before their swimming capacity is exceeded. To achieve a uniform velocity distribution baffling is typically used behind the screens. Screens should be cleaned frequently to reduce head loss due to plugging, and to avoid "hot spots" of high velocity on the screen caused by debris build-up that can cause harm to fish.

Screen Approach Velocity: Maximum approach velocity at screens should be based on the sustained swimming speed of the target species and fish size, or of the slowest fish of interest that will likely be present at the screen location. The lowest sustained swimming speed of juvenile BCT should be used as the maximum screen approach velocity. Figure 3-5 shows a prolonged swimming speed for juvenile BCT from 0.7-1.5 ft/s (38mm-70mm). According to the guidelines used for the Kackley Springs project, the outmigrants are expected to be approximately 122mm-220mm (4.8"-8.7") long, significantly larger than the 38mm-70mm fish tested for Figure 3-5. Assuming the same size outmigrants are expected at Oneida as Kackley Springs, we suggest starting with the NMFS approach velocity of 0.4 ft/s for a guideline. This approach velocity is well below the prolonged swimming speed of the target species and size. Other approach velocities may be considered in order to have a smaller facility, recognizing that it may not be ideal for all life stages present in the reservoir.

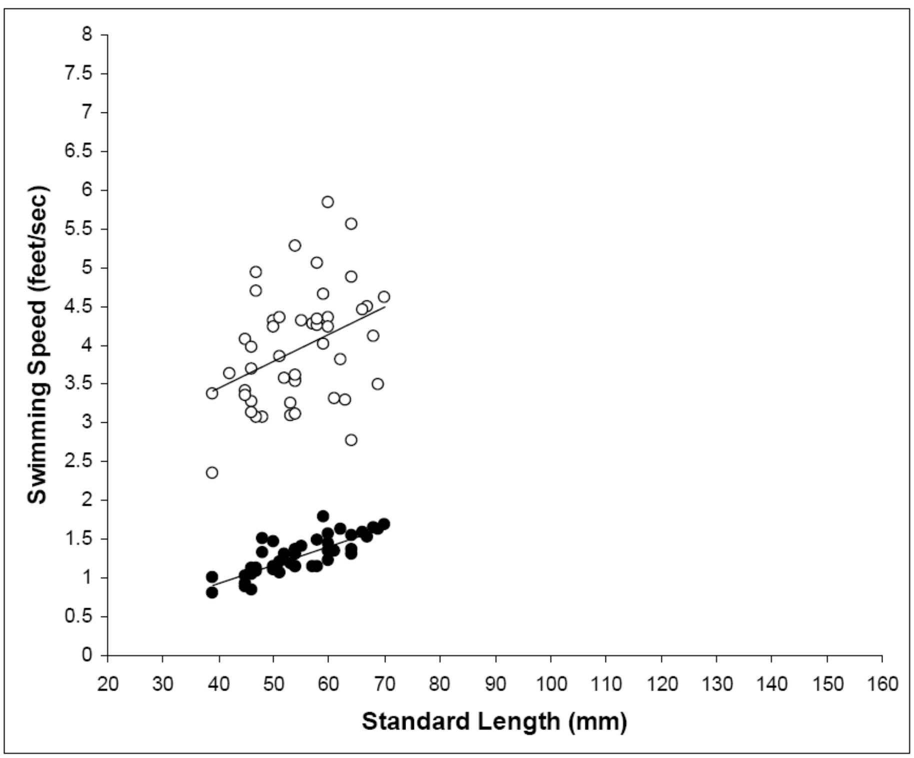


Figure 3-5. Results of swimming performance tests for juvenile BCT (Oncorhynchus clarki utah) for burst and prolonged swim speeds. (from Morphology and swimming performance of Utah fishes. UDOT web site http://www.udot.utah.gov/main/).

Screen Sweeping Velocity: The sweeping velocity along the front of the screen should be a minimum of 0.4 ft/s, and ideally between 0.8 ft/s and 3.0 ft/s. The sweeping velocity should always be greater than the approach velocity and should result in a total time of 60 seconds or less exposed to the screen before entering a bypass route. The design should result in velocities that always increase in the downstream direction, but increase slowly along the length of the screens, with no more than 0.2 ft/s change per foot.

Fish Bypass: The bypass should be made of smooth and durable material with wide bends, open channel flow, where possible, and an outfall which minimizes predation opportunities. We suggest using the following NMFS criteria as the Oneida guideline:

- Minimum Bypass Diameter: 10 inches (24" better for debris handling)
- Minimum Bypass Flow Depth: 40% of the diameter.
- Bypass Velocity: Between 6 and 12 ft/s
- Maintain supercritical flow throughout return pipe so no hydraulic jumps are produced.

Using rougher pipe will increase the slope and reduce the bypass length but may cause injury and/or disorientation to fish. Using rougher pipes may be considered if ECC members agree this is acceptable.

Using 10 inch diameter pipe is only recommended at sites with very low debris loads. Recent project experience indicates that 18”-24” diameter pipe is more appropriate for long fish return pipes where debris control may be a problem.

Impact Velocities: Maximum impact velocity into a receiving pool, including vertical and horizontal velocity components should be less than 25 ft/s. Higher velocities can cause disorientation or injury, and can contribute to predation losses.

3.4.2.2 Devices Considered Experimental by NMFS.

NMFS defines positive-exclusion barrier screens (PESBS) as experimental fish passage devices. These technologies screen the entire flow entering a diversion. Eicher Screens and Modular Inclined Screens are technologies that may be considered. According to NMFS:

> *“PESBS have been installed and evaluated at numerous facilities (Abernathy et al. 1989, 1990; Rainey 1990; and Johnson 1988). A variety of screen types (e.g., fixed-vertical, drum, fixed-inclined) and screen materials (e.g., woven cloth [mesh], perforated plate, profile wire) have proven effective, when used in the*

context of a satisfactory design for the specific site. Facilities designed to previously referenced criteria consistently resulted in a guidance efficiencies of over 98% (Hosey 1990; Neitzel 1985, 1986, 1990a,b,c,d; Neitzel 1991).

The main detriment of PESBS is cost, because of the low velocity requirement and structure complexity. At the headworks, the need to clean the screen, remove trash, control sediment, and provide regular maintenance (e.g., seasonal installation, replacing seals, etc.) also increases costs."

3.4.3 General Facility Design Goals

Facility design elements ensure that the facility is able to be used for the design duration and purpose in which it was designed. General fish friendly design elements include:

- Design must not expose fish to any moving parts and not cause noise or vibrations.
- Edges in the flow path must be ground smooth to minimize risk of lacerations.
- Concrete surfaces must be finished to ensure smooth surfaces, with a minimum of one-inch wide 45° corner chamfers.
- Design should consider use of dull colors to reduce avoidance.

Access and Security: Lighting should be provided at the facility for night time maintenance and operation. The facility should be secured to discourage vandalism, preclude poaching opportunity, and to provide public safety. At a minimum, facilities and any automated controls must have locked access. Personnel access must be provided at all times to the facility to facilitate operational and maintenance requirements. A locked gate and appropriate signage should be provided to discourage unauthorized access.

Design Life: In order to be considered a permanent structure the design life must be 10-year or longer. We suggest using a minimum design life of the current FERC license, which is 30 yrs. Structures should be designed to stay stable in the 100-yr flood, with minimal damage sustained and able to be operational for fish passage after only minor repairs.

4. DEVELOPMENT OF FISH PASSAGE ALTERNATIVES

This section provides documentation of the alternative development process, including: all alternatives initially considered; alternatives considered but eliminated from further development; and a list of alternatives that will be developed in this report. The intent with this section is to provide PacifiCorp and the ECC with a full record of the alternatives considered which may be useful to the parties in the future.

4.1 INITIAL LIST OF IDEAS CONSIDERED

After gathering the site information and understanding the fish passage objectives at Oneida, R2 engineers held a brainstorming meeting to develop a list of fish passage ideas to consider at Oneida. A variety of ideas were identified, including;

For Upstream passage:

- A constructed semi-natural channel to allow both upstream and downstream passage, much as a natural stream channel would provide.
- A ladder with: an entrance adjacent to the tailrace return; a constructed fishway through the field below the earthen dike on the east side of the flow line; and a fish exit into the reservoir near the recreation area/boat launch.
- A ladder with: an entrance adjacent to the tailrace return; a fishway across the tailrace on the downstream face of powerhouse; a constructed fishway through the field below the earthen dike on the west side of the flow line; and fish exit into the reservoir at the west end of earthen dike.
- A ladder with: an entrance adjacent to the tailrace return; a fish trap at the upstream end of the ladder; and transport (via truck, cable car, etc.) to haul fish up to a reservoir release point.
- A ladder with: an entrance in the bypass reach of the Bear River; a ladder up the river bank followed by a constructed fishway through the field below the earthen dike; and a fish exit into the reservoir on the west end of the earthen dike.
- A ladder with: an entrance in the bypass reach of the Bear River; a trap at the upstream end of ladder; and transport (via cable car, etc.) up to a reservoir release point.

For Downstream passage:

- Operational changes to pass fish over spillway.

- A surface collector near the intake structure to prevent downstream migrants from entering the penstock, with a fish bypass pipe to return fish downstream of dam.
- A surface collector on dam to prevent downstream migrants from entering the spillway, with a fish bypass pipe to return fish downstream of dam.
- A surface collector near the intake structure to prevent downstream migrants from entering the penstock, with a trap and haul facility.
- Use of exclusion or guide nets with the surface collector designs.
- An Eicher Screen or Modular Intake Screen to screen penstock flow, and provide a bypass pipeline to a sorting facility or back to the Bear River downstream of the dam.

Through the discussion of the design goals and guidelines with the ECC members, some of the above ideas were refined, some were added to the list and others were eliminated. Section 4.2 provides a discussion of the selection of alternatives, with a recommended list of alternatives that the ECC wanted to be further developed in this report.

4.2 ALTERNATIVES CONSIDERED AND ELIMINATED FROM CONSIDERATION

In the ECC meeting on December 8th to discuss design guidance for the fish passage at Oneida, R2 presented the initial list of ideas to be considered and helped the ECC to understand the intent, limitations, and characteristics of each alternative. During the discussion clarifications were made to some of the alternatives, and others were eliminated. The following sections document which alternatives were eliminated, and the reasons why they were not to be developed further.

4.2.1 Upstream Alternatives Eliminated

The semi-natural channel around the dam was proposed as an upstream and downstream passage alternative that would function much like a natural channel. Typically, this would result in the layout of an artificial river or channel with a gradient of about 2 to 3%. This alternative was eliminated due to R2's experience on other similar projects where this option has been considered, but does not prove to be a practical alternative due to site constraints and practical constructability issues. For the Oneida site with a required fishway rise of about 143 feet, this would require a new 0.9 to 1.4 mile long channel. While attracting fish into both the upstream and downstream ends of an engineering fish passage channel has the same challenges as other entrance structures, the land ownership, long channel construction and associated costs, and environmental concerns are all difficult to overcome. Furthermore, given the necessary length of this type of fishway, experience at other sites indicates that stakeholders may want to add habitat features to the channel, which could cause fish to delay their journey. The above concerns relative to an engineered fish ladder with a steeper slope (and significantly shorter length) led the group to eliminate this alternative.

Alternatives with fishway exit locations on the east side of the earthen dike will not be considered because of their proximity to the day use area. Poaching of fish, vandalism concerns, and interference with recreational use are all negative factors that make this location less ideal.

Alternatives with the fishway on the east side of the flow line were also eliminated. With the fishway exit on the west side of the earthen dike, putting the fishway on the east side of the flow line would mean either crossing the flow line in the field, or building part of the fishway on the dike itself. It was decided that construction on the earthen dike should be avoided if possible, and crossing the flow line in the field would not be practical due to the elevation needed to get over the flow line, nor desirable due to potential operations and maintenance challenges on the flow line which may render the fishway unusable during maintenance activities.

4.2.2 Downstream Alternatives Eliminated

The initial brainstorming exercise identified the concept of operational changes to spill water during downstream fish passage windows to facilitate downstream fish passage through the spillway. Due to operational constraints at Oneida, any alternatives that include spilling water and passing fish over the spillway will not be considered. Spillway flow is not common at Oneida, and increasing spill when not necessary would take flow away from the project's goal of power generation.

4.3 LIST OF RECOMMENDED ALTERNATIVES TO BE CONSIDERED

Below is a refined list of those alternatives that will be presented in more detail in this report. Section 5 provides additional information on the upstream alternatives, and Section 6 describes the downstream alternatives.

4.3.1 Upstream Passage

Ladder Alternatives:

- Alternative U1: Fishway entrance on the south side of the tailrace return; a fishway across the tailrace on the face of powerhouse; a half Ice Harbor ladder at 10% maximum slope and 1-foot drops between pools; a low-gradient constructed fishway through the field below the earthen dike; and a fish exit structure with five modulating weirs at the west end of the earthen dike.

- Alternative U2: Fishway entrance on the north side of the tailrace return; a half Ice Harbor ladder at 8% maximum slope and 0.5-foot drops between pools; a low-gradient constructed fishway through the field below the earthen dike; and a fish exit structure with 10-modulating weirs at the west end of the earthen dike.
- Alternative U3: Fishway entrance on the east bank of the Bear River (in the bypass reach), located approximately 1,200 feet upstream from the tailrace return between the powerhouse and the Oneida dam; a half Ice Harbor ladder at 10% max slope and 1-foot drops between pools; and a fish exit with 5-modulating weirs at west end of the earthen dike.

Trap and Haul Alternatives:

- Alternative U4: Fishway entrance on the south side of the tailrace return, with a ladder up to a fish trap and holding tank. Fish would be loaded into transport trucks via a loading hopper and an overhead crane for transport up to a reservoir release point.
- Alternative U5: Fishway entrance on the north side of the tailrace return, with a ladder up to a fish trap and holding tank. Fish would be loaded into transport trucks via a loading hopper and an overhead crane for transport up to a reservoir release point.

4.3.2 Downstream Passage

- Alternative D1: Do not construct a separate downstream passage system. If Alternative U1, U2, or U3 is constructed, then downstream migrating adults could use the upstream ladder to descend into the tailwater. Downstream passage for juvenile migrants would be possible through the upstream ladder and through the trashrack openings (1-5/16") and through the turbines. Guide nets upstream of the ladder exit could be added as an additional measure to increase downstream passage efficiency through the ladder. If no upstream fish ladder were constructed then it would be necessary to provide larger trashrack spacing to allow downstream adult passage through the turbines if no other downstream routes were possible, otherwise fish would be trapped in the reservoir. Installation of fish friendly turbines, if and when they become available for high head Francis turbines, would be necessary, as estimated adult survival through the existing turbines does not look promising. See Section 6.1.2.3.1 on turbine mortality and Section 6.1.2.3.2 on fish friendly turbines for more discussion.
- Alternative D2: Construct a separate downstream passage system consisting of a fixed partial flow (250 cfs) V-screen structure on the bank adjacent to the intake, and a fish return pipe that discharges downstream migrating fish in the Bear River below the powerhouse. Guide nets leading up to the V-screen would be an optional addition to improve attraction. Blocking off the top portion of the trashracks and creating more attraction flow to a V-screen collection facility located directly adjacent to the trashracks would be another optional measure to improve attraction to the V-screen facility.

- Alternative D3: Construct a separate downstream passage system consisting of a fixed partial flow (250 cfs) V-screen structure on the bank adjacent to the intake, with a trap and haul system to return fish to the Bear River downstream of the powerhouse. Guide nets leading up to the V-screen would be an optional addition to improve attraction. Blocking off the top portion of the trashracks and creating attraction flow to the V-screen facility located directly adjacent to trashracks would be another optional measure to improve attraction to the V-screen collection facility.
- Alternative D4: Construct a separate downstream passage system consisting of a fixed full flow (2,600 cfs) V-screen structure on the bank adjacent to the intake, and a fish return pipe that discharges downstream migrating fish in the Bear River below the powerhouse or to a trap and haul facility.
- Alternative D5: Install Eicher screens in a bifurcated flow line to screen the full turbine flow, and a fish return pipe that discharges downstream migrating fish in the Bear River below the powerhouse (or to a trap and haul facility as a variation on this alternative).
- Alternative D6: Install Modular Inclined screens at the intake or in the flow line to screen the full turbine flow, and a fish return pipe that discharges downstream migrating fish in the Bear River below the powerhouse (or to a trap and haul facility as a variation on this alternative).
- Alternative D7: Capture downstream migrating fish at the upstream end of the Oneida reservoir, then transport the fish around the reservoir and into the Bear River downstream of the dam.

5. UPSTREAM ALTERNATIVES

Upstream alternatives were developed to a functional design level that describes how the fish passage system would work, determines its compatibility with the project operational constraints, provides a basis for an estimate of probable construction costs, and allows a comparison of the alternatives. The following sections describe each of the upstream alternatives. Drawings for each alternative are provided in the Drawing section, at the end of the report text.

5.1 ALTERNATIVE U1: SOUTH TAILRACE ENTRANCE, 10% SLOPE LADDER

5.1.1 Description of Alternative

The goal for this alternative is to provide upstream fish passage from the Bear River just downstream of the powerhouse to the Oneida reservoir as shown on Drawings 2 and 3. In this alternative the fishway entrance is located on the south side of tailrace return. After the entrance, fish pass through a short vertical slot ladder gaining elevation before entering an open channel flow fishway across the tailrace on the face of the powerhouse. After crossing the tailrace, fish continue gaining elevation as they navigate the approximately 3,000 foot long half Ice Harbor ladder which has a 10% maximum slope and 1-foot maximum head drop between the fishway pools. Fish exit the fishway through an exit structure at the west end of earthen dike, which has five automated weirs that maintain a constant flow into the ladder across the 5%-95% operational range of the reservoir.

5.1.2 System Overview and Functional Description

5.1.2.1 Entrance

The fishway entrance is the most critical component in the design of an upstream passage system. The most critical fishway entrance design elements are listed below:

- Entrance location and configuration
- Energy and shape of jet
- Attraction flow

The conceptual basis of each design element of the entrance is described in the sub-sections below.

Entrance Location and Configuration

The fishway entrance must be located at a point where fish can easily locate the flow, with hydraulic conditions that attract fish into the system. In this alternative the entrance structure would be located adjacent to and just downstream of the tailrace return channel. At this point it is unknown if this location will be the best location for the entrance. It may be the preferred location if fish are found to move up river left, and would encounter the entrance before the tailrace flow. The entrance slots would be configured to produce a jet perpendicular to the river flow or slightly downstream in order to propagate as far as possible into the river flow so upstream migrating fish would be able to find the jet and be attracted to the entrance flow.

Based on our observations during the site visit, this location or a similar location just upstream of the powerhouse (see Alternative U2) would both likely be highly effective entrance locations. Observing various powerhouse flows and videotaping and/or measuring velocities in the area would provide data that would help to determine if this location is the most appropriate. Model studies or fish tracking could also be used to determine the local hydraulics and fish movement in the area.

Energy and Shape of Entrance Jet

In order to attract different species with varying swimming abilities, the entrance proposed in this alternative would have two entrance slots with differing head drops. This can be accomplished by dividing the entrance flow upstream of the entrance into two paths; a low head entrance that is stepped down before the entrance thereby losing its head in multiple steps, and a high head entrance that drops its entire head through one entrance slot. The high head drop would produce an attractive high energy jet, and the low head entrance would allow all species of interest to enter. For this report we are assuming a high head entrance drop of 1.5 ft and a low head entrance drop of 0.75 ft. This configuration would provide more flexibility than a single entrance slot configuration. An example of this type of configuration can be seen in Drawing 3.

A full water column slot entrance design would be used to provide passage for benthic, mid-water and surface swimmers. The tailwater water surface elevation varies by approximately 4.5 feet within the fish passage flows, assuming a 1.5-foot minimum flow depth at low tailwater the slot would need to be a minimum of 6 feet high to accommodate the tailwater variation.

The outflow jet must produce streaming flow conditions, and should be as close to a square as possible to maximize its propagation into the receiving water. Obviously with varying tailwater elevation this jet shape will not be achievable for all tailwater elevations, and the final shape and configuration will be limited by the head drop and attraction flow as well as the tailwater elevation.

Attraction Flow

Attraction flow is defined as the amount of flow provided at a fishway entrance to attract fish into the fish passage system. Typically, agency guidelines call for 5% to 10% of the total powerhouse flow to be provided at a fishway entrance. This is largely a judgment call and is very depending on individual site constraints; however, it is based on sound, regional experience for salmon and steelhead, which have similar swimming characteristics to BCT.
As a reasonable starting point with the fish entrance design, we have identified a target flow of 5% of the total turbine flow. This is largely due to the confined site, relatively small tailrace area, and on our opinion that the entrance location and hydraulic conditions will be attractive to BCT.

In order to provide this 5% attraction flow at the entrance, the flow would need to be 130 cfs at the high fish passage flow (2,600 cfs) and 13 cfs at the low fish passage flow (260 cfs). As described in Section 5.4.2.2, the fishway flow is proposed to be approximately 12.7 cfs to accommodate the fish ladder hydraulic requirements. Since the upstream fishway flow is much lower than the maximum attraction flow required at the entrance, water will need to be added to the entrance to create this attraction flow. Approximately 120 cfs will need to be provided through a pumped auxiliary water supply (AWS) system that takes water from the tailrace after power generation, rather than from the reservoir as this is a more economical use of the available water and reduces the impacts to the overall plant generation capability.

Auxiliary Water Supply (AWS)

AWS flow is typically supplied to the system by pumping out of the tailrace or river flow, or by tapping the penstock. In this report we will just look at pumping from the tailrace to provide the AWS flow as tapping the penstock is not an option due to the high head and power generation that would be lost. The AWS system would consist of screens on the tailrace, low head - high flow pumps, baffling to distribute the flow across the screens evenly, a screen cleaner system, wall and/or floor diffusers, and an automated control system for flow control and screen cleaning. All upstream alternatives presented in this report have an AWS system to provide attraction water.

5.1.2.2 Fishway

The fishway flow (upstream of the AWS) is provided by water taken from the reservoir. The ECC expressed the desire to have as low a fishway flow as possible in order to minimize the water taken from the reservoir, since all water taken from the reservoir will need to be either replaced by purchase of water rights upstream or by direct purchase of lost power generation (if the company will allow this option), and to minimize the size of the fishway itself. The fishway flow is assumed to by 12.7 cfs, see Section 5.1.2.2.3 for a discussion on the ladder dimensions and flow.

From the fishway entrance, the fish would enter a multiple step ladder to bring them up to the elevation of the fishway across the tailrace. This ladder section would have several steps that are flooded at the high tailrace flows, and exposed at low tailrace water surface elevation. Because of this variable tailwater elevation in this intermittently inundated section of the fishway, it will need to be designed differently than the rest of the fishway. We are showing this section of the fishway as a vertical slot ladder since this type of ladder operates under variable water surface elevations better than the half ice harbor ladder. It would also be possible to design a half ice harbor type ladder with automated weirs similar to the exit structure.

The vertical slot ladder fishway will gain elevation on the south side of the tailrace in order to cross the face of the powerhouse. The fishway across the tailrace is required in this alternative to transport fish to the north side of the tailrace where the fishway will continue up the slope and eventually to the exit in the reservoir. Figure 5-1 shows the face of the powerhouse where the fishway would be attached. The elevation of the base of the fishway would set on top of the concrete walls, which would not impede tailrace flow. (Note: an alternative to route the fishway around the back side of the powerhouse was considered and rejected due to the infrastructure that would be affected.)

Vertical Slot Ladder

After the fish pass through the entrance slot they are attracted upstream through the entrance pool to a vertical slot ladder at the upstream end. The vertical slot ladder portion of the fishway is provided because the vertical slot ladder performs well in variable tailwater environments. The slots should be designed to convey the upstream ladder flow with 1-foot drops at low tailwater conditions. At high tailwater conditions additional water can be added to the lower pools of the vertical slot ladder through floor and/or wall diffusers if necessary in order to maintain attractive flow conditions into and through the ladder. The head drop per slot will be lower at high tailwater conditions.

Transport Channel across Tailrace

An approximately 150 foot long transport channel would need to be constructed across the tailrace in order to convey fish to the north side of the tailrace, where they will continue up the fish ladder. The transport channel is designed to operate under open channel flow conditions with no hydraulic or lighting transitions. Transport channel velocities should be between 1 ft/s and 2 ft/s in order to keep fish moving upstream while not exceeding their swimming ability.

Figure 5-1. Photo taken from South side of the tailrace looking from South to North across tailrace. Shows face of powerhouse where proposed fishway would cross tailrace.

With a 12.7 cfs fishway flow and a 1 ft/s velocity, then the cross sectional area of the wetted channel would need to be 12.7 square feet. For this feasibility level report we are assuming a channel 3 feet wide and 4.2 feet deep with 2 feet of freeboard. A cover should be provided to allow natural light to the channel while providing partial shade. The water surface slope at this flow would be approximately 0.01%, which results in less than 0.02 feet of head loss over the 150 ft long channel, or essentially flat.

An optional item in the transport channel would be a place to observe and enumerate fish. It could include a crowder, count window and a camera. This optional item could be added to any of the alternatives if desired by the stakeholders.

Half Ice Harbor Ladder

After crossing the tailrace the fishway proposed will be a half ice harbor fish ladder design of different slopes. The first section will continue up the east bank slope of the Bear River staying west of the flow line with a maximum slope of 10%, which is the typical maximum slope for this and most styles of fish ladders. The fishway will then continue across the field below the earth fill dike at an approximate slope of 2%, based on the existing ground slope. The final portion of ladder before the exit structure will be at approximately 7.5% based on the existing ground slope. The ladder slopes are based on minimizing construction costs by following the existing grade where possible, and using the maximum ladder slope of 10% at the beginning will result in the shortest ladder construction on the steep river bank slope.

Ice harbor and half ice harbor ladders were developed by the U.S. Army Corps of Engineers for use on the Ice Harbor Dam on the Snake River. This particular ladder design was developed to be a more stable ladder than previous designs and to provide passage to multiple species. Since its development they have been used at many dams in the Pacific Northwest region to provide reliable fish passage. They are designed to provide weir flow and orifice flow with pools between the weirs large enough to dissipate the water energy. For long ladders they are typically more stable than vertical slot ladders. They are selected due to their ability to provide passage to multiple species (some like to jump over weirs, and some like to swim through the orifices), and their track record of success at other sites.

The proposed ladder has 1-foot head drops between the pools and a minimum of 10 ft between subsequent weir crests, giving the ladder an overall maximum slope of 10%. This head drop would result in an orifice velocity of approximately 8 ft/s. Fish would be able to use their burst speed to swim through the submerged orifice, or swim up or jump over the weir flow. This condition should be passable to all of the upstream migrating fish of interest at Oneida. The pools as designed will sufficiently dissipate the energy of the falling water and allow resting for the upstream migrants.

The first ladder design that was proposed in December was a ladder with 6-foot wide pools, a 3-foot wide weir crest, and a 15-inch by 12-inch orifice, similar to the new ladder currently in operation at the River Mill Dam on the Clackamas River in Oregon. The ladder flow was calculated to be approximately 21.6 cfs with this configuration and one foot of head drop between pools. This ladder design was selected because of the similarity of the total head at the two projects, and because it represents a “standard” size of this style of ladder. The ECC was not comfortable with using a ladder flow of that magnitude because of the cost of using that much water for non-generation purposes. It was suggested that the water would need to be replaced by purchasing water rights upstream of the project, and that it might be expensive and difficult to find water rights to buy. In order to reduce the magnitude of the water needed we present a smaller ladder in this report with a flow of 12.7 cfs.

The challenge is to keep fish moving upstream in the fishway: if fish hold, or back out of the fishway then the project fails. It is often difficult to predict the exact behavior of water in a fishway, and impossible to predict the behavior of fish, so the best we can do is create attractive conditions and rely on known performance at similar installations. To our knowledge there is no other ladder of this rise and length, with this relatively low flow. Typically, higher fishway flows would decrease the risk of passage failure. There are many short ladders (leading into hatcheries or over low head diversion) with similarly low flows, but none of this scale. Some additional studies would be warranted to assure the ECC of successful fish passage before investing such a large sum of money in ladder construction. Further literature research, study and modeling would be required to determine the likelihood of success for the target species with these ladder parameters.

5.1.2.3 Fishway Exit

At the end of the fishway is the exit structure which provides a channel for fish to exit the fishway and enter the reservoir. The fishway exit needs to provide hydraulic conditions that continue to attract fish to move forward and into the reservoir while attenuating any forebay water surface elevation fluctuations, and accommodating the exit into the variable water surface. This can be achieved by providing adjustable weirs that maintain the hydraulics and equal head drops through the exit section of the fishway.

The fishway exit is located far enough away from a spillway or powerhouse intake to minimize risk of fish “fall back” through these routes. The exit is located on the west side of the earthen dike away from the public access area. The fishway exit should have a coarse trash rack with minimum spacing of 8-inches, which is intended to keep out large debris and allow easy removal of debris that gets deposited on the trashrack.

The fishway exit needs to be able to function as designed for all of the design fish passage forebay water surface elevations. The fluctuation in reservoir water surface elevation for the fish passage design is approximately 3.8 feet. Alternative U1 accommodates this fluctuation with five automated weirs and which would adjust to maintain a constant flow into the fishway while maintaining five equal head drops through the exit structure.

5.2 ALTERNATIVE U2: NORTH TAILRACE ENTRANCE, 8% SLOPE LADDER

5.2.1 Description of Alternative

The goal for this alternative is to provide upstream fish passage from the Bear River just upstream of the powerhouse, on the north side of the tailrace, to the Oneida reservoir as shown on Drawing 4. In this alternative the fishway entrance is located on the north side of tailrace return. After the entrance, fish pass through a short vertical slot ladder gaining elevation until rising above any tailwater variation. After the vertical slot ladder fish enter the half ice harbor ladder and continue gaining elevation at 8% maximum slope and 6 inch maximum head drop between pools. Fish exit the fishway through an exit structure at the west end of earthen dike, which has ten automated weirs that maintain a constant flow into the ladder across the 5%-95% operational range of the reservoir.

5.2.2 System overview and Functional Description

5.2.2.1 Entrance

The fishway entrance is identical to the Alternative U1 entrance except in this alternative the entrance structure would be located adjacent to and just upstream (north side) of the tailrace return channel. The entrance layout can be seen on the entrance area plan shown on Drawing 7. This might be the preferred location if fish are moving past the tailrace flow and seen congregating on the north side of the tailrace looking for a route upstream. Observing various powerhouse flows and videotaping and/or measuring velocities in the area would help to determine if this location is appropriate. Model studies or fish tracking could also be used to determine the local hydraulics and fish movement in the area.

See Section 5.1.2.1 for a description of the entrance design elements.

5.2.2.2 Fishway

The fishway design elements are similar to the Alternative U1 fishway except there is no fishway across the tailrace needed (since the entrance is already on the north side) and the maximum ladder slope is 8% with 6 inch steps.

See Section 5.1.2.2 for a description of the fishway design elements.

5.2.2.3 Fishway Exit

The fishway exit design elements are similar to the Alternative U1 exit except there are 10 automatically adjusting weirs needed to accommodate the reservoir water surface fluctuations due to the lower 6 inch step height.

See Section 5.1.2.3 for a description of the fishway exit design elements.

5.3 ALTERNATIVE U3: ENTRANCE IN BYPASS REACH, 10% SLOPE LADDER

5.3.1 Description of Alternative

The goal for this alternative is to provide upstream fish passage from the Bear River bypass reach to the Oneida reservoir as shown on Drawing 5. This alternative varies from alternative U1 in its entrance location, and ladder alignment. The goal of these changes was to show an alternate entrance location in the bypass reach and to show the shortest possible ladder alignment with a 10% slope. In this alternative the fishway entrance is located on the east bank of the Bear River (in the bypass reach), located approximately 1200 feet upstream from tailrace return between the powerhouse and the Oneida dam. After the entrance, fish pass through a short vertical slot ladder gaining elevation until rising above any tailwater variation. After the vertical slot ladder fish enter the half ice harbor ladder and continue gaining elevation at 10% maximum slope and 1 foot maximum head drop between pools. Fish exit the fishway through an exit structure at the west end of earthen dike, which has 5 automated weirs that maintain a constant flow into the ladder across the 5%-95% operational range of the reservoir.

5.3.2 System overview and Functional Description

5.3.2.1 Entrance

The fishway entrance is identical to the Alternative U1 entrance except in this alternative the entrance structure would be located approximately 1200 feet upstream from tailrace return between the powerhouse and the Oneida dam. This might be the preferred location if fish are shown to move up into the bypass reach when flow is added to the bypass reach. At this location there would be almost no flow entering from upstream so fish moving up the bypass reach would not have trouble finding the entrance as there would be little competing flow. The main question is whether fish would hold around the tailrace flow, or whether they would continue up the bypass reach. At a minimum a hydraulic model of the bypass reach should be done in order to determine the depths and velocities in the channel at different flows. Model studies of the flow at the tailrace/bypass reach confluence and fish tracking could also be used to determine the local hydraulics and predict fish movement into the channel.

See Section 5.1.2.1 for a description of the entrance design elements.

5.3.2.2 Fishway

The fishway design elements are similar to the Alternative U1 fishway except there is no fishway across the tailrace needed.

See Section 5.1.2.2 for a description of the fishway design elements.

5.3.2.3 Fishway Exit

The fishway exit design elements are identical to the Alternative U1 exit.

See Section 5.1.2.3 for a description of the fishway exit design elements.

5.4 ALTERNATIVE U4: SOUTH TAILRACE ENTRANCE WITH TRAP AND HAUL

5.4.1 Description of Alternative

The goal for this alternative is to provide upstream fish passage from the Bear River just downstream of the powerhouse to upstream of the Oneida Dam via fish transport truck as shown in Drawing 6. In this alternative the fishway entrance is located on the south side of tailrace return. After the entrance, fish pass through a short vertical slot ladder gaining elevation to get above the influence of tailrace fluctuations. At the top of the ladder fish would enter a fishway leading to a holding pool. Fish would be attracted into and/or crowded into a hopper. The hopper would then be sealed and lifted by overhead crane to a fish transport truck where the fish would be transferred to the truck via water to water transfer. Then the fish would be transported by truck to a release point in the reservoir or upstream into the Bear River.

5.4.2 System overview and Functional Description

5.4.2.1 Entrance

The fishway entrance is identical to the Alternative U1 entrance

5.4.2.2 Fishway

The fishway is identical to the lower part of the Alternative U1 fishway. In this alternative fish will gain elevation through the fishway and then enter holding ponds to wait for transport upstream rather than continue up a ladder to the reservoir.

5.4.2.3 Holding Ponds

After the vertical slot portion of the fishway has gained sufficient elevation the fishway will transition to a fishway channel leading to the holding ponds. Attraction water will flow out of the holding ponds to attract fish to enter. A V-trap, or finger weir could be used so that once fish enter the holding ponds they will not back out. In order to load fish water through the hopper can be turned on to attract fish into the hopper and crowders can be used to force the remaining fish into the hopper for transport to the truck.

5.4.2.4 Hopper

The hopper would be designed to load one truck for transport. It would be designed in conjunction with the other infrastructure to work as a system and be able to carry fish from the holding ponds to the fish truck in a seamless manner.

5.4.2.5 Transport Truck

Very specialized trucks for fish transport are used at trap and haul facilities. The size of tank and type of life support on the truck is specific to the species and life stages present and the length of transport (holding time). For this CDR we are assuming a truck with 1200 gallon tank and full life support systems including aeration, recirculation, oxygen and tank baffling. Fish loading would be water to water transfer from the hopper to the truck tank through a port in the top of the tank. Fish release would be through a port fitted with a knife gate at the rear of the truck and a flexible hose of sufficient length to deliver the fish to the desired release location. Other transport methods including using smaller individual holding tanks loaded onto a flatbed, or using a trailer tank pulled behind a pickup should be considered if this alternative is selected for further development.

5.5 ALTERNATIVE U5: NORTH TAILRACE ENTRANCE WITH TRAP AND HAUL

5.5.1 Description of Alternative

The goal for this alternative is to provide upstream fish passage from the Bear River just upstream of the powerhouse to upstream of the Oneida Dam via fish transport truck as shown in Drawing 7. In this alternative the fishway entrance is located on the north side of tailrace return. After the entrance, fish pass through a short vertical slot ladder gaining elevation to get above the influence of tailrace fluctuations. At the top of the ladder fish would enter a fishway leading to a holding pool. Fish would be attracted into and/or crowded into a hopper. The hopper would then be sealed and lifted by overhead crane to a fish transport truck where the fish would be transferred to the truck via water to water transfer. Then the fish would be transported by truck to a release point in the reservoir or upstream into the Bear River.

5.5.2 System overview and Functional Description

Alternative U5 only differs from alternative U4 in that the entrance and the rest of the facility are located on the north side of the tailrace rather than the south side. Drawing 7 shows Alternative 5 layout. See Section 5.4 for discussion of design elements.

6. DOWNSTREAM ALTERNATIVES

Downstream passage alternatives were developed to a functional design level that describes how the fish passage system would work, determines its compatibility with the project operational constraints, provides a basis for an estimate of probably construction costs, and allows a comparison of the alternatives. The following sections describe each of the downstream passage alternatives. Drawings for each alternative are provided in the Drawing section, at the end of the report text.

6.1 ALTERNATIVE D1 – NO DEDICATED DOWNSTREAM PASSAGE

Alternative D1 documents the current situation, assuming no dedicated downstream passage system is provided. If U1, U2, or U3 is constructed, then downstream adult migrants could also use the upstream ladder system to move downstream. If U5 or U6 is constructed then there would be no downstream route available to fish too big to pass through the trashrack. Downstream passage would be possible for juvenile migrants through the trashrack (clear openings 1-5/16") and turbines.

Guide nets upstream of the ladder exit could be added to the ladder alternatives as an additional measure to increase downstream passage efficiency by guiding fish to the ladder exit.

6.1.1 Description of Alternative

Alternative D1 was included to look at what would happen if upstream passage was constructed and no separate downstream passage facility was constructed. This could be done as part of a phased approach with the expectation of building downstream facilities in future years, or if it were decided that project goals could be met with only upstream passage facilities. Conceptually this alternative could only work if an upstream fishway were constructed. If a trap and haul alternative were used for upstream passage, then no hydraulic connection between the upstream and downstream systems would be available for fish to use, and the only route for downstream passage would be through the turbines.

In this alternative there is a clear difference between adult and juvenile downstream passage. Juvenile fish would typically be able to pass through the trashrack and then through the turbines, while adult fish would not have that option. If no upstream fish ladder were constructed, then the only way to provide a downstream exit route for adults would be to increase the trashrack spacing to allow downstream adult passage through the turbines. This would not be an advisable course of action due to the predicted high mortality rates for adult BCT, as discussed in Section 6.1.2.3.1 below.

6.1.2 System overview and Functional Description

In this alternative no separate system is provided for downstream passage, so the system discussion below is looking at an upstream ladder and the turbines as downstream passage routes.

6.1.2.1 Entrance

The ladder entrance (upstream fishway exit) flow would be the same as the fishway flow of approximately 12.7 cfs. The low surface outlet flow and the location away from the intake structure would make the entrance difficult for downstream migrants to locate. Adult fish would have no other option and may take some time to locate the downstream route. Juveniles would have the option of taking the alternate downstream route through the turbines, since the attraction flow at the turbine entrance would be much greater than the 12.7 cfs at the ladder.

6.1.2.2 Downstream passage through ladder

Downstream passage through a ladder is not an ideal solution for outmigrating juveniles. It does however provide some hydraulic connectivity between the upstream and downstream sides of the project, and will be used by some of the fish migrating downstream. As noted above, the downstream outlet at the ladder would be relatively difficult to find due to its low flow compared to powerhouse flow, and passage through the ladder can be dangerous for juveniles due to predation risk and associated stress. Predation risk is particularly high for small fish transiting a ladder because opportunistic predator fish often hold in the pools and wait for prey to pass by.

6.1.2.3 Downstream passage through turbines

As discussed above, downstream passage through the turbine is only possible for fish that can pass through the trashrack open spaces. For this document it is assumed that all juvenile downstream migrants would be able to pass through the trashrack, while adults would not. To better understand the consequences of downstream passage through the turbines at Oneida, an analysis of estimated turbine mortality rates was performed.

Estimated Turbine Mortality

In conjunction with the U.S. Department of Energy's Advanced Hydro Turbine System Program (AHTSP), hundreds of turbine mortality study results were compiled and used to develop predictive equations of turbine mortality based on specific turbine characteristics (Franke et al. 1997). Kaplan and Francis turbines were considered separately in the review, since these are different turbine designs and understandably result in very different impacts on fish passing through them. The predictive equation for mortality through Francis turbines was used to estimate the likely mortality rate through the existing Francis turbines at the Oneida Project.

The predictive equation uses turbine size, rotational speed, head, number of buckets (or vanes), flow, mechanical efficiency, and the length of the fish entrained to estimate the probability that a fish of a given size will come near to or in contact with a structural element as it passes through the turbine. The predictive equation also adjusts for head and efficiency. The equation is used to estimate the probability that a fish passing through the turbine will experience significant negative impacts. Strike, shear, grinding and cavitation (if it occurs) all are most pronounced very near to or in contact with the turbine blades, and pressure changes and turbulence are accounted for by the adjustments made for head and efficiency. A correlation factor is then developed that correlates actual field mortality measurements to the calculated probability estimate. This factor will be different for different species of fish, as some species of fish fare better passing through turbines than others. The large majority of field studies at hydro projects in North America have been focused on salmonid species. Therefore, there is a greater confidence in estimates of mortality for salmonids than for other species, since there is a larger data set to work from. In developing the estimates of mortality for the Oneida turbines, the review was limited to salmonid species, particularly BCT, and mountain whitefish, since these are native species of interest on the Bear River.

There are no existing studies to use as references with 610 mm salmonids being tested through Francis turbines. Therefore, R2 performed some extrapolation on the upper end of the adult BCT. If we used linear extrapolation the mortality predicted was more than 100%, and if we used a polynomial fit the predicted mortality was lower than that for 330 mm fish. Both of these results are clearly wrong, so instead we used the same size factor for the 610 mm fish as for the largest in the field study. Using this method, the initial estimates are reported below, but there is a lot of uncertainty surrounding the results for the 610 mm estimate.

The analysis results reported were generated using the following assumptions and parameters; the turbine operating at it best efficiency point (which appears to be about 1,000 cfs), a net head of 140 feet, turbine diameter of 97 inches, 180 rpm rotation speed, and 17 bucket turbines. The estimated mortalities for the range of juvenile and adult BCT are listed below:

- 122 mm: 28% +/- 12%
- 220 mm: 34% +/- 15%
- 330 mm: 39% +/- 17%
- 610 mm: 58% +/- 26%

For the outmigrating juvenile BCT (122 mm – 220 mm) that can currently pass through the trashrack, the estimated mortality ranges from 16% to 49%. For adults that are trying to pass downstream of the dam currently there is no route except during high flow spill events over the spillway. If the trashrack were modified to allow adult passage through the turbines, then the expected range for adult mortality would be 22% to 84%, and could be even higher for large adults.

Fish Friendly Turbines

The idea of replacing the turbines at Oneida with fish friendly turbines was identified as a possible alternative to address the relatively high predicted mortality through the turbines. Fish friendly turbines are newer turbines that have been developed to increase the chances of survival for fish that pass through the turbine. Fish friendly turbines allow fish to pass downstream of hydro projects via passage directly through the turbines, which potentially eliminates the need to pass fish by diverting water for non-generation purposes. Direct spillage, or collection and bypass systems are the other methods to provide downstream fish passage, but these systems all result in power generation losses. Fish friendly turbine technologies have been developed mostly for lower head Kaplan turbines, like those installed at Wanapum Dam on the Columbia River with a design head of about 90 feet. At this point the fish friendly turbine options at Oneida are very limited due to the lack of a full scale and tested turbine technology that is applicable to the high-head, Francis turbine arrangements.

A new turbine design that reduces fish passage injury and mortality for higher head Francis turbines similar to those at Oneida has been developed under the U.S. Department of Energy's (DOE) Advanced Hydro Turbine Systems (AHTS) program by Alden Research Laboratory. The initial results from pilot-scale testing done in 2001 and 2002 were promising, but no full scale turbines have been installed to date. Based on pilot-scale test results, predictions suggested at least a 96 percent fish survival rate for a full-scale unit. Turbine passage survival depended primarily on fish length and operational head in the pilot scale tests, a finding consistent with blade strike as the primary cause of fish mortality.

In 2009, the Electric Power Research Institute (EPRI) received an award from the DOE to conduct a multi-year program to continue the turbine's development and bring it to full-scale deployment. With the ongoing development funded by the DOE, this option may be available for Oneida in future years.

Conclusions Regarding Passage through the Turbines

The juvenile predicted mortality rates are relatively high for the program goals, but may warrant further biological studies to validate or update the predictive abilities of the USDOE predictive method. Additionally, a fish passage survival / population model could be developed for the Oneida system to help predict the juvenile turbine survival necessary to meet the biological program goals. We recommend further discussion on this topic prior to making decisions on downstream juvenile passage systems.

Alternately, the adult survival predicted with passage through the turbine route is poor, which was the expected outcome due to the high head and Francis turbine configuration. A higher adult survival would likely be necessary than what the turbine route could provide. The biological importance of successful adult downstream passage and necessary survival rates for the program goals should be further quantified if dedicated downstream adult passage is not provided.

6.2 ALTERNATIVE D2: PARTIAL FLOW COLLECTOR WITH FISH RETURN PIPE

6.2.1 Description of Alternative

The goal of this alternative is to provide a downstream passage route through a "partial flow" collector, which is intended to attract fish away from the turbine entrance by providing attraction flow leading to an entrance that is known to be attractive to fish, rather than by screening the entire turbine flow. These types of fish collection systems rely on fish behavior and reservoir hydraulics, rather than a true physical barrier which blocks fish from entering the turbines. These types of collectors have shown high fish collection efficiencies ranging in the desirable 70% to over 90% range at some projects; however, other installations show variable or poor performance, more in the 30% to 50% range. Design of downstream fish passage facilities is not an exact science, and site specific variables, fish species, and project operations are key variables to their success. If successful, partial flow style collectors can offer large capital and operational cost savings over full exclusionary screening alternatives.

For this alternative, a 250 cfs V-screen structure is illustrated that would provide a significant surface flow outlet. Fish would be returned via flow in a fish return pipe that would discharge in the Bear River below the powerhouse. This will give a viable downstream passage option other than through the turbines, or down any upstream passage fishway that may be built (alternatives U1-U3). This downstream alternative should be able to pass all species and all life stages of interest.

Guide nets leading up to the V-screen would be an optional addition to improve attraction, as would blocking off the top portion of the trashracks to create better flow patterns to the V-screen entrance.

6.2.2 System overview and Functional Description

6.2.2.1 V-screen Location and Configuration

Locating the surface flow outlet in the zone where the bulk reservoir flow exits the reservoir will help to guide the downstream migrants near the proximity of the surface flow outlet, as outmigrating fish typically follow the flow. Locating the entrance in an area where downstream migrants concentrate will increase the probability of migrants encountering the entrance. The philosophy of designing the exit to simulate the configuration of a natural lake outlet is a common approach, with a broader and shallower exit configuration preceded by a gradual acceleration towards the entrance. An alternate configuration found successful at some sites includes a weir type entrance, with a faster acceleration. In either case, the overall facility would be similar, and the gradual acceleration approach is illustrated in Drawing 9.

The presence of other concentrating mechanisms (e.g., eddies that lead fish to the outlet, guide nets, etc.) can further increase the probability that downstream migrants will find the outlet. Similarly, counteracting hydraulics can also be a concern. Competing flows (e.g., eddies that lead fish away from the outlet) can reduce passage efficiency. The balance of these positive and negative dynamics is difficult to predict, but through measurement and studies to gain an understanding of these dynamics the overall passage efficiency can be increased.

Model studies of the flow in the forebay and fish tracking studies could be used to determine the local hydraulics and to better predict fish movement in the forebay area to help locate the V-screen entrance. Additionally, comparison to similar operating systems can help to identify the most desirable location. Similar systems exist on the Columbia River with ice-and-trash sluices and removable spillway weirs; however, these projects are much larger scale and may not offer a good prediction of performance at Oneida. Additionally, there are a few systems in operation and/or design and construction on smaller rivers (Upper Baker River FSC, Cowlitz Falls Surface Collector, Rounde Butte collector, Swift FSC, Cushman FSC, Cougar Project collector, and improvements to the Cowlitz Falls system) which would all prove useful to monitor over the next several years to assist with the design of an Oneida system.

V-Screen

Once downstream migrating fish find the entrance to the V-screen structure, they will sense the downstream velocity and be attracted to follow flow and enter the structure. The flow will then slowly increase in velocity until reaching a capture velocity. Then the flow is partially dewatered before entering the fish return pipe. Most of the attraction flow into the V-screen structure would be pumped through the screens and back into the reservoir so that it can still be used for power generation. Only a small portion (approximately 13 cfs) would be used to convey fish through the fish bypass and be lost for power generation.

The most important hydraulic conditions to achieve through the V-screen structure are the following:

- The velocity at the entrance should be greater than the ambient velocity in the reservoir;
- The flow must achieve capture velocity (> 8 fps) for juvenile outmigrants;
- The screen should be designed to avoid deceleration upstream of the capture point;
- Avoid rapid acceleration within the V-screen structure upstream of the capture point

The 250 cfs flow was selected to represent a reasonable design flow amount based on the overall turbine capacity (which is nearly 10% of the 2,600 cfs capacity), and on observations at other projects that a relatively “large” amount of flow is necessary to attract fish. Based on site observations and on experience with similar systems, we would expect a system at this site to be successful with design flows ranging from a possible low of about 100 cfs, to a high range of 400 cfs.

Other variables that are important to consider with a surface collector design include: total flow, entrance width, entrance depth, routing of pumped attraction flow back to the reservoir (to avoid negative hydraulic or sediment concerns in the reservoir), and the capture mechanism (velocity gradient through the collector), screen cleaner details, and screen design for uniform flow. A typical screen design involves primary screens to dewater the majority of the flow, secondary screens to accelerate the flow towards the bypass pipe, and screen baffle systems to help provide uniform flow over the screens.

Fish Return Pipe

Once fish pass through the V-screen structure, the water will flow over a flow control gate and into a fish return pipe which will transport fish as smoothly as possible to the outfall location. A flow of approximately 13 cfs is shown, with a 2-foot diameter pipe. Debris handling is very important in fish return pipe design as debris stuck in the entrance could reduce flow in the return pipe and debris stuck in the pipe could injure and disorient fish. A trashrack at the v-screen entrance, frequent cleaning of the trashrack, smooth pipe design with long-radius bends (>10 times the pipe diameter are desirable) and observations and cleanout ports are key operation and design elements. Following the guidelines for fish return pipes should ensure that fish can transit the pipe while maintaining proper position and not tumbling in turbulent flow. If the guidelines are followed, fish will emerge at the outfall with minimal disorientation and be able to avoid predators and minimize predation.

Outfall

The fish return pipe outfall should be in a location to minimize predation and disorientation, especially of juvenile fish, and minimize velocity impact on adults. The bypass could release into an open channel which then returns to the river. Release in a riffle river reach with relatively fast downstream velocity and moderate flow depth is generally preferable to slow moving deep water where predators can wait. The relatively fast moving water in riffles also causes some surface disturbance which gives some cover from other predators.

6.3 ALTERNATIVE D3: PARTIAL FLOW COLLECTOR WITH TRANSPORT FISH RETURN

6.3.1 Description of Alternative

Construct a separate downstream passage system consisting of a fixed partial flow (250 cfs) V-screen structure on the bank adjacent to the intake, with a fish collection and trap and haul system to return fish to the Bear River downstream of the powerhouse. This alternative is very similar to Alternative D2, with the bypass pipe replaced by a fish holding and transport station and fish transport trucks. The same guide nets leading up to the V-screen would be an optional addition to improve attraction, as would blocking off top portion of trashracks and creating attraction flow to V-screen located directly adjacent to trashracks may improve attraction.

Please see Section 6.2 for descriptions of the screen goals, location, configuration, etc. The remaining sections below for this alternative describe the fish bypass system for Alternative D3, which is shown on Drawing 10.

6.3.2 System overview and Functional Description

6.3.2.1 Fish Collection and Holding

Once fish enter the bypass pipe described for Alternative D2, they would be routed to a flow dewatering and fish separation device, then into fish holding ponds. Holding facilities are necessary with this type of system to provide a buffer area to collect fish, and to allow time for personnel to load and transport the fish back to the river. The fish loading and transport operations are typically done in batches, with a minimum transport time of one cycle every 1 to 3 days (depends on the system and biological needs), and a maximum cycle frequency during peak runs that is dependent on the size of the holding facilities and transport trucks. Some facilities operate five or more transport cycles in a single day during the peak run times. Because the system would be designed to collect both adults and juvenile fish, separation by size is desirable prior to holding to avoid predation and stress to the smaller fish. All excess water that enters the holding area will be pumped back into the reservoir for no loss of power generating flow.

The fish holding ponds would need to be sized based on the numbers and size of fish anticipated to enter the system on a peak day. At least two ponds or tanks would be required based on the size separation, and more capacity may be desirable if large runs are expected in a single day to accommodate truck loading and transport cycle times. Fish typically travel in schools, and a rule of thumb is to design collection and holding facilities to accommodate 10% of the peak run in a single day. The layout shown on Drawing 10 is intended to be schematic, which shows a holding area and a fish loading system. If this concept is carried forward, additional work would be required to help size the holding facilities, and fit them into the site at the desired location.

6.3.2.2 Fish Truck Loading

There are several options and proven technologies available to safely and reliably load fish from holding facilities into the transport trucks. The concepts shown on Drawing 10 include: 1) direct loading from tanks into trucks that load from below the holding tanks; and 2) use of a fish crowder and hopper loading system that loads fish from holding ponds or tanks, then lifts and transfers the fish into the truck. For both cases, it is important to utilize a water-to-water transfer design, where individual fish are never handled, and are never spilled or dropped into the truck without being submerged in water. Additionally, it is desirable to size the tank or hopper volumes to accommodate up to one full truck load, to minimize handling requirements and minimize stress on fish.

The selection of a final recommended system will depend on the physical site constraints, the numbers and sizes of holding ponds or tanks determined to be necessary, and an analysis of the specific site constraints to allow truck access near the loading facilities. For the purpose of this alternative, reasonable assumptions have been provided to develop the cost estimate.

6.3.2.3 Fish Transport Truck

Very specialized trucks for fish transport are used at fish collection and transport facilities. The size of tank and type of life support systems provided are specific to the species and life stages present and the length of transport time. For this report we are assuming a truck with a 1,200 gallon tank and full life support systems including aeration, recirculation, oxygen and tank baffling. PacifiCorp has recently purchased this size and style of truck for the Lewis River fish passage projects, so we have recent specification and cost data for these trucks. Fish loading would be via water-to-water transfer from the hopper or overhead tanks to the truck tank through a port in the top of the tank. Fish release would be through a port fitted with a knife gate at the rear of the truck, and a chute or flexible hose of sufficient length to deliver the fish to the desired release location.

Other transport methods including using smaller individual holding tanks for small lots of fish can be considered. Smaller tanks can be loaded onto a flatbed truck, or the use of a trailer tank pulled behind a pickup could be considered depending on the calculated tank volume requirements if this alternative is selected for further development.

6.4 ALTERNATIVE D4: FULL EXCLUSIONARY SCREENING

6.4.1 Description of Alternative

The goal of this alternative is to screen all of the power generating flow through a 2,600 cfs V-screen structure, and provide fish passage through a fish return pipe back to the Bear River. Drawing 11 shows a downstream passage system consisting of a fixed, full flow (2,600 cfs) double V-screen structure on the bank adjacent to the intake, and a fish return pipe that discharges downstream migrating fish in the Bear River below the powerhouse. Guide nets leading up to the V-screen would be an optional addition to improve attraction.

This alternative will physically prevent any fish from passing through the turbines, and represents the least risk and most costly approach to the downstream passage goals. This downstream alternative should be able to safely pass all species and all life stages of interest if designed properly. Unlike downstream passage systems designed for smolts, this system must be able to pass adults downstream since adult BCT return downstream after spawning, unlike salmon which die after spawning. In this alternative fish are returned to the Bear River downstream of the powerhouse through a fish return pipe.

The advantages of this type of screen include the ability to use all of the turbine flow as attraction flow into the system, and the ability to physically prevent any fish from entering the turbines. The disadvantages are largely associated with the capital and operating costs of such a facility, and the requirement to screen and manage debris from all flow. Screening to protect fish requires very small screen mesh or openings, which will greatly increase the debris management requirements at the site. While screens of 2,600 cfs are technically feasible, it is important to note that there are currently no screens in operation for this high of a flow, typically due to the stringent debris handling requirements.

6.4.2 System overview and Functional Description

The screen and fish bypass facility would be similar to that described for Alternative D2, but 10 times larger. See Section 6.2.2 for a detailed system overview of a v-screen bypass facility. A configuration consisting of two or three V-screens would be recommended, due to their proven performance at existing facilities, and the ability to provide a redundant bypass facility.

This alternative could also be designed to work with a fish holding and transport facility in lieu of the bypass pipe, as described for Alternative D4.

6.5 ALTERNATIVE D5: EICHER SCREEN

The goal of this alternative is to screen all of the power generating flow through Eicher screens installed in the flow line, and provide fish passage through a fish return pipe back to the Bear River. Drawing 12 shows three Eicher screens installed in three 9-foot diameter pipes that divide the power flow into three equal parts. A fish return pipe discharges downstream migrating fish in the Bear River below the powerhouse.

6.5.1 Description of Alternative

An Eicher Screen is a patented screen device consisting of a shallow inclined plane screen inserted into a closed, circular penstock that typically leads to the project turbines. This screen operates in a relatively high velocity in the closed conduit to separate fish from bulk flow. This screen design is not yet accepted by regulatory fisheries agencies due to the high-velocity screening, and is in fact classified as an experimental technology by NMFS. However, prototype and full scale applications have achieved favorable results in Oregon, Washington, and British Columbia, and we believe this technology would be appropriate for the Oneida site and project goals.

Characteristics found to be important to the successful use of an Eicher Screen include:

- Fish move down the diversion conduit in relatively high water velocity (up to 6 fps), and are able to maintain normal swimming posture with body upright and pointed upstream.
- Fish detect and /or touch screen or fluid boundary layer and fish dart away to avoid obstruction.
- Rapid water velocity in conduit carries fish towards bypass location as they dart away from screen.

Evaluations of successful Eicher Screens have shown that successful fish passage is provide as long as the ratio of the velocity parallel to the screen to the velocity through the screen is maintained at approximately three to one. Due to structural constraints and proven applications, it is recommended that the Eicher Screen diameter be limited to 9 feet for the Oneida project.

6.5.2 System Overview and Functional Description

6.5.2.1 Eicher Screen

The basic concept of an Eicher Screen is to insert a smooth, elliptical screen positioned at a shallow angle inside a circular penstock pipe. Fish and the corresponding bypass flows exit the penstock through a pipe mounted in the penstock at the downstream end of the screen. The screen is mounted on a center pivot, which allows the screen to be tilted for back-flushing debris. Fish could pass into the turbine during the cleaning cycles, which is another concern the agencies have with this style of screening system; however, the cleaning cycles are typically only 15 to 20 minutes, and the cleaning frequency is depending on the debris loading. Screen cleaning cycles can be timed to happen during times of the day when fish are not moving in order to reduce the chance of entrainment.

As shown on Drawing 12, an Eicher Screen alternative could be provided downstream of where the 16-foot diameter flow line emerges from the earthen dike fill material. A section of the flow line approximately 100 feet long would be removed, and in its place three Eicher screens would be installed. As noted above, we recommend a 9 foot maximum diameter for the Oneida installation, so the 16 foot diameter flow line at Oneida would need to be divided into three separate 9-foot diameter Eicher Screen pipe sections in order to be able to screen the maximum flow. Transitions upstream and downstream of the screen would be needed to transition from the 16 ft pipe to the 9 ft diameter pipes and back again. A vault would be installed for access and observation of the entire Eicher Screen installation.

6.5.2.2 Fish Return Pipe

The fish return pipe begins as an outlet at the top of the penstock near the downstream end of the Eicher Screen. A small percentage of the flow will enter the return pipe and caries fish which have been screened from the main flow into a pressure bypass pipe. The screens developed to date have bypasses ranging from 18 inch to 30 inch diameter. A final pipe diameter would be selected based on estimated debris load, and bypass flow required to transport the fish back to the tailrace.

The Eicher Screen is designed to allow fish to be guided along or above its surface, without contacting the screen, to the top of the screen, where a small percentage of the flow and all the fish are accelerated into a pressurized pipe bypass system. The fish bypass typically is designed to withdraw 5- to 15-percent of the flow. Bypass discharge is controlled by the hydraulic head differential between the discharge and the reservoir elevation. Excess water not needed for the fish return flow could be pumped back to the reservoir after emerging from the pressure bypass pipe.

The pressurized bypass pipe carries the water back up to an elevation close to the reservoir water surface elevation where it discharges into an open channel flow fish return pipe. Higher reservoir water surface elevations will result in higher flow in the fish return pipe. By incorporating a multi-level discharge these changes in bypass flow could be minimized.

The bypass system shown on Drawing 12 identifies all of the major components necessary to implement this system, and to prepare a planning level cost estimate. There are opportunities to fine tune this schematic layout, including custom full-port gate designs and bypass channel layout if this concept is carried forward in the future.

6.6 ALTERNATIVE D6: MODULAR INCLINED SCREENS (MIS)

The goal of this alternative is to screen all of the power generating flow through a Modular Inclined Screen (MIS) installed at the intake structure, and provide fish passage through a fish return pipe back to the Bear River. Drawing 13 shows a bank of MIS's installed in vaults on the front of the intake structure. A fish return pipe discharges downstream migrating fish in the Bear River below the powerhouse.

6.6.1 Description of Alternative

Eicher Screens and MIS's are very similar in design elements, and they are considered to be basically equivalent as fish passage systems. They both use an inclined plane screen design to separate fish from bulk flow. They essentially have the same hydraulic patterns. The MIS screen, based on its rectangular shape can be easily adapted to intakes, where the Eicher Screen is more adapted for penstock applications. Additional information is provided in Section 6.5.1 regarding necessary characteristics. Similar to the Eicher Screen, MIS screens are still considered as experimental technology by NMFS.

6.6.2 System overview and Functional Description

6.6.2.1 Modular Inclined Screen (MIS)

The basic concept of a MIS Screen is similar to an Eicher Screen, except the MIS is rectangular rather than elliptical. A MIS is designed to provide fish screening and a fish bypass at many types of intakes and in pipelines. The screen operates at water velocities of up to about 10 fps in the approach channel; however, laboratory tests of the MIS showed survival of greater than 99% with approach velocities of up to 6 fps.

Multiple MIS screens would be required to screen all of the flow at Oneida. Upstream of the intake water would enter rectangular channels fitted with the MIS and the bulk of the flow would pass through the MIS and into the power flow intake, with a small percentage diverted through the fish bypass. Similar to Eicher Screens, the fish bypass flows exit the top of the screen through a pipe at the downstream end of the screen.

In this alternative the MIS system is shown at the intake structure, but they could also be installed in a rectangular flow line.

6.6.2.2 Fish Return Pipe

The fish return pipe has the same requirements and characteristics as the Eicher Screen bypass, described in Section 6.5.2.2.

6.7 ALTERNATIVE D7: UPSTREAM CAPTURE LOCATION

The goal of this alternative would be to utilize permanent and/or temporary facilities that would allow capture of downstream migrants at or near the upstream end of the reservoir. Once captured, the fish could be transported around the reservoir and dam, and returned to the Bear River downstream of the powerhouse. This alternative would help to address concerns raised by ECC members that fish passage and survival through the reservoir may not be ideal due to predation or their ability to safely navigate their way through the reservoir.

The Oneida reservoir is relatively narrow and river-like compared with large storage or flood control reservoirs, and with relatively shallow depths means there will be sufficient bulk velocity downstream for fish to find their way. Fish will likely follow these velocity cues, and also will follow shorelines to navigate their way to the end of the reservoir. Based on our experience with studies at similar reservoirs, we believe fish would likely be able to find their way to a collector located near the dam. Predation, on the other hand, could be a much larger concern in the Oneida reservoir. Walleye and other predators known to exist at Oneida could eliminate a large part of the downstream migrating population while transiting the reservoir.

Drawing 14 shows an overall plan of the reservoir, and illustrates a potential collection site on the Bear River just upstream of the reservoir and the transport route necessary to truck fish back to the river. A range of concepts has been evaluated at similar sites, with collection facilities ranging from a new 10 to 12 foot high barrier dam requiring upstream and downstream fish passage and collection facilities, to a temporary single screw trap or array of screw traps with lead nets deployed across the river or the entrance to the reservoir.

Based on the BCT needs, we do not believe it would be beneficial to develop concepts based on a permanent barrier dam or derivatives of these concepts such as an electric barrier or velocity barrier. This would create the need for a new fish ladder, and could also delay migration. Additionally, from an operational feasibility perspective, permanent collectors at the head of reservoirs with uncontrolled flows are typically eliminated from further consideration due to serious concerns regarding the ability to handle large debris loads entering the reservoirs given the need to screen all of this flow.

For this report, we suggest consideration and ongoing discussion of seasonal type collectors, that could be deployed when fish are present and flows allow reliable performance. These could be low initial cost, but would be labor intensive and would likely have relatively high annual operational and maintenance costs.

In order to further develop this downstream passage alternative it will require more knowledge of the fish migration patterns, seasons, and target numbers of fish to be collected. Additionally, further data should be collected to help determine and quantify the overall risk of predation to downstream migrants in the reservoir. If the risk is sufficiently severe then capture at the upstream end of the reservoir, as well as fish population management should be considered and developed further in the future.

7. OPINION OF PROBABLE COST

Opinions of probable costs were developed to help the ECC understand both the relative and approximate absolute costs associated with the various alternatives, and are summarized in Table 7-1. These costs were estimated based on the schematic drawings and descriptions presented in this report, and on quantitative and qualitative comparisons to similar installations where R2 has sufficient knowledge to offer an opinion. This level of cost estimate is broadly defined by the Association for the Advancement of Cost Engineers (AACE) International as a Class 5 cost estimate.

Class 5 estimates are generally prepared based on very limited information, and subsequently have wide accuracy ranges. Typically, engineering is 0% to 10% complete. They are typically used for any number of business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, or long-range capital planning. Expected accuracy ranges are from -20% to -50% on the low side and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances. As little as 1 hour or less to perhaps more than 200 hours may have been spent preparing the estimate depending on the project and estimating methodology (AACE International Recommended Practices and Standards).

For these estimates, less than 20 hours were invested in developing the costs. The intent of these estimates is more useful at this point of development to compare the alternatives. They should not be used for capital program budgeting, as all of the designs need additional concept development, and site research (such as geotechnical investigations, dam safety reviews, etc.).

Consistent assumptions were utilized with the development of these capital cost estimates, including use of 2011 dollars, a 30% contingency on the estimated construction cost to address unknown issues and a general construction contingency and a 30% value for engineering, permitting, construction engineering services, and owner administration.

Similar consistent assumptions were utilized for the annual operation and maintenance costs between the alternatives, including R2's estimates of personnel costs, power requirements, equipment maintenance and replacement needs over the remaining 21 years of the FERC license period. An estimated cost of $80,000/year was assumed for a full time equivalent (FTE) staff cost to operate the facilities. Power costs were assumed at $0.05 / kW-hr. Additional assumptions are listed in the footnotes in Table 7-1.

Costs of biological studies, or initial monitoring and evaluation programs that are typically associated with fish passage projects were not estimated at this time.

Table 7-1. Opinion of Probable Cost (OPC) of Alternatives, presented in 2011 dollars.

Alternative	**Capital Cost**[1]	**Present Value of O&M Costs**[2]	**Present Value Total Cost**
U1 (Ladder at 10%)	$21,500,000	$3,250,000	$24,750,000
U2 (Ladder at 8%)	$21,600,000	$3,250,000	$24,850,000
U3 (Ladder at 10% with entrance in Bypass reach)	$17,900,000	$4,000,000	$21,900,000
U4 and U5 (Trap and Haul)	$5,600,000	$4,150,000	$9,750,000
D2 (250 cfs v-Screen with return pipe)	$14,400,000	$4,250,000	$18,650,000
D3 (250 cfs v-Screen with trap and haul facility)	$14,000,000	$5,000,000[3]	$19,000,000
D4 (full flow v-screen)	$30,000,000	$10,000,000	$40,000,000
D5 (Eicher Screen)	$20,000,000	$3,000,000[4]	$23,000,000
D6 (Modular Inclined screen)	$20,000,000	$3,000,000[4]	$23,000,000
D7 (Upstream Capture)	TBD[5]	TBD[5]	TBD[5]

(1) Optional items (such as guide nets, trashrack blocks, etc.) are not included in these costs.

(2) Based on present value of estimated annual operation costs until the end of current 30 year license (assumed 21 years remaining) with discount rate of 3% above inflation. Includes pumping costs, water costs and extra hours for employees. Power costs estimated at $0.05/kW-hr.

(3) If upstream and downstream trap and haul systems are installed some savings will be realized due to equipment and personnel used for both systems.

(4) Costs include estimated cost for headloss of power generation flow, based on a power cost of $0.05/kW-hr.

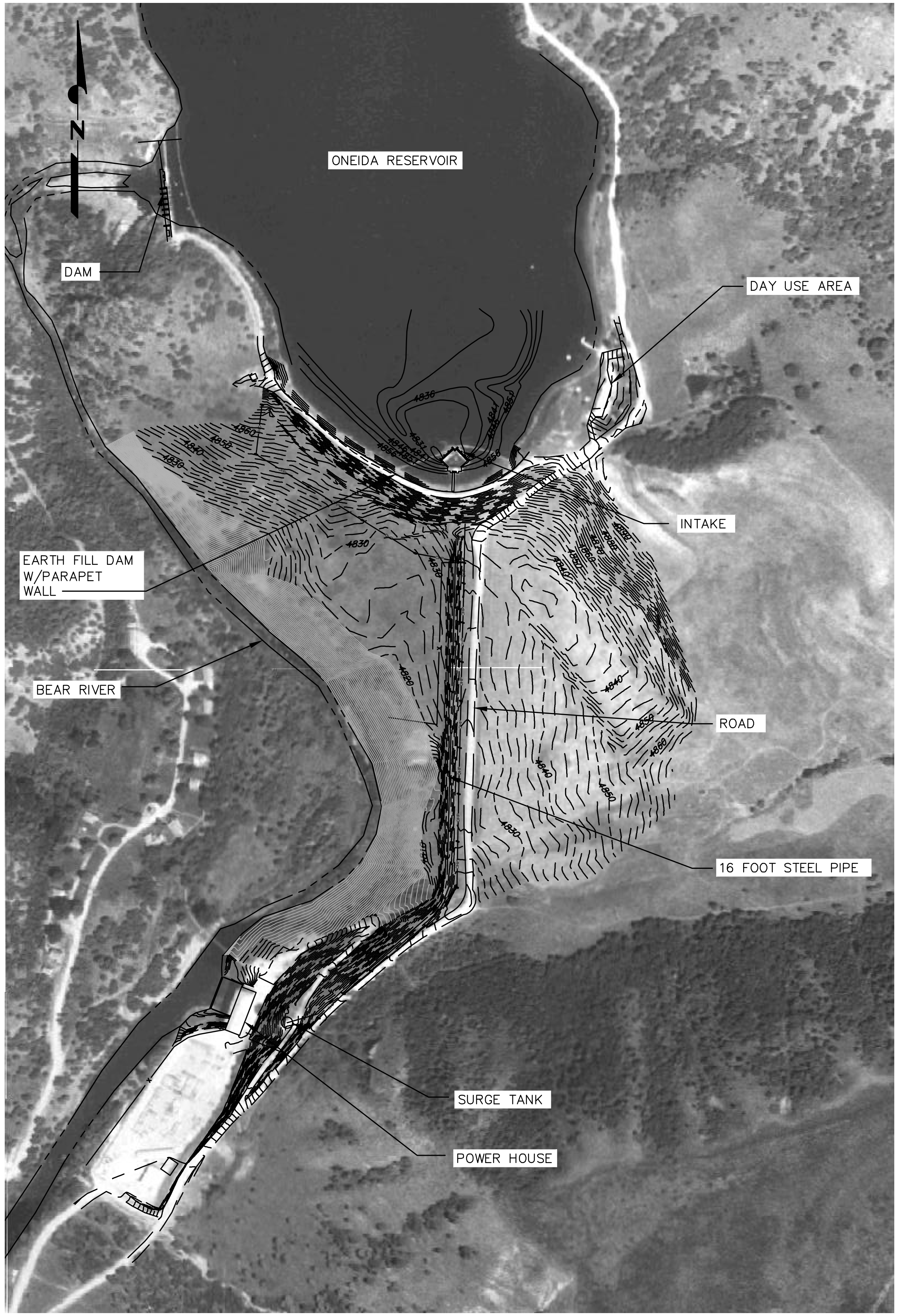
(5) This alternative is relatively undefined at this point for the draft report, and requires further discussion to estimate costs for the final report.

The client acknowledges that R2 has no control over costs of labor, materials, competitive bidding environments and procedures, unidentified field conditions, financial and/or market conditions, or any other factors likely to affect the OPC of this project, all of which are and will unavoidably remain in a state of change, especially in light of the high volatility if the market attributable to Act of Gods and other market event beyond the control of the parties. Client further acknowledges that this OPC is a "snapshot in time" and that the reliability of this OPC will degrade over time. Client agrees that R2 cannot and does not make any warranty, promise, guarantee or representation, either express or implied, that proposals, bids, project construction costs, or cost of O&M functions will not vary significantly from R2's good faith Class 5 OPC estimate.

8. RECOMMENDED DATA COLLECTION NEEDS (NEXT STEPS)

To be provided following ECC review of the draft report.

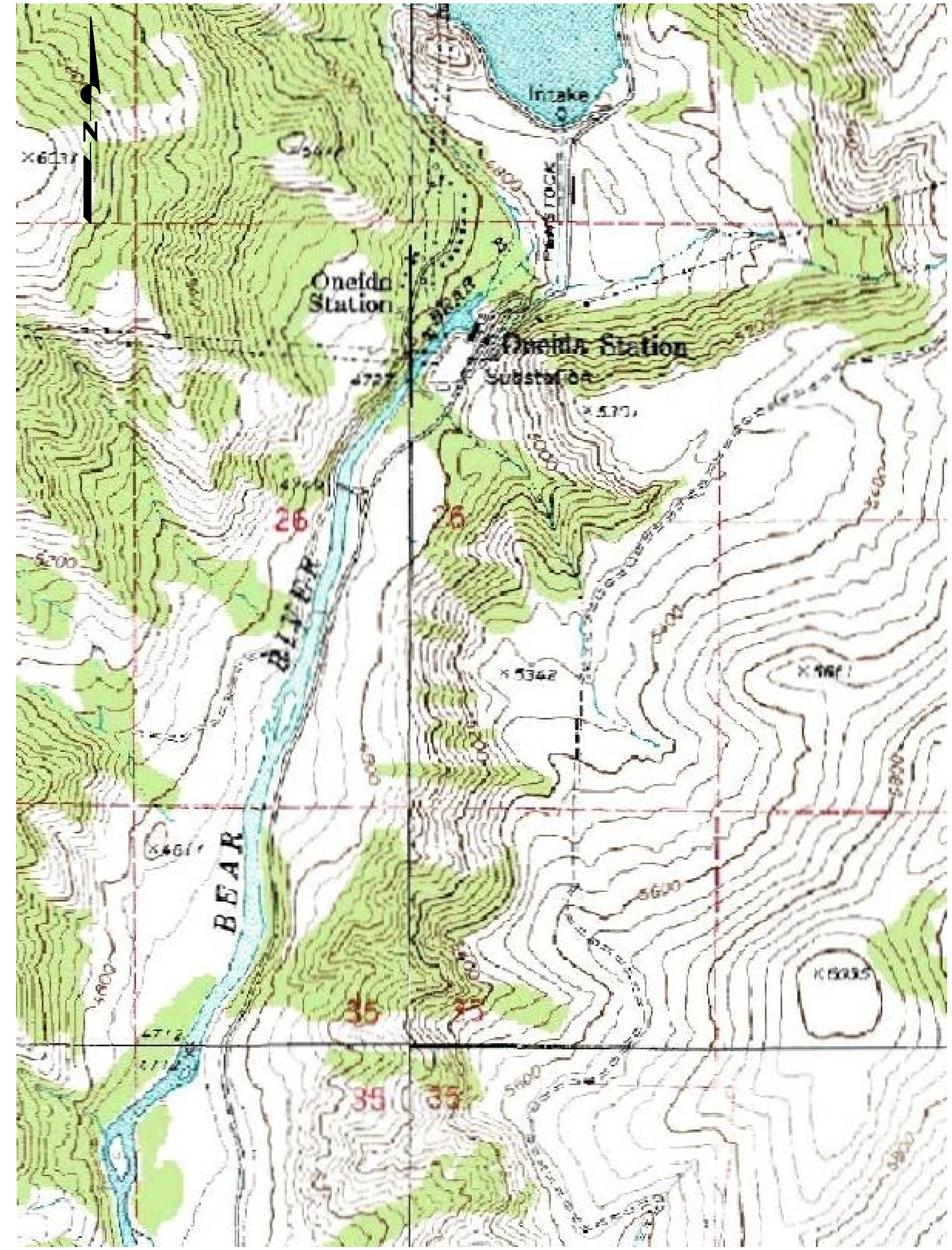
DRAWINGS



SITE PLAN WITH SURVEY

500' 0 500' 1000'

1"=1000'



USGS MAP OF AREA

1/4 0 1/4 1/2

1"=1/2 MILE

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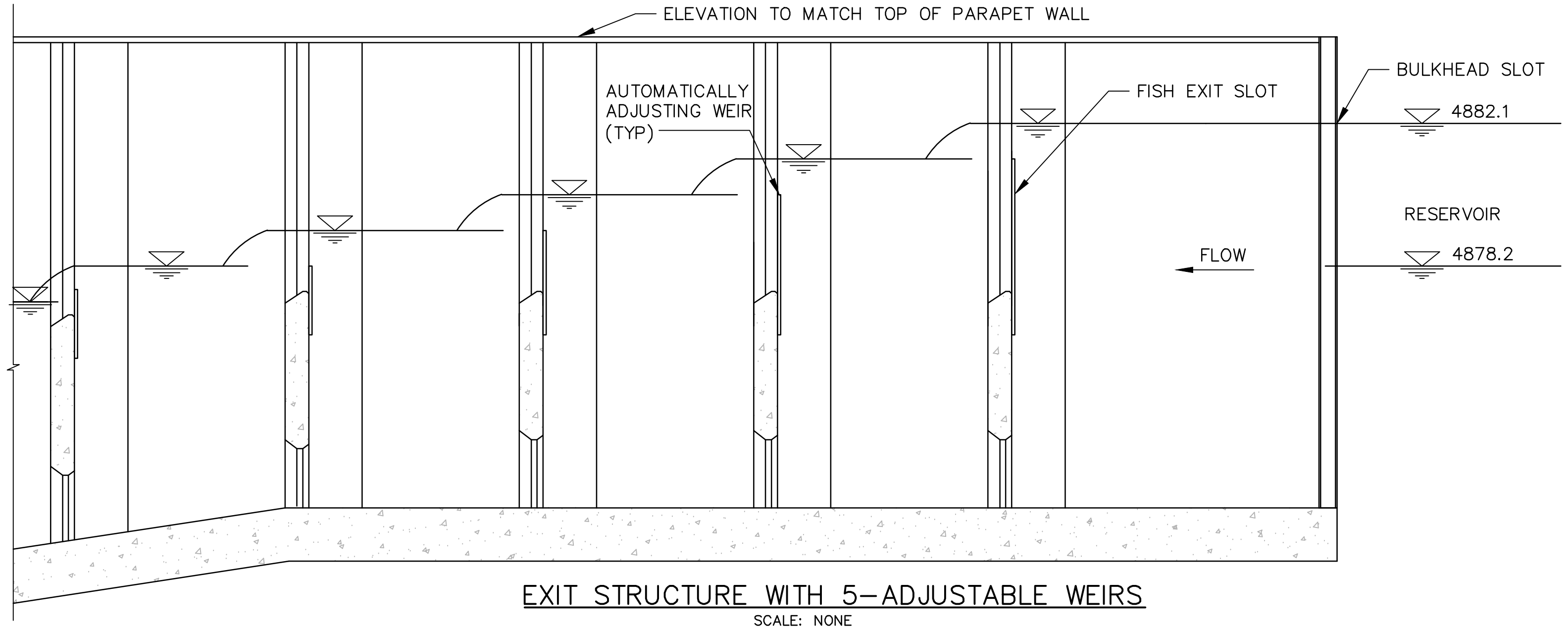
PACIFICORP

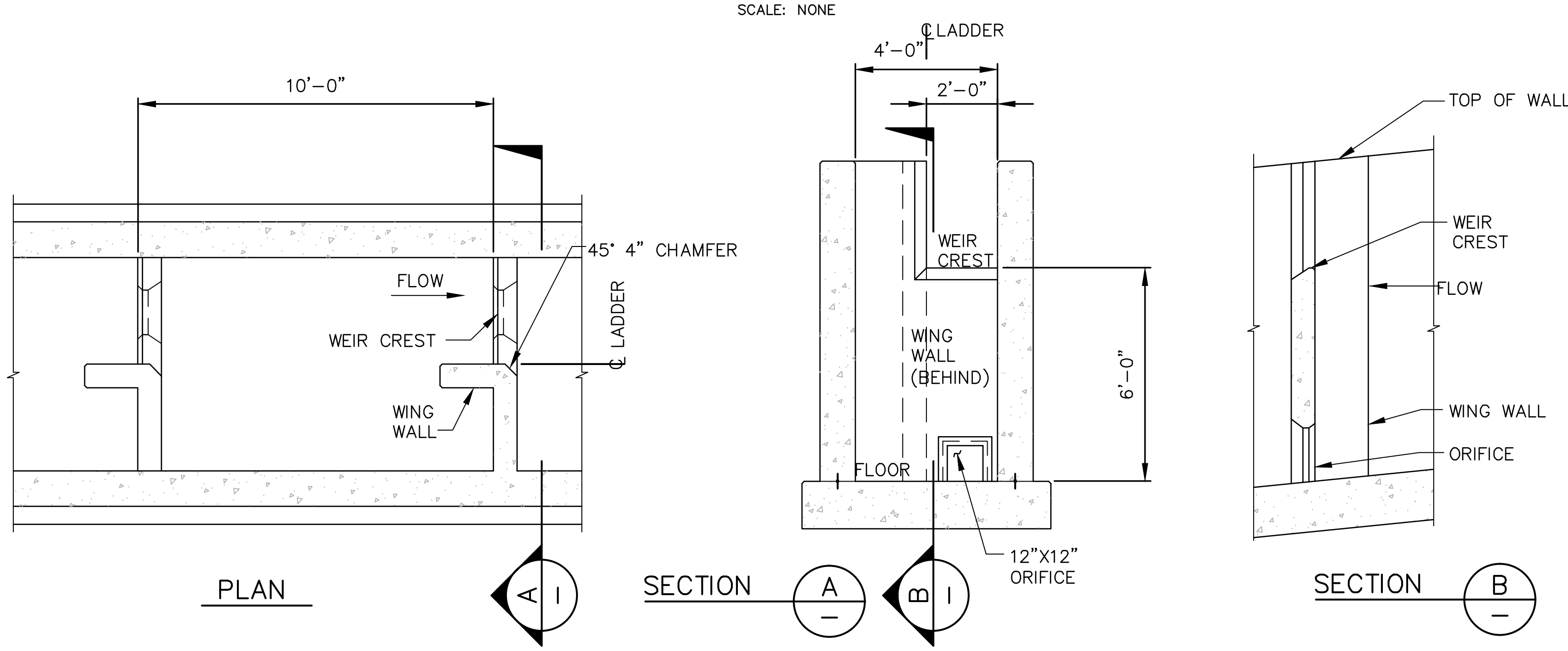
CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

OVERALL SITE PLAN
DRAWING 1

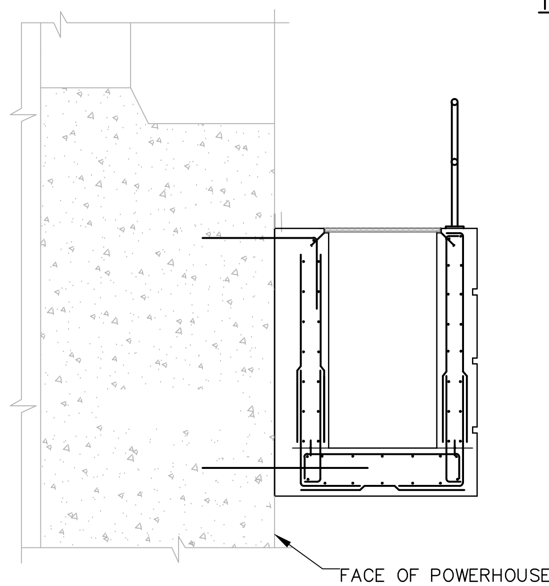
\\Nas\shared projects\1852 Oneida\Drawings\1852-Fig 01.DWG, 3/8/2011 2:56:50 PM



EXIT STRUCTURE WITH 5-ADJUSTABLE WEIRS
SCALE: NONE



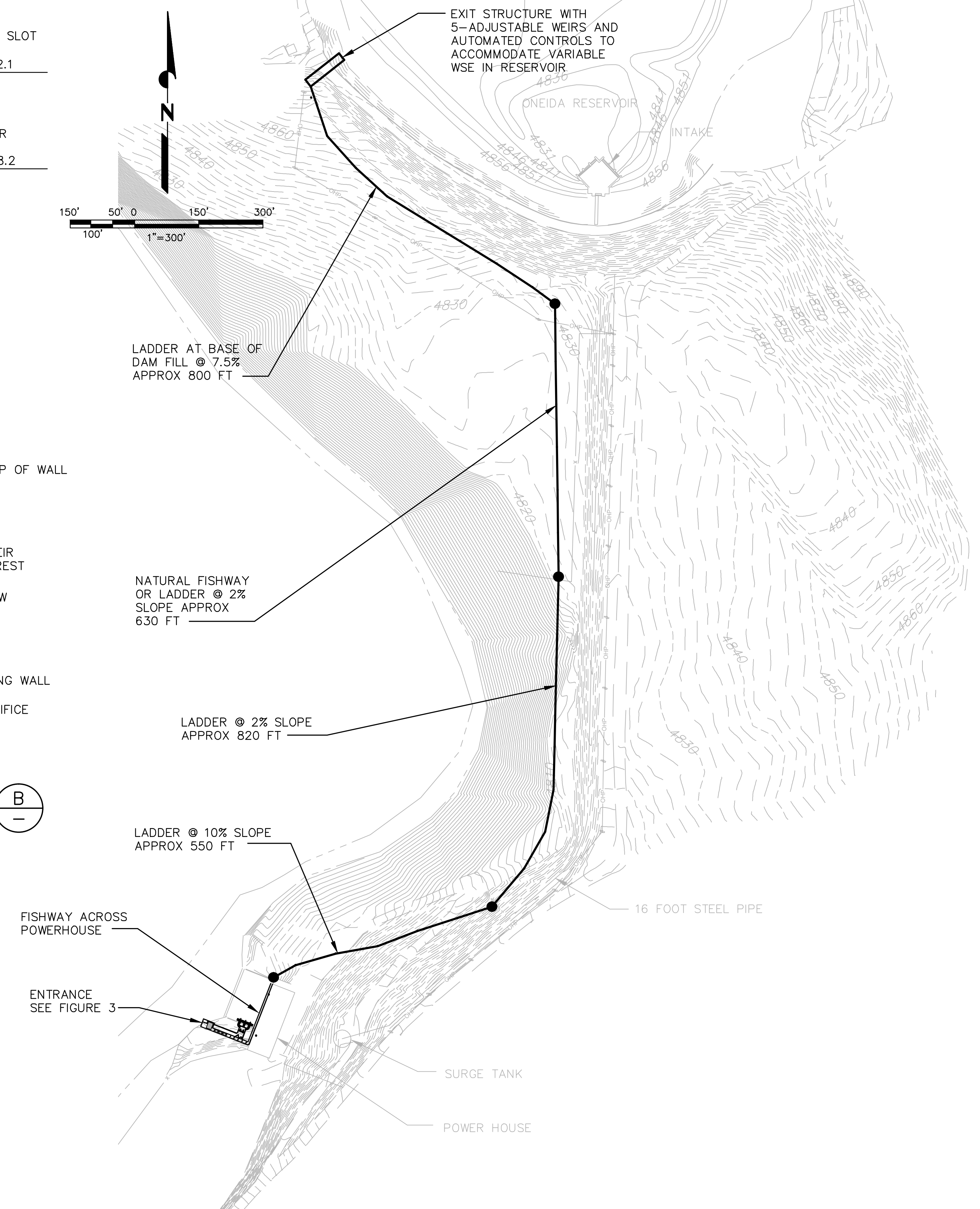
TYPICAL 1/2 ICE HARBOR
3' 2' 1' 0 2.5' 5'
3/16"=1'-0"



FISHWAY ACROSS POWERHOUSE
3' 2' 1' 0 2.5' 5'
3/16"=1'-0"

ALTERNATIVE U1

LADDER FLOW:	12.7 CFS
HEAD DROP PER POOL:	1 FT
ORIFICE VELOCITY:	8 FT/S
MAX SLOPE:	10%
ENERGY DISSIPATION FACTOR:	3.7
TOTAL LENGTH:	3,000 LF
POOL LENGTH:	10 FT
WATER TRAVEL TIME:	67 MIN



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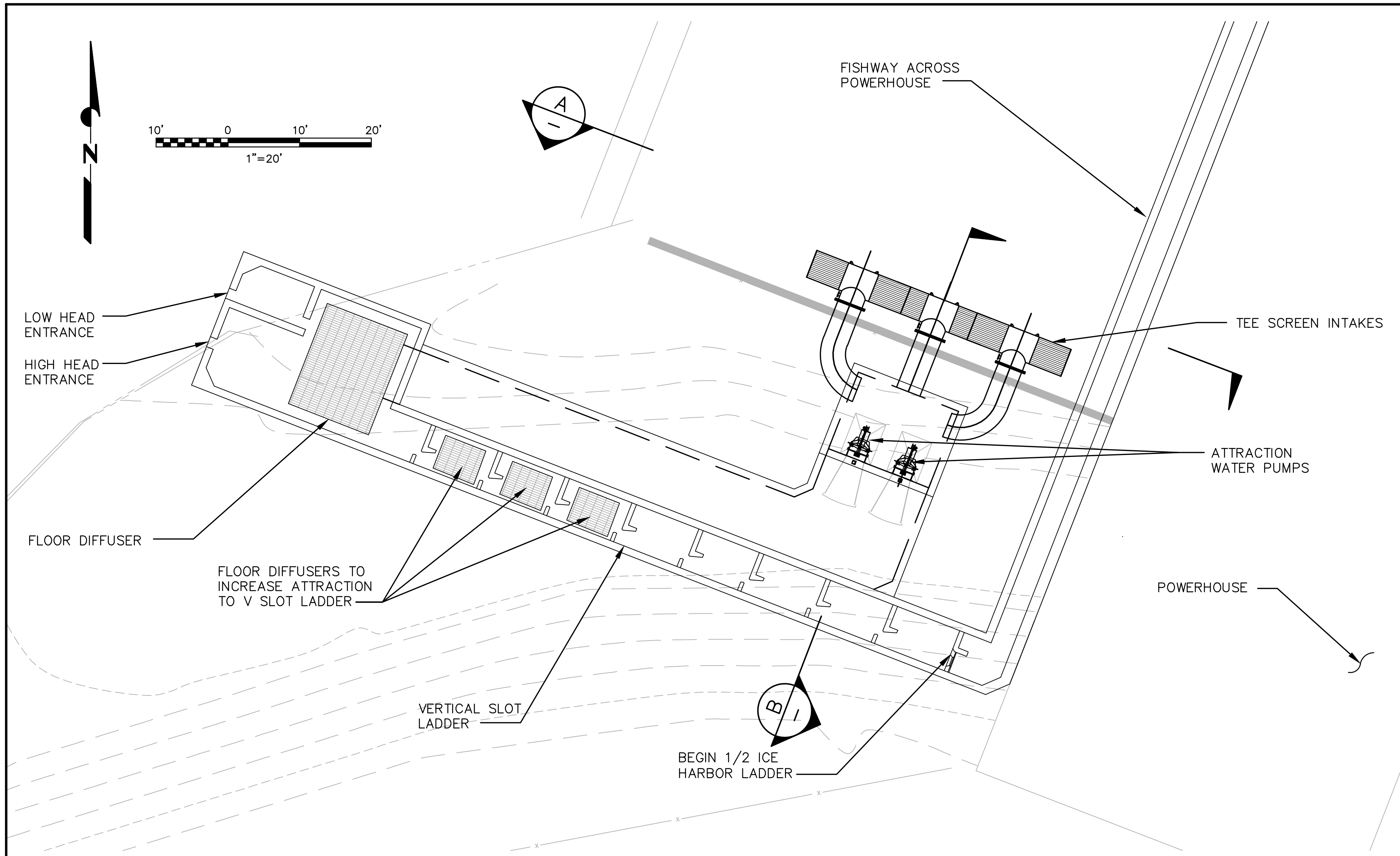
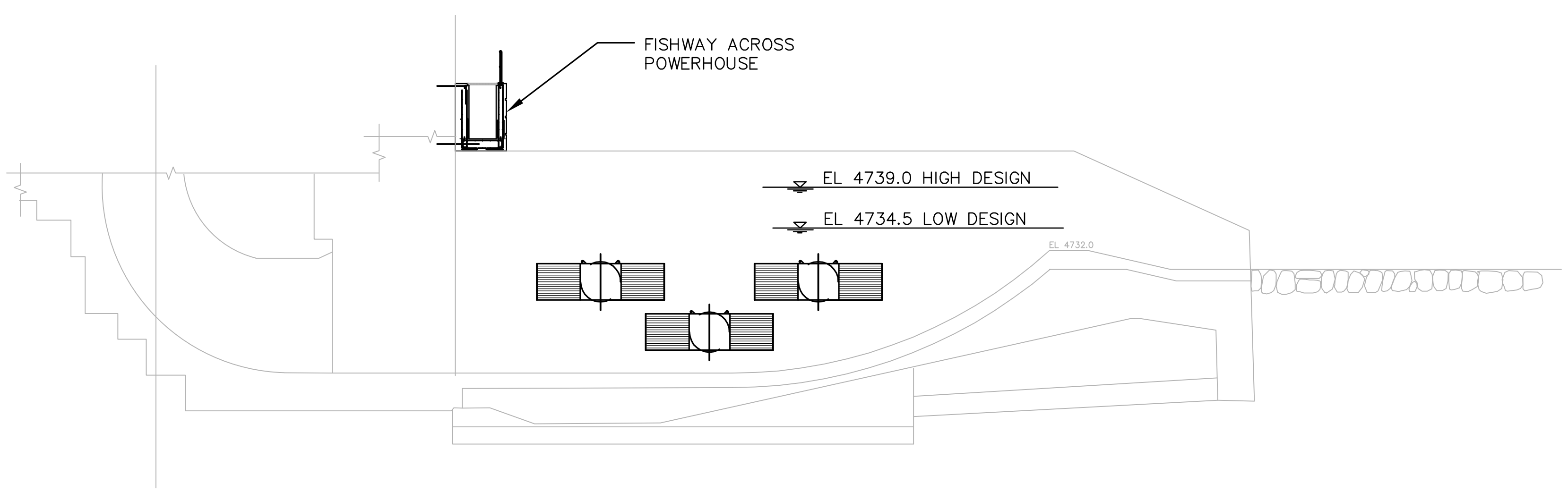
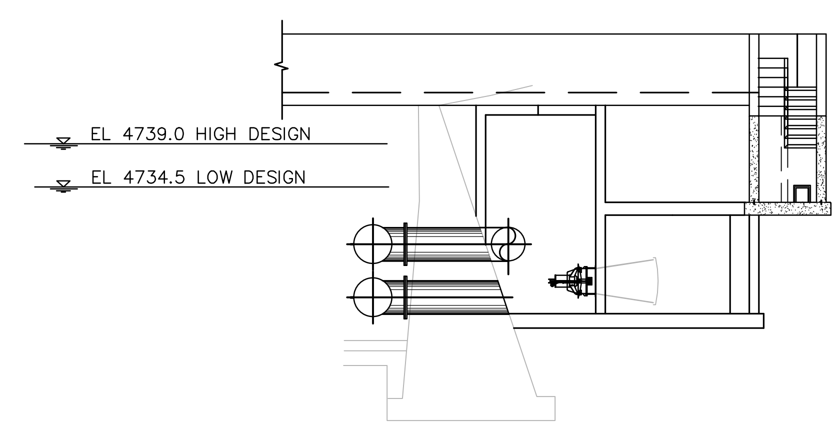
PACIFICORP
CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA
ALTERNATIVE U1: SOUTH TAILRACE ENTRANCE
10% SLOPE LADDER
DRAWING 2



FISH ENTRANCE PLAN



SECTION A



SECTION B

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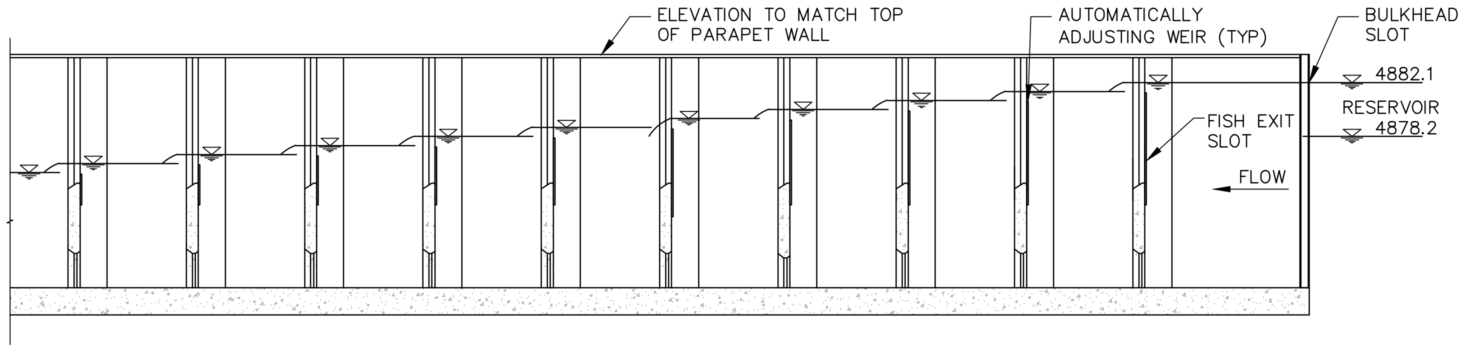
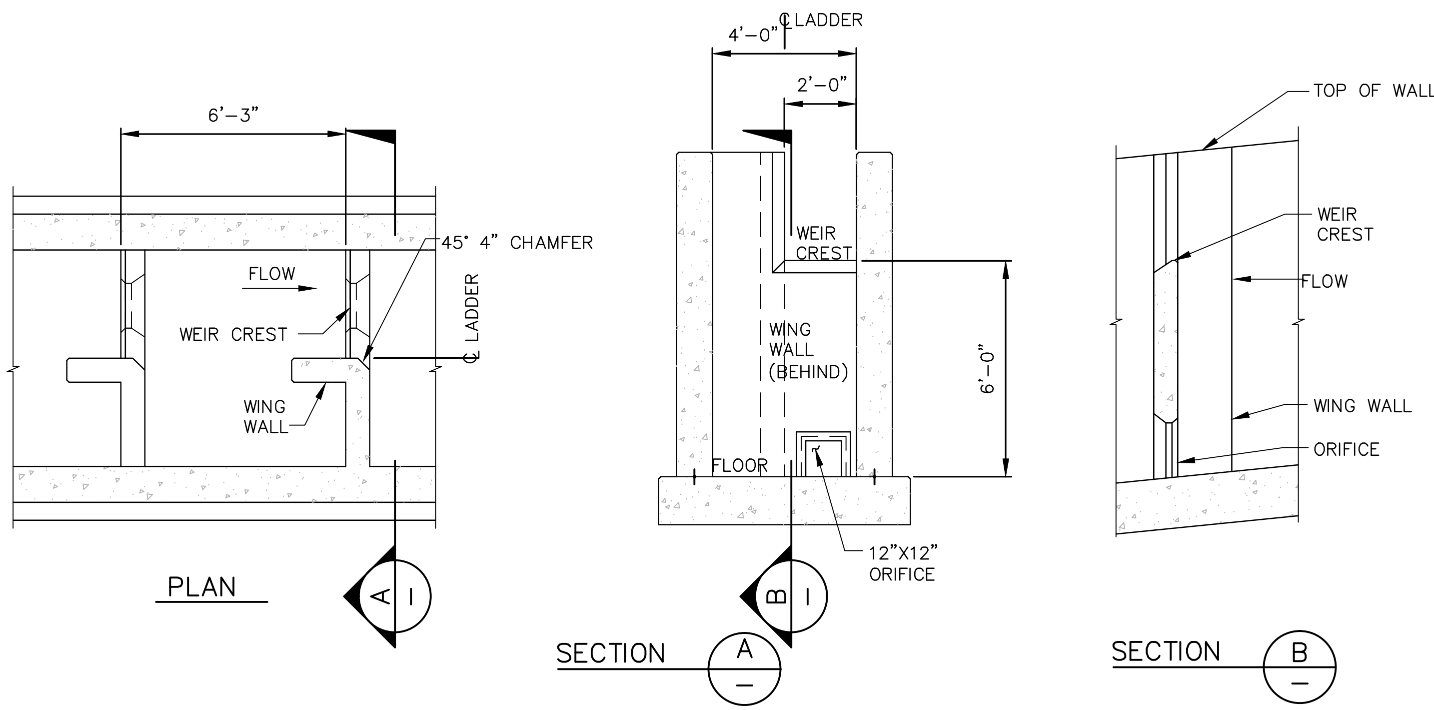
PACIFICORP
CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

ALTERNATIVE U1 FISHWAY ENTRANCE
DRAWING 3



EXIT STRUCTURE WITH 10-ADJUSTABLE WEIRS



PLAN

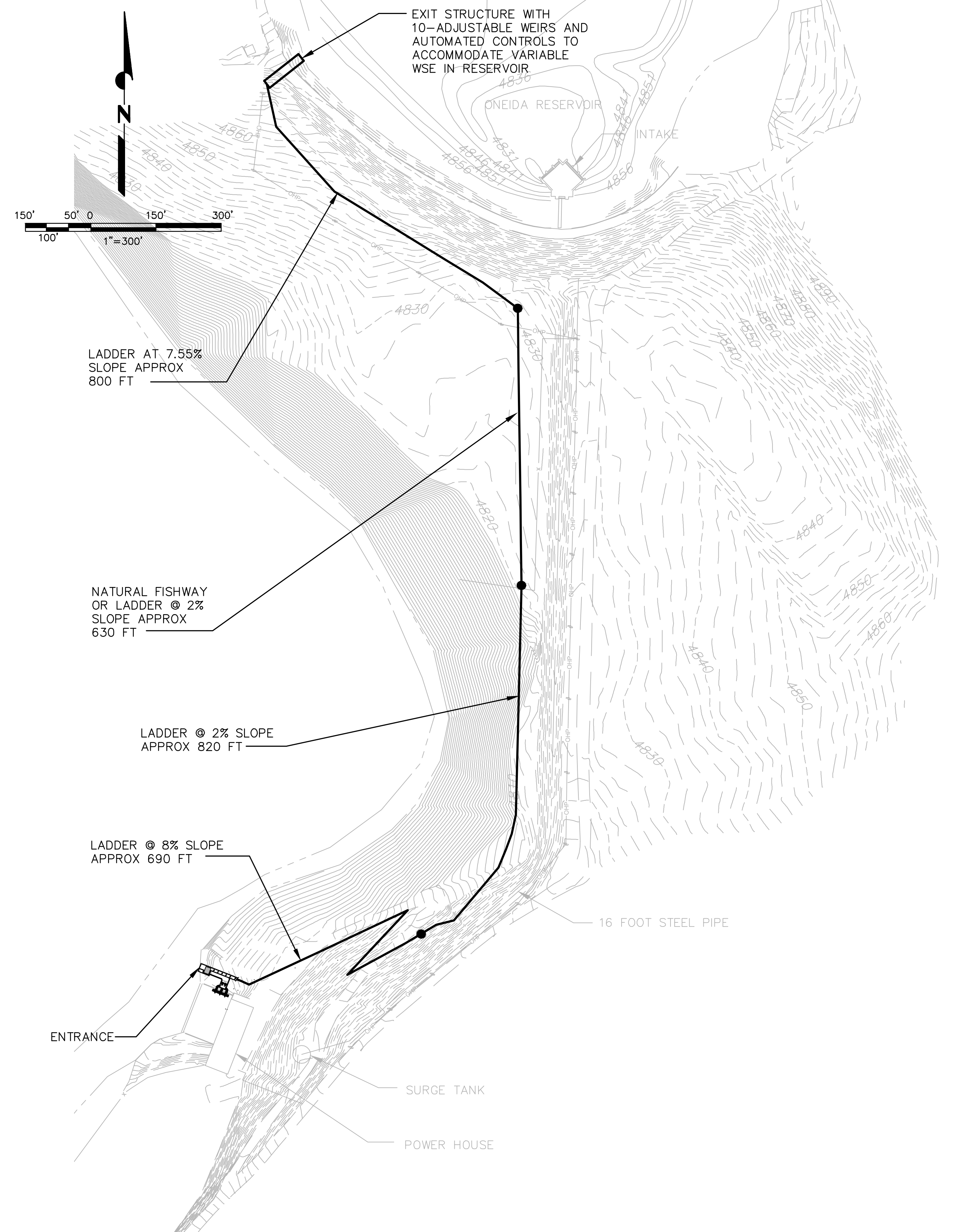
SECTION A

SECTION B

TYPICAL 1/2 ICE HARBOR

ALTERNATIVE U2

LADDER FLOW:	12.7 CFS
HEAD DROP PER POOL:	6 IN
ORIFICE VELOCITY:	5.7 FT/S
MAX SLOPE:	8%
ENERGY DISSIPATION FACTOR:	3.1
TOTAL LENGTH:	3,000 LF
POOL LENGTH:	6.25 FT
WATER TRAVEL TIME:	71 MIN



PACIFICORP
CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

ALTERNATIVE U2: NORTH TAILRACE ENTRANCE, 8% SLOPE LADDER
DRAWING 4

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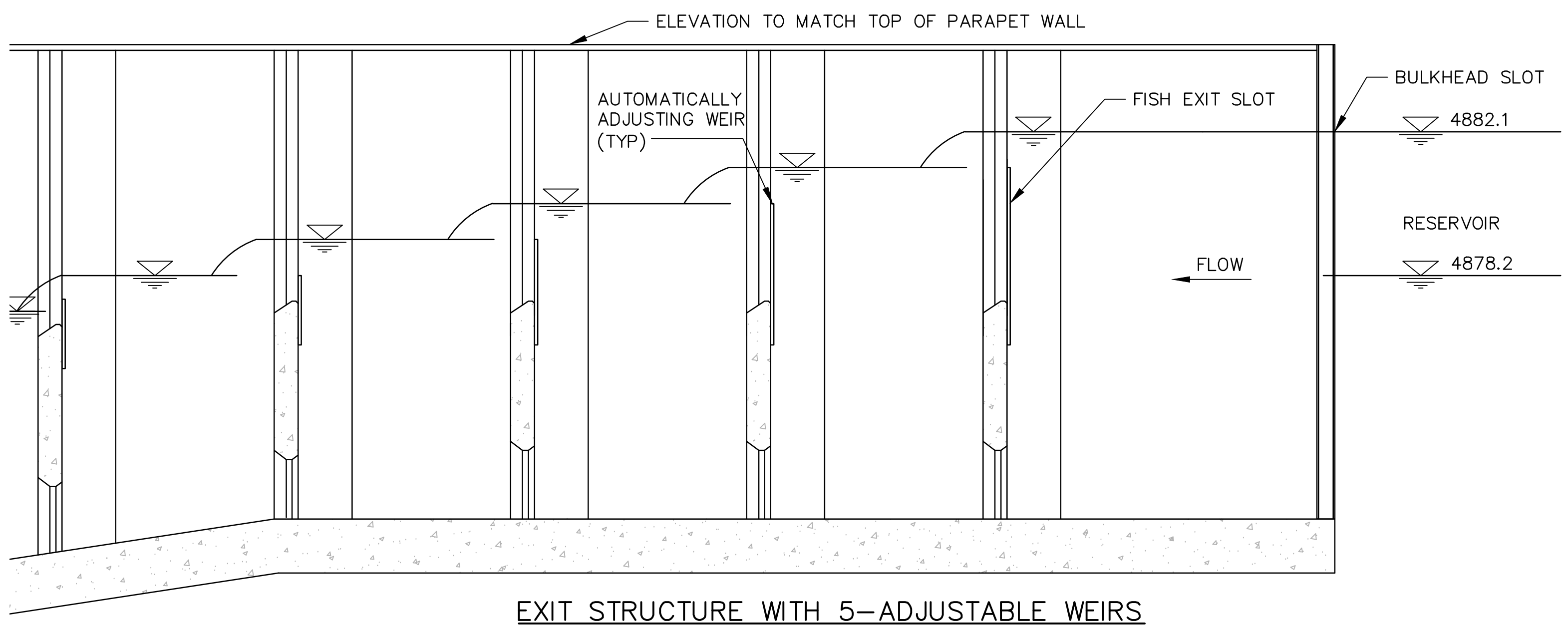
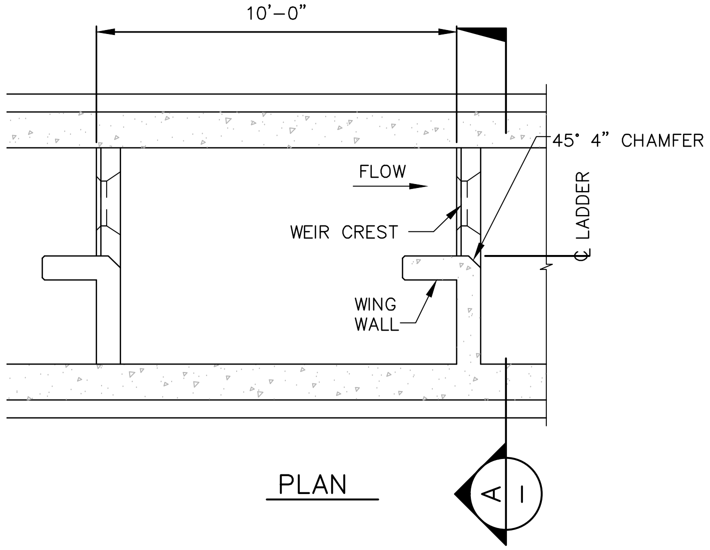
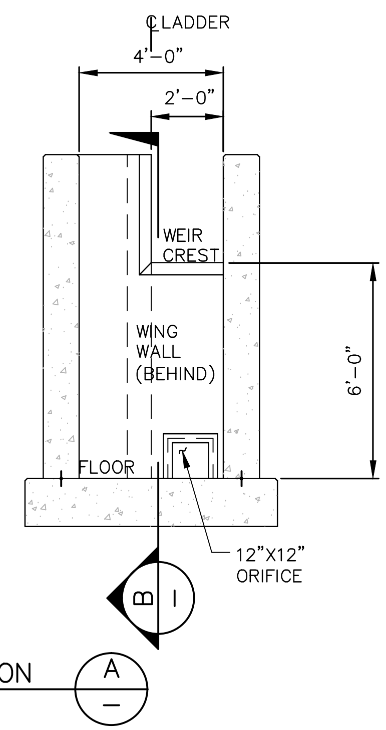


EXIT STRUCTURE WITH 5–ADJUSTABLE WEIRS

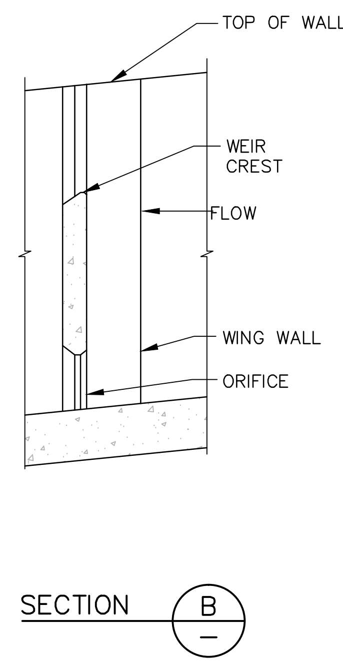
SCALE: NONE



PLAN



SECTION A

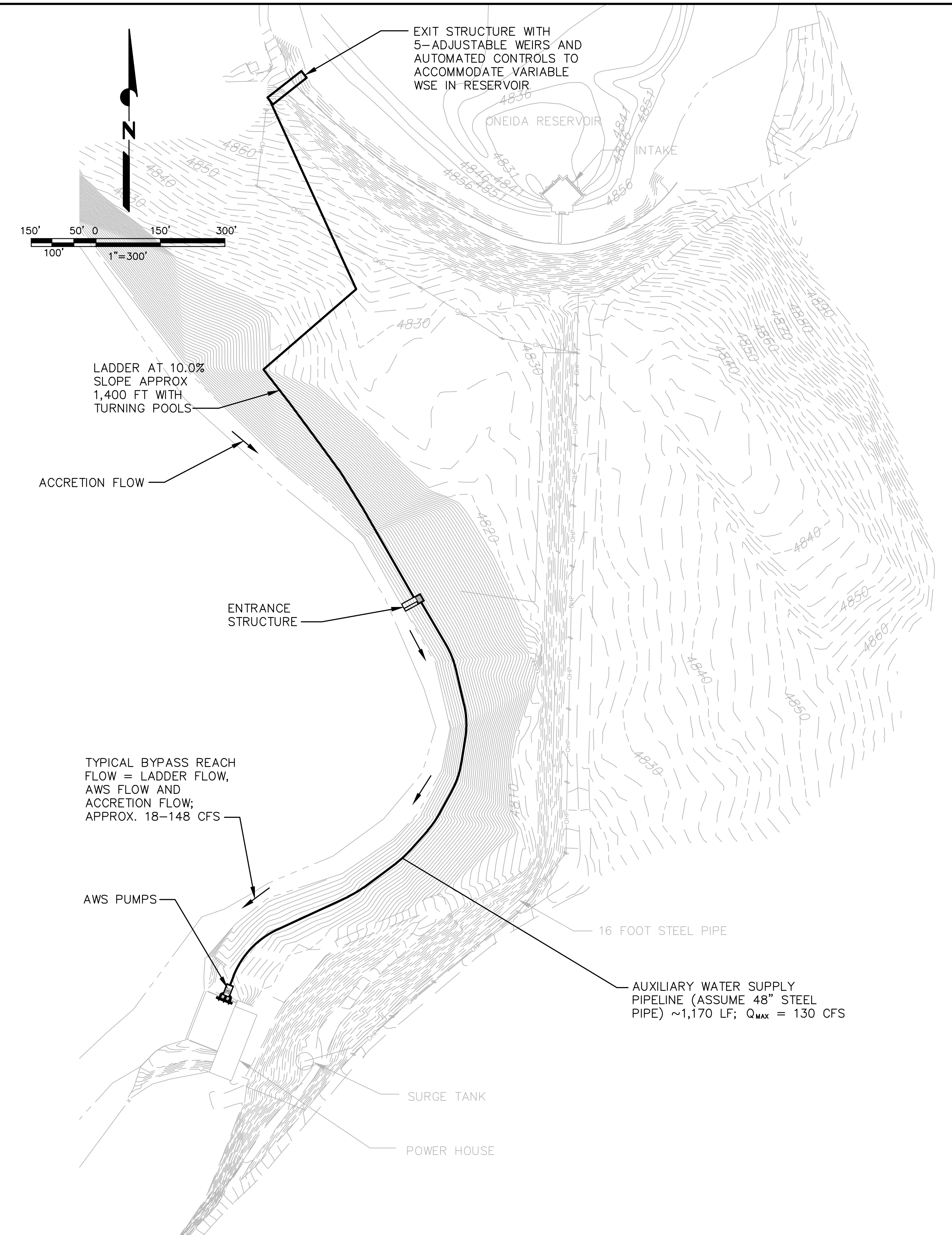


SECTION B

1/2 ICE HARBOR

3' 2' 1' 0 2.5' 5'

3/16"=1'–0"



ALTERNATIVE U3

LADDER FLOW:	12.7 CFS
HEAD DROP PER POOL:	1 FT
ORIFICE VELOCITY:	8 FT/S
MAX SLOPE:	10%
ENERGY DISSIPATION FACTOR:	3.7
TOTAL LENGTH:	1,400 LF
POOL LENGTH:	10 FT
WATER TRAVEL TIME IN LADDER:	42 MIN

PACIFICORP

CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

ALTERNATIVE U3: ENTRANCE IN BYPASS REACH
10% SLOPE LADDER
DRAWING 5

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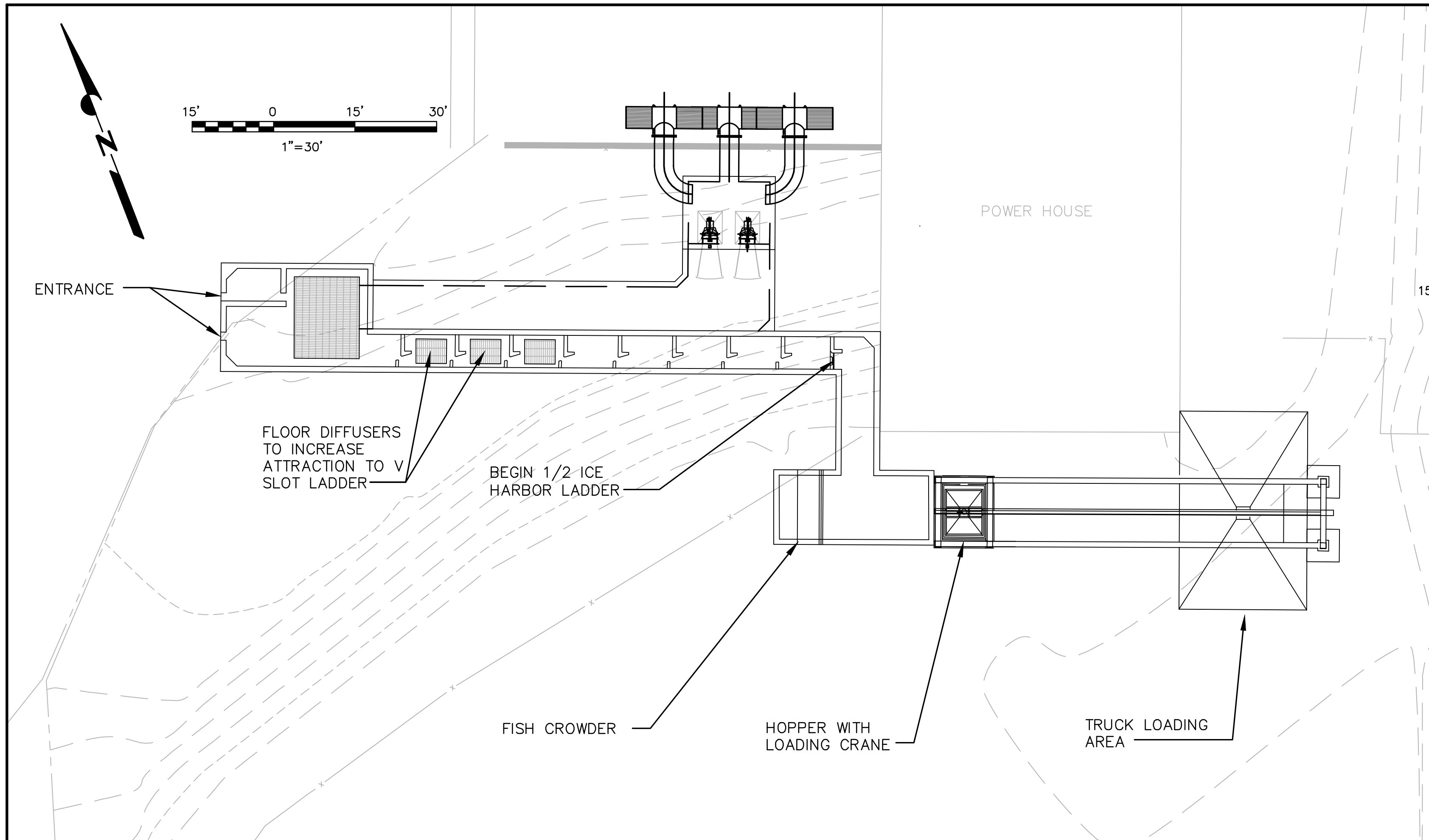
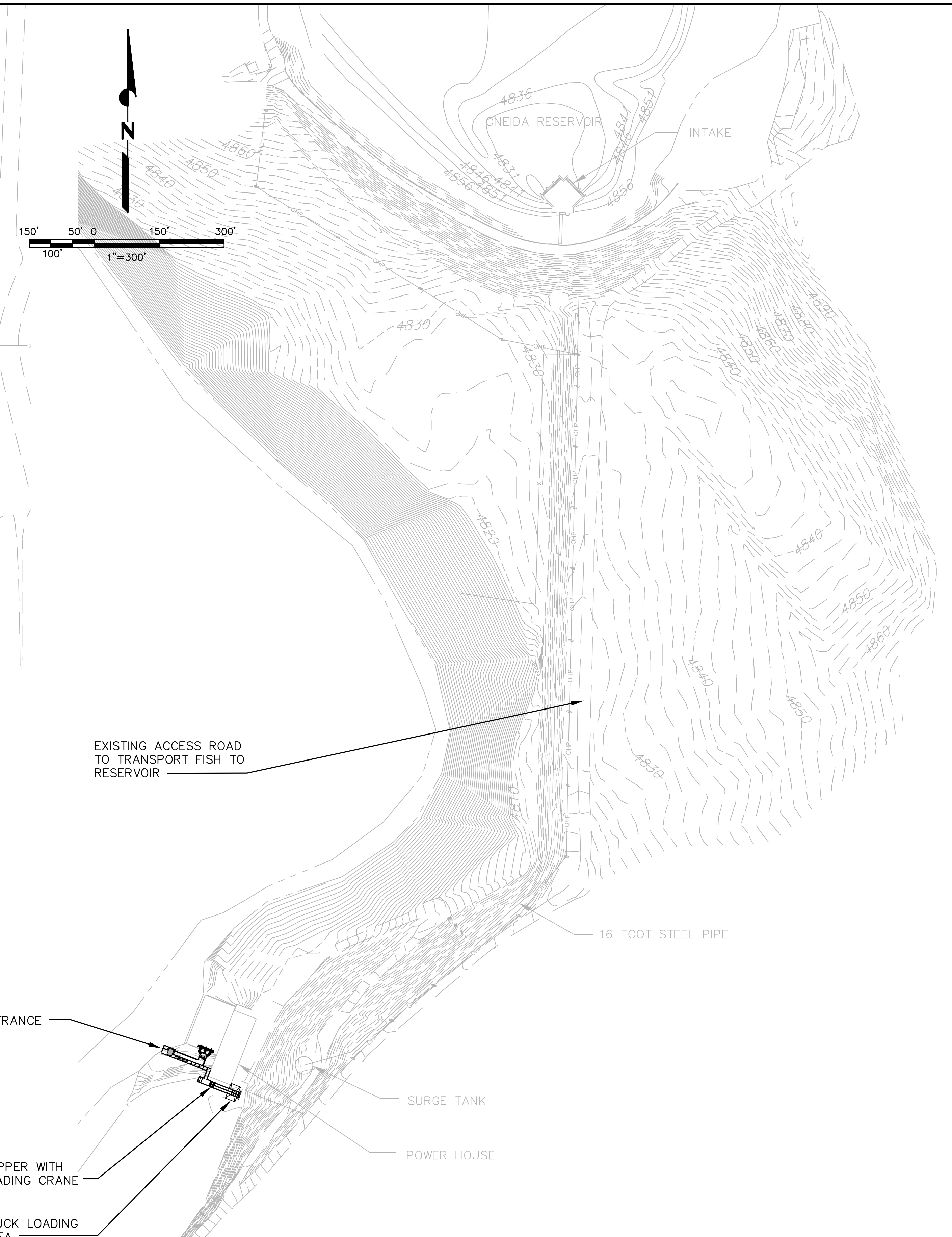


ENTRANCE AREA PLAN



LOADING HOPPER

ALTERNATIVE U4

HOPPER SIZE:	1200 GALLONS
HOPPER FLOW:	BASED ON ATTRACTION
MAX ADULT FISH/DAY:	356 (3 LBS EACH)
MAX TRIPS/DAY:	5

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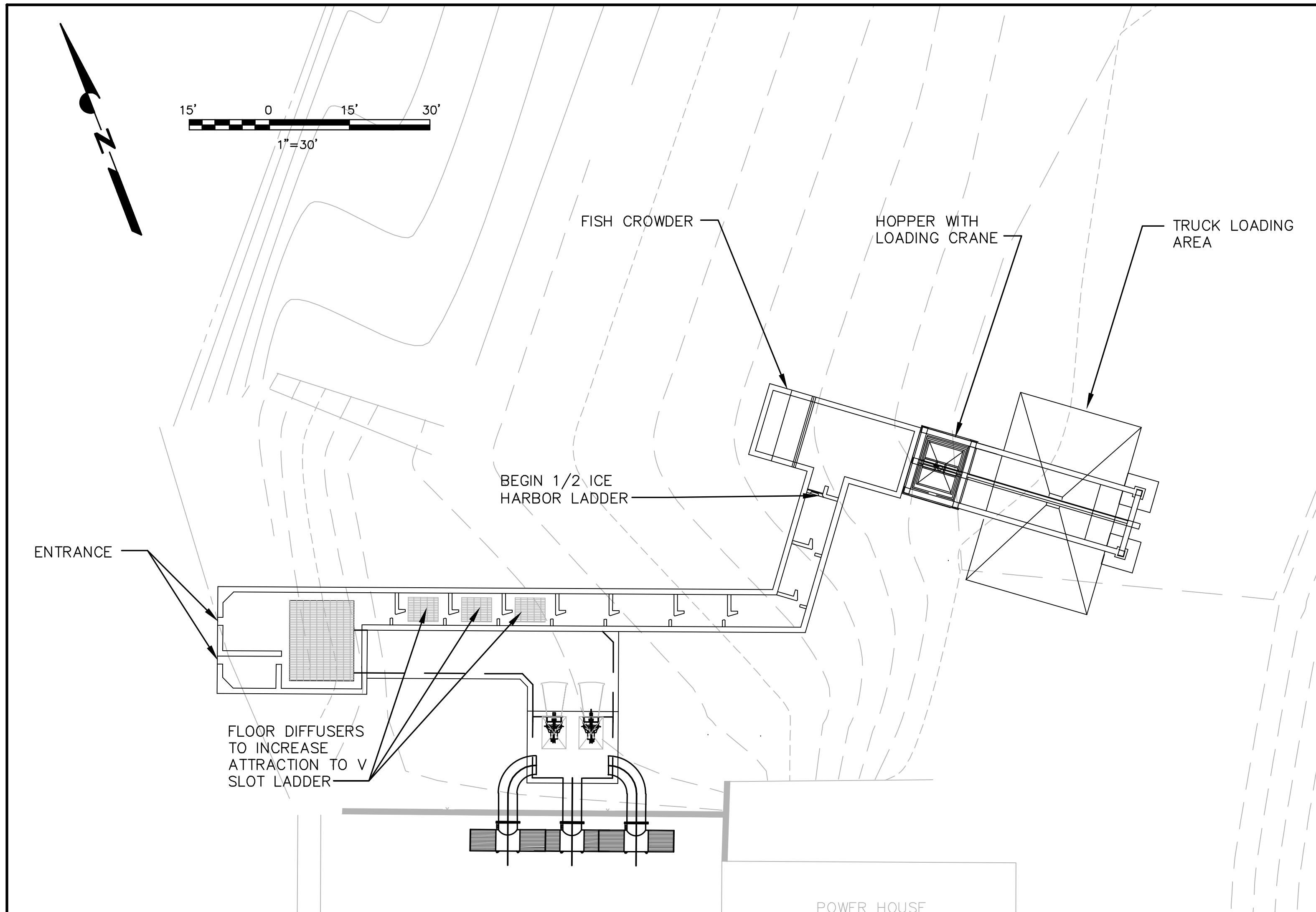
CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

ALTERNATIVE U4: SOUTH TAILRACE ENTRANCE WITH TRAP AND HAUL
DRAWING 6

\\Nas\shared projects\1852 Oneida\Drawings\1852-Fig 06.DWG, 3/8/2011 3:20:10 PM

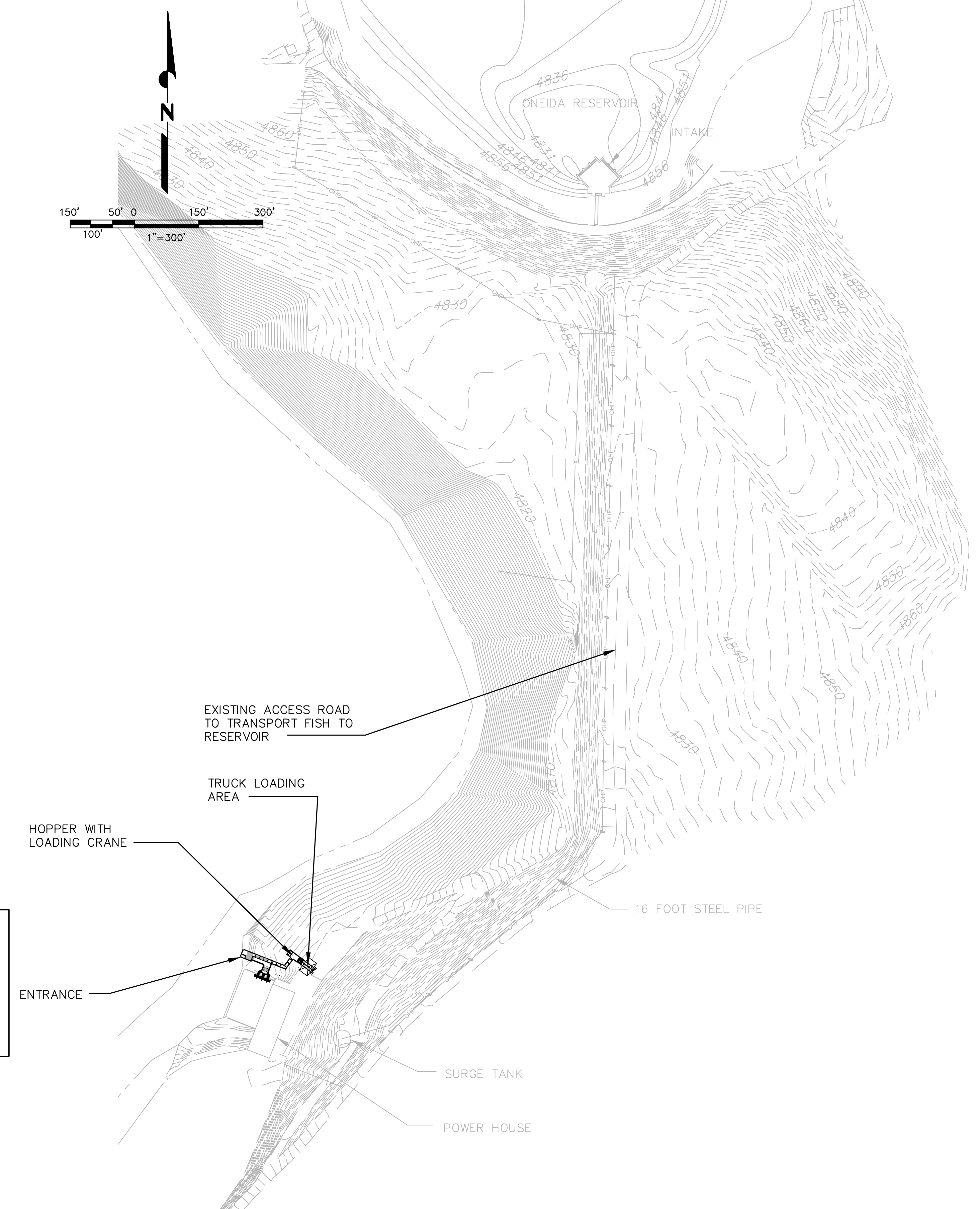


ENTRANCE AREA PLAN

LOADING HOPPER

ALTERNATIVE U5

HOPPER SIZE:	1200 GALLONS
HOPPER FLOW:	BASED ON ATTRACTION
MAX ADULT FISH/DAY:	356 (3 LBS EACH)
MAX TRIPS/DAY:	5



PACIFICORP

CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

ALTERNATIVE U5: NORTH TAILRACE ENTRANCE WITH TRAP AND HAUL

DRAWING 7

Resource Consultants, Inc.
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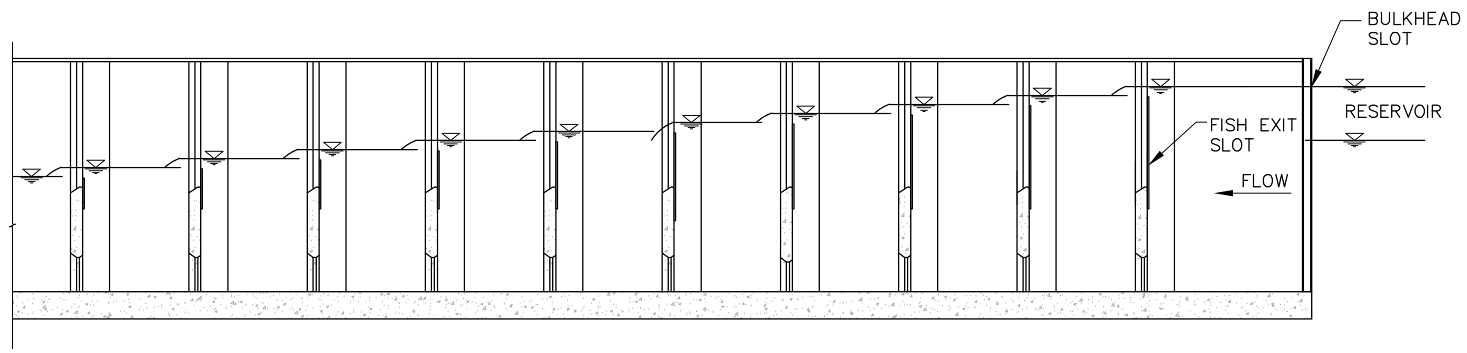
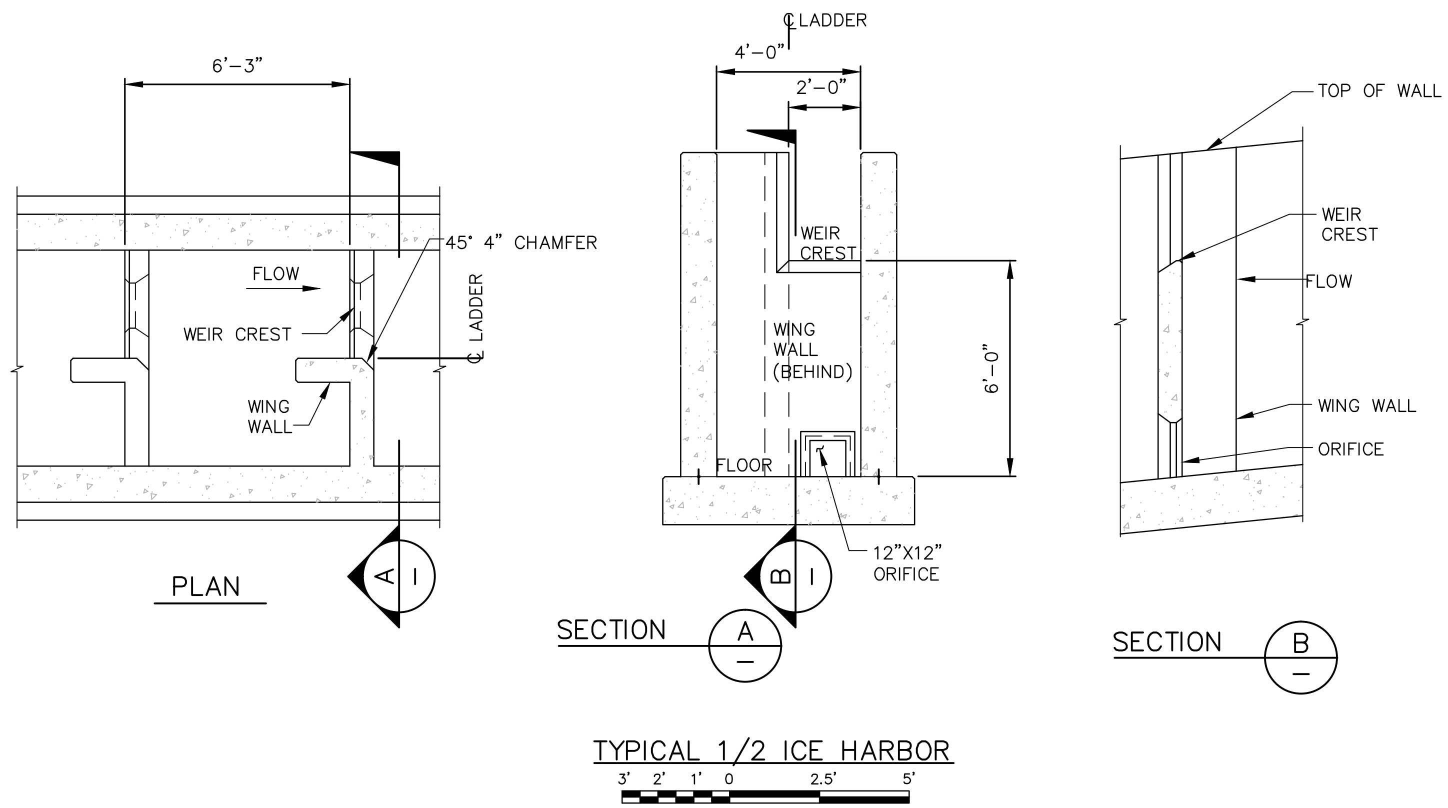
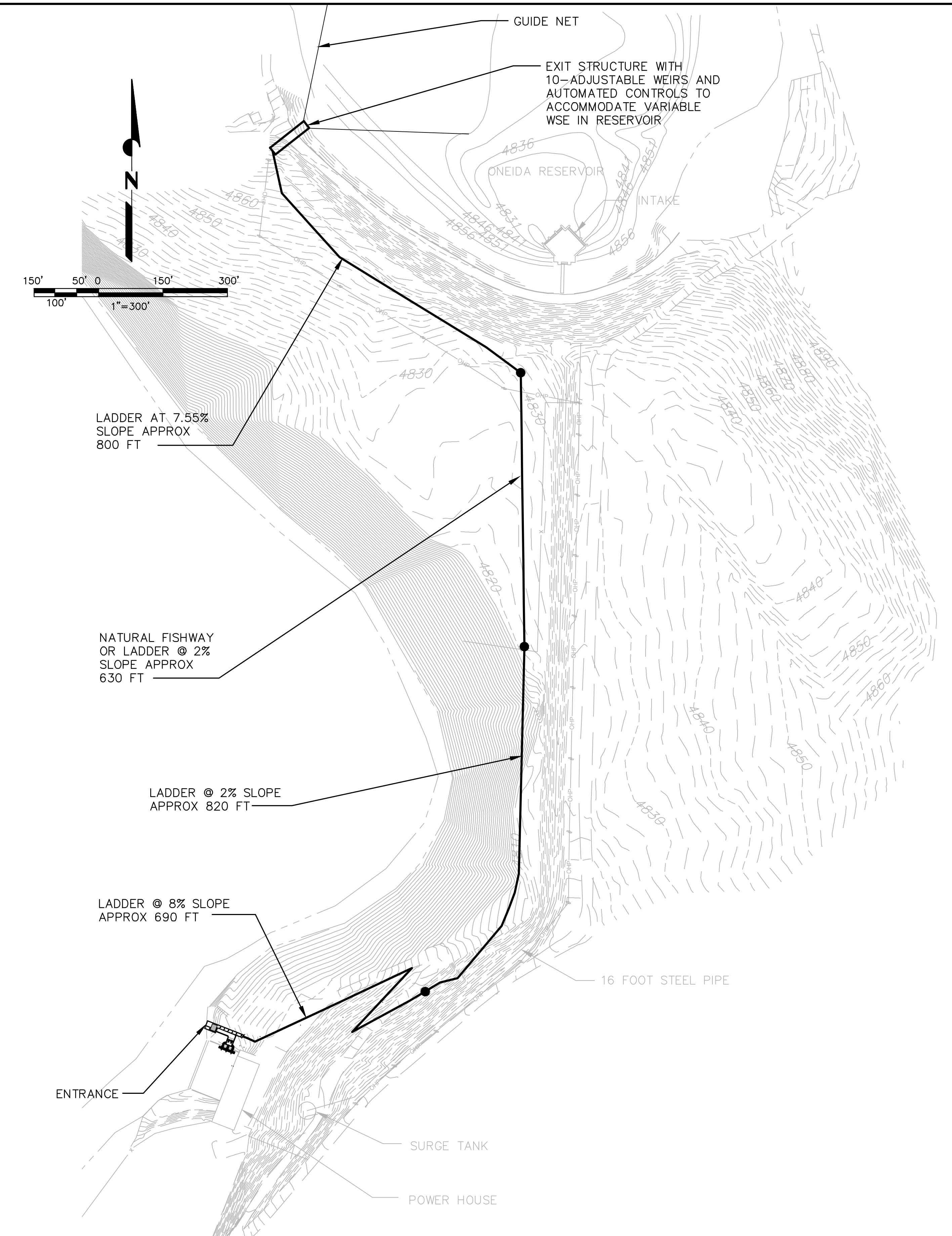
\\Nas\Shared Projects\1852 Oneida\Drawings\1852-Fig 07.DWG, 3/8/2011 5:29:33 PM



EXIT STRUCTURE WITH 10-ADJUSTABLE WEIRS



TYPICAL 1/2 ICE HARBOR



ALTERNATIVE D1

LADDER FLOW:	12.7 CFS
HEAD DROP PER POOL:	6 IN
ORIFICE VELOCITY:	5.7 FT/S
MAX SLOPE:	8%
ENERGY DISSIPATION FACTOR:	3.1
TOTAL LENGTH:	3,000 LF
POOL LENGTH:	6.25 FT
WATER TRAVEL TIME:	71 MIN

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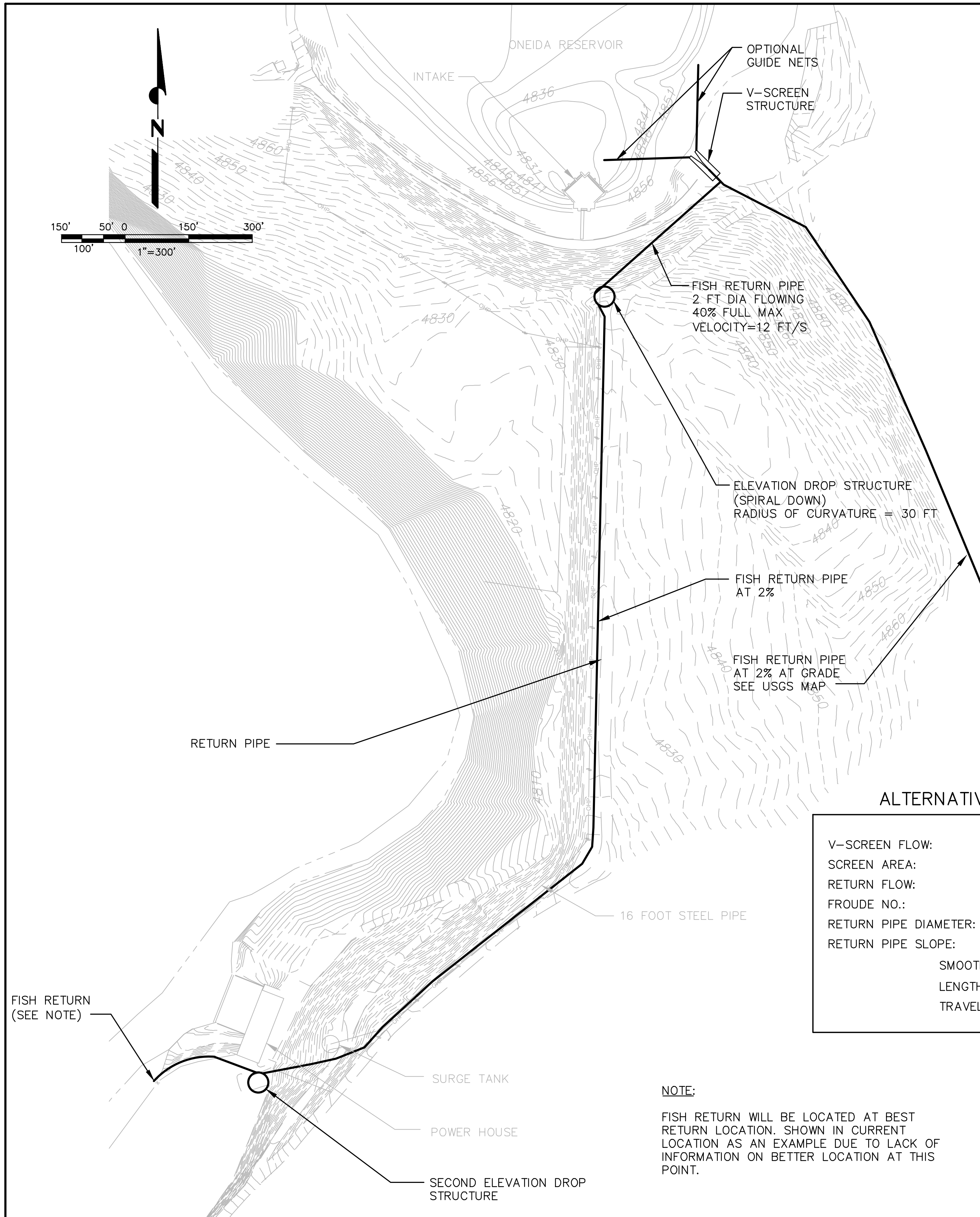
PACIFICORP
CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

ALTERNATIVE D1: NO DEDICATED DOWNSTREAM PASSAGE
DRAWING 8

\\Nas\Shared Projects\1852 Oneida\Drawings\1852-Fig 08.DWG, 3/8/2011 5:34:02 PM

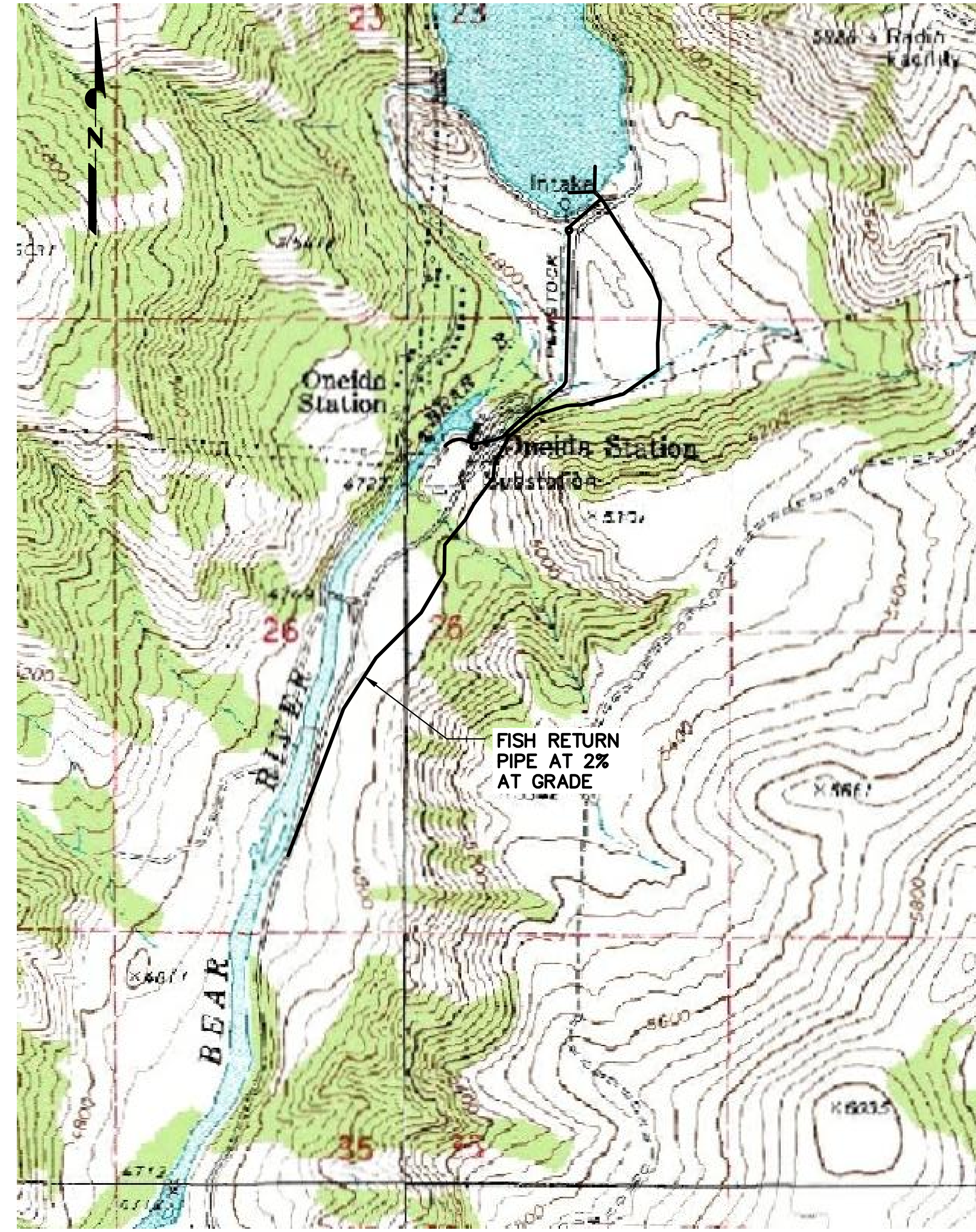


ALTERNATIVE D2

V–SCREEN FLOW:	250 CFS
SCREEN AREA:	650 FT^2
RETURN FLOW:	13 CFS
FROUDE NO.:	2.5
RETURN PIPE DIAMETER:	2 FT
RETURN PIPE SLOPE:	
SMOOTH: (N=0.011)	2%
LENGTH =	7200 LF
TRAVEL TIME =	10 MIN

NOTE:

FISH RETURN WILL BE LOCATED AT BEST RETURN LOCATION. SHOWN IN CURRENT LOCATION AS AN EXAMPLE DUE TO LACK OF INFORMATION ON BETTER LOCATION AT THIS POINT.



USGS MAP OF AREA

1/4 0 1/4 1/2
1"=1/2 MILE

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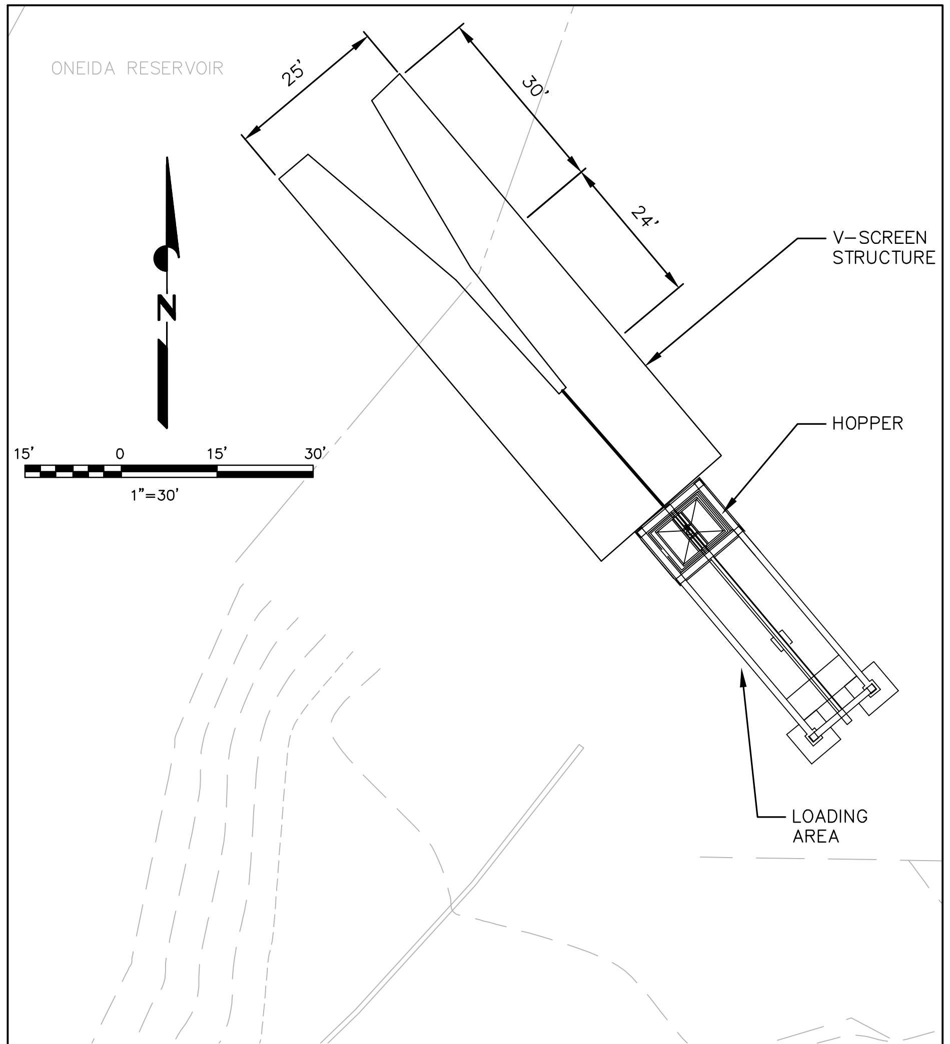
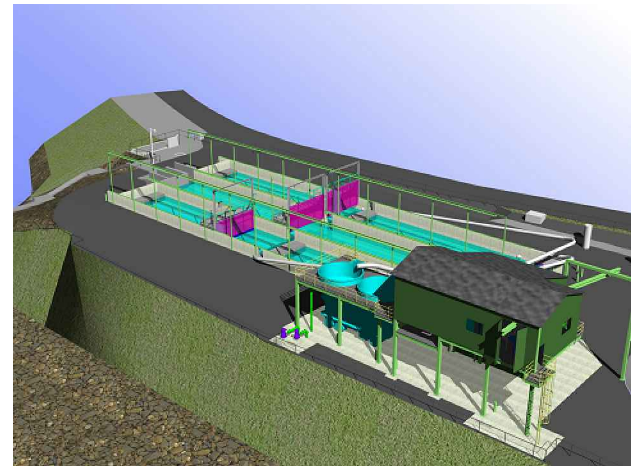
PACIFICORP

CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

ALTERNATIVE D2: PARTIAL FLOW COLLECTOR WITH FISH RETURN PIPE
DRAWING 9

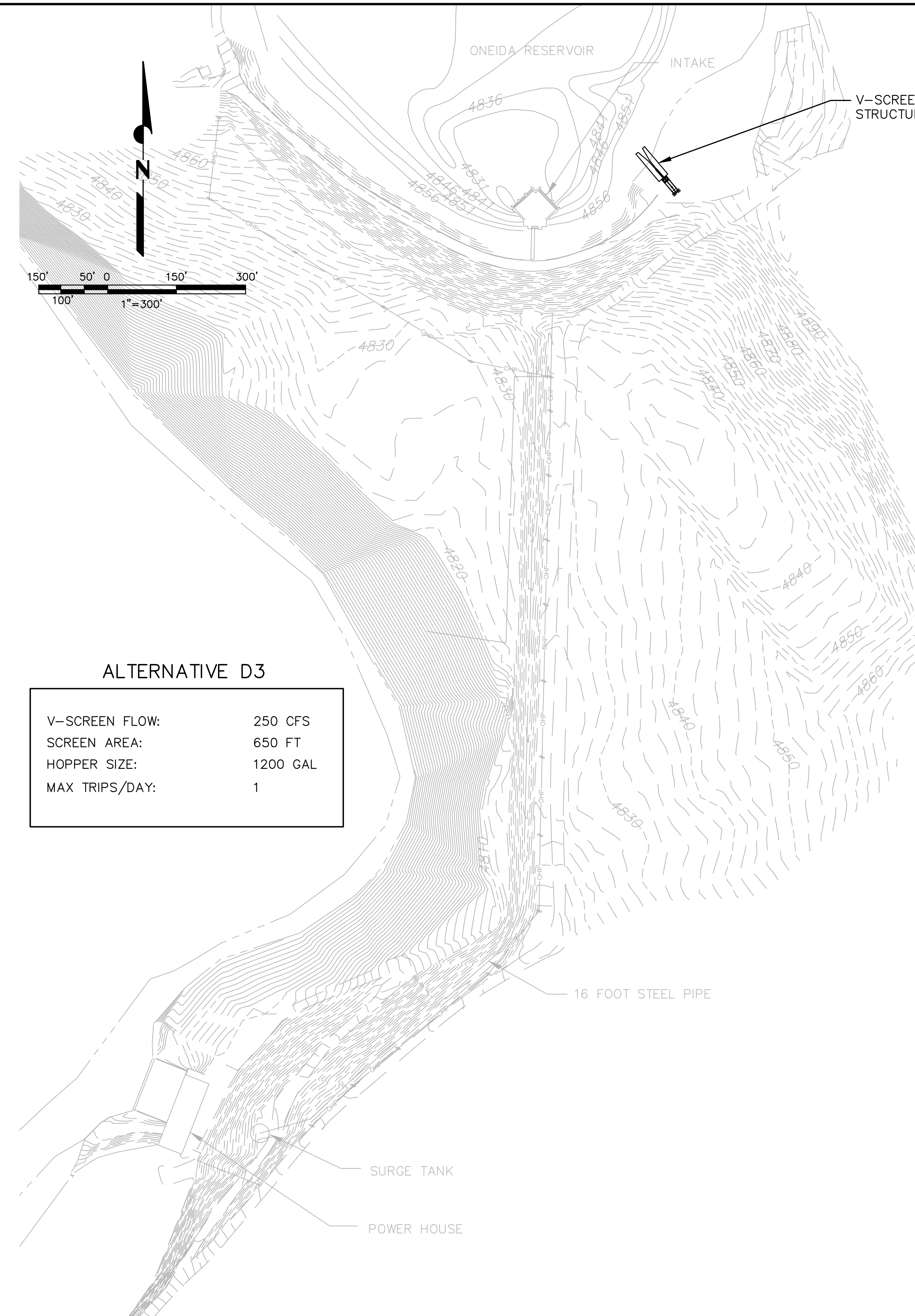


AREA PLAN



TRUCK LOADING DRIVE THRU

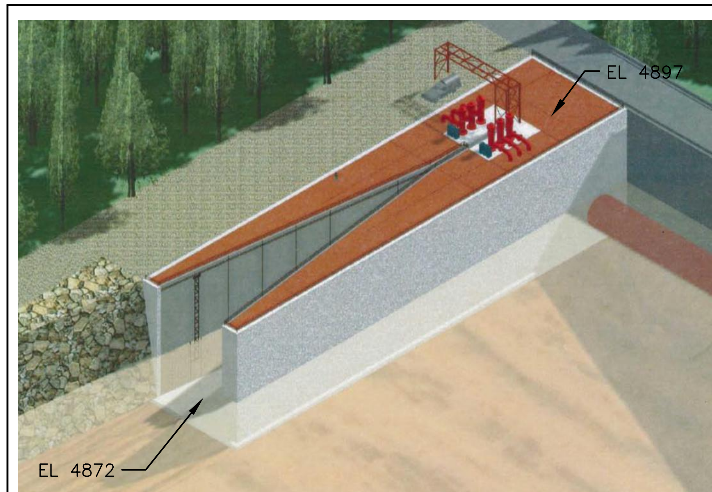
TRUCK LOADING RAMP



ALTERNATIVE D3

V-SCREEN FLOW:	250 CFS
SCREEN AREA:	650 FT
HOPPER SIZE:	1200 GAL
MAX TRIPS/DAY:	1

LOADING HOPPER



V-SCREEN STRUCTURE

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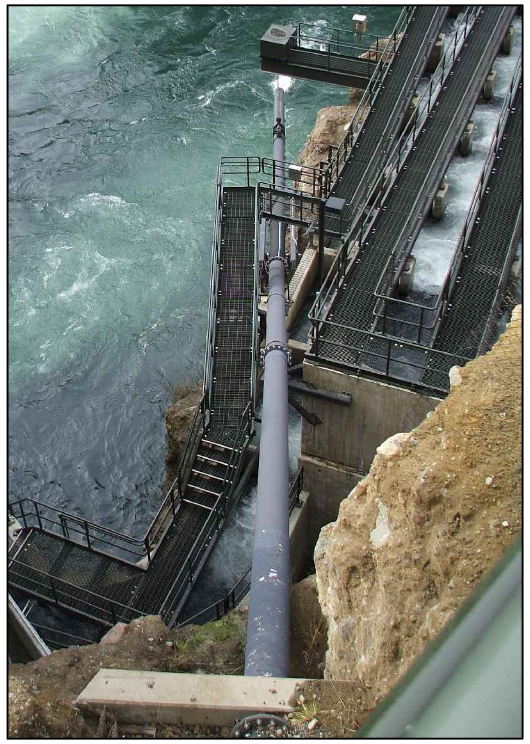
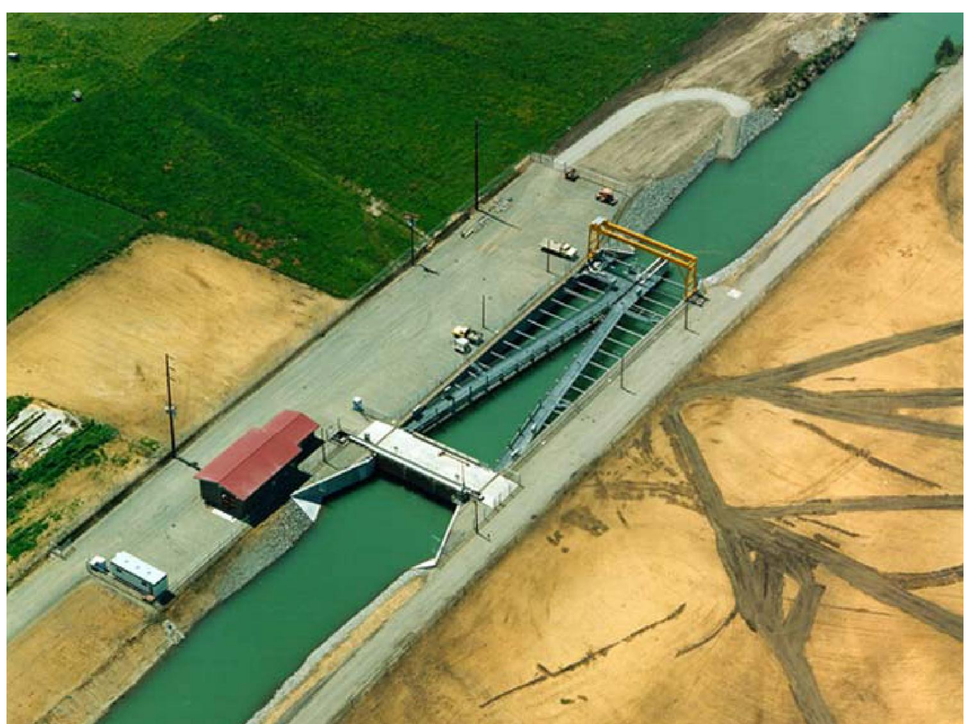
PACIFICORP

CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

ALTERNATIVE D3: PARTIAL FLOW COLLECTOR
WITH TRANSPORT FISH RETURN
DRAWING 10



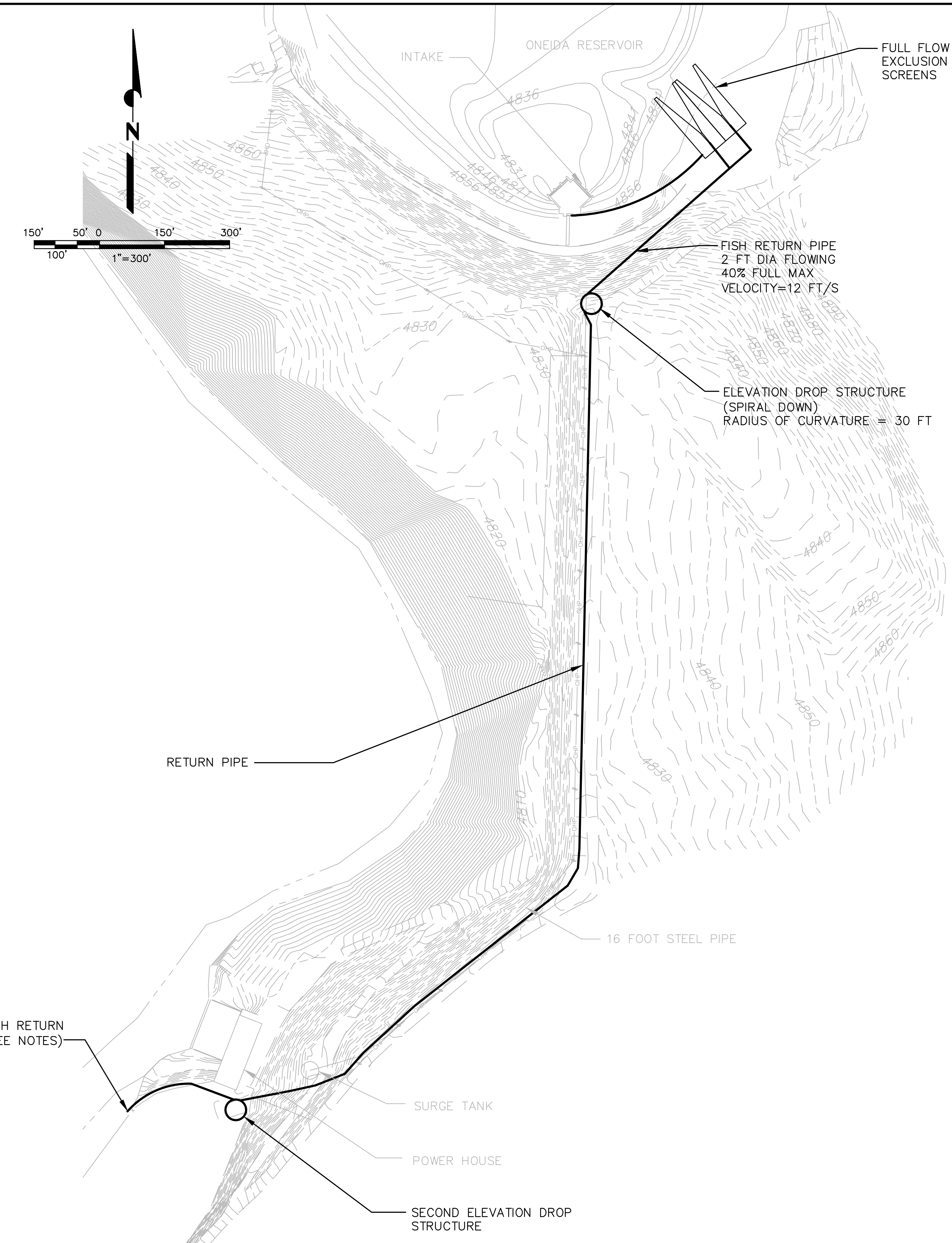
FISH RETURN PIPE



FULL FLOW V–SCREEN

ALTERNATIVE D4

MAX V–SCREEN FLOW:	2600 CFS
SCREEN AREA:	6500 FT^2
RETURN FLOW:	13 CFS
FROUDE NO.:	2.5
RETURN PIPE DIAMETER:	2 FT
RETURN PIPE SLOPE:	
SMOOTH: (N=0.011)	2%
LENGTH	= 7200 LF
TRAVEL TIME	=10 MIN



NOTES:

1. FISH RETURN WILL BE LOCATED AT BEST RETURN LOCATION. SHOWN IN CURRENT LOCATION AS AN EXAMPLE DUE TO LACK OF INFORMATION ON BETTER LOCATION AT THIS POINT.
2. ALTERNATIVE SHOWN WITH FISH RETURN PIPE. TRAP AND HAUL COULD ALSO BE USED WITH THIS ALTERNATIVE.

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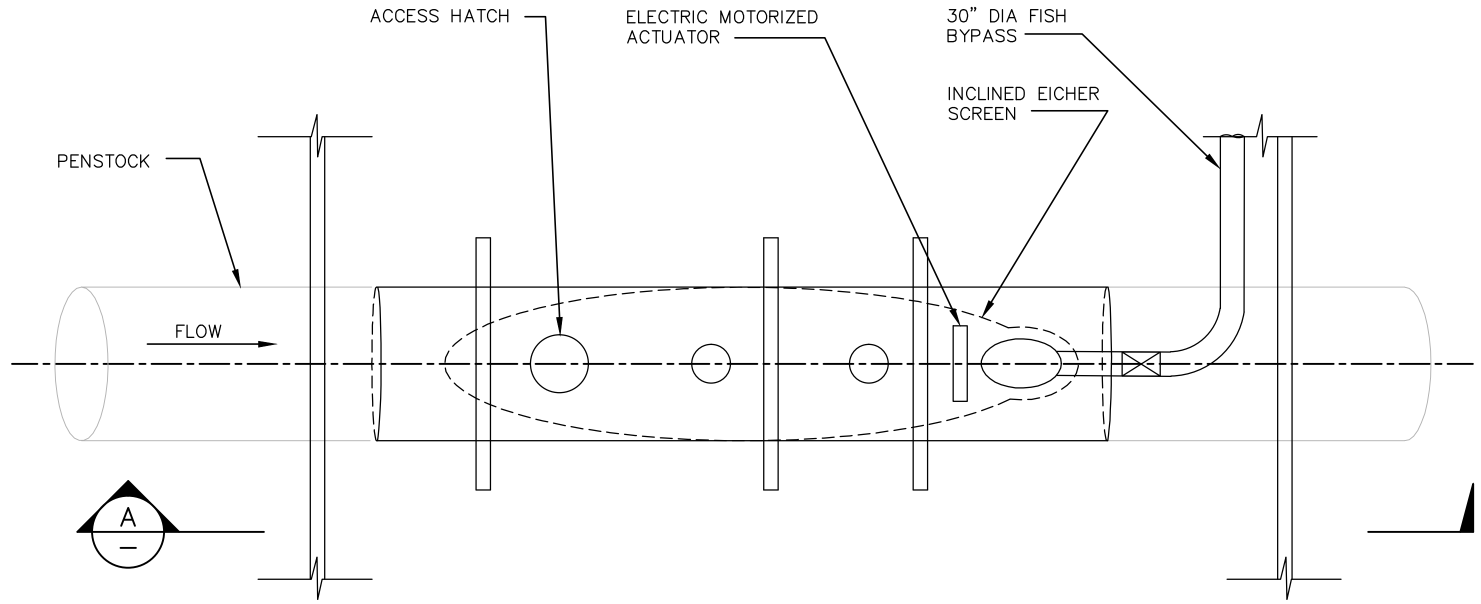
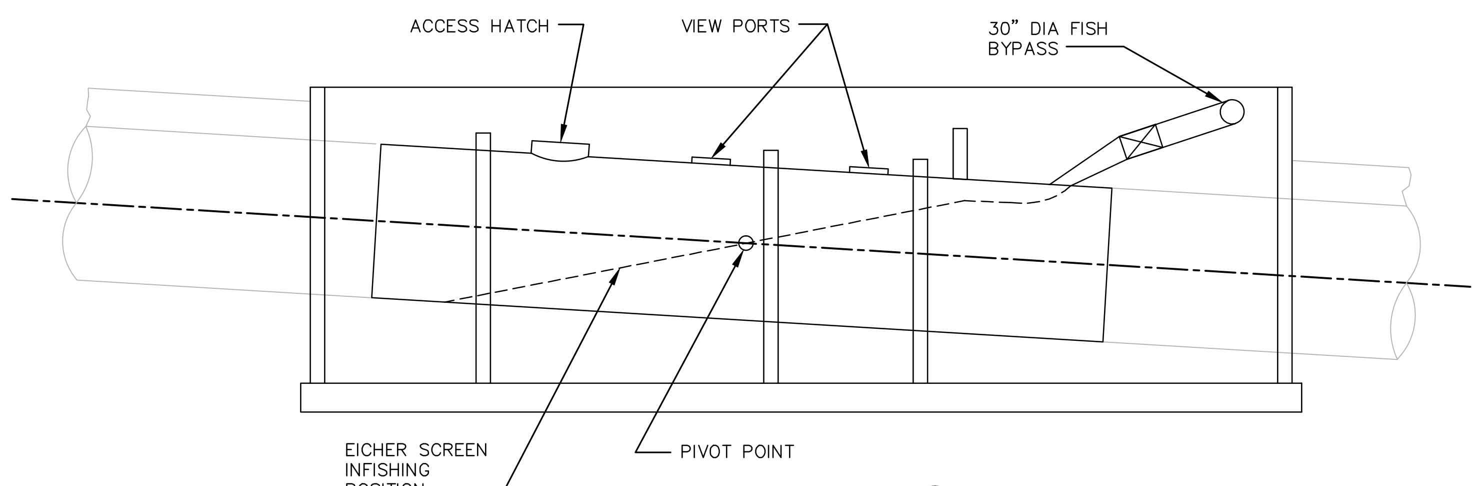
PACIFICORP

CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

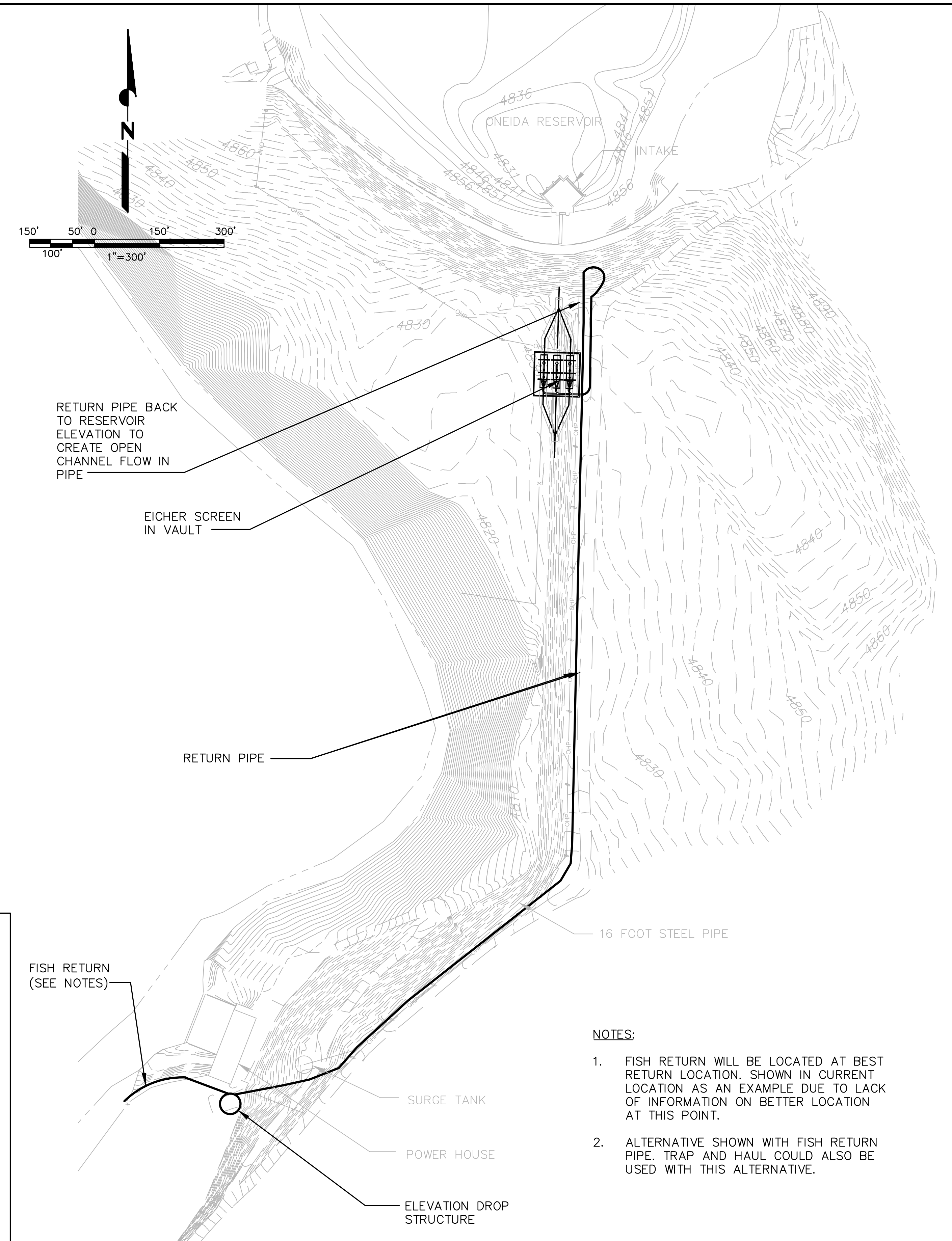
ALTERNATIVE D4: FULL EXCLUSIONARY SCREENING
DRAWING 11



TYPICAL EICHER SCREEN PLAN



SECTION A



NOTES:

1. FISH RETURN WILL BE LOCATED AT BEST RETURN LOCATION. SHOWN IN CURRENT LOCATION AS AN EXAMPLE DUE TO LACK OF INFORMATION ON BETTER LOCATION AT THIS POINT.
2. ALTERNATIVE SHOWN WITH FISH RETURN PIPE. TRAP AND HAUL COULD ALSO BE USED WITH THIS ALTERNATIVE.

TYPICAL EICHER SCREEN PLAN

TYPICAL EICHER SCREEN INSIDE

PACIFICORP
CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

ALTERNATIVE D6: EICHER SCREEN
DRAWING 12

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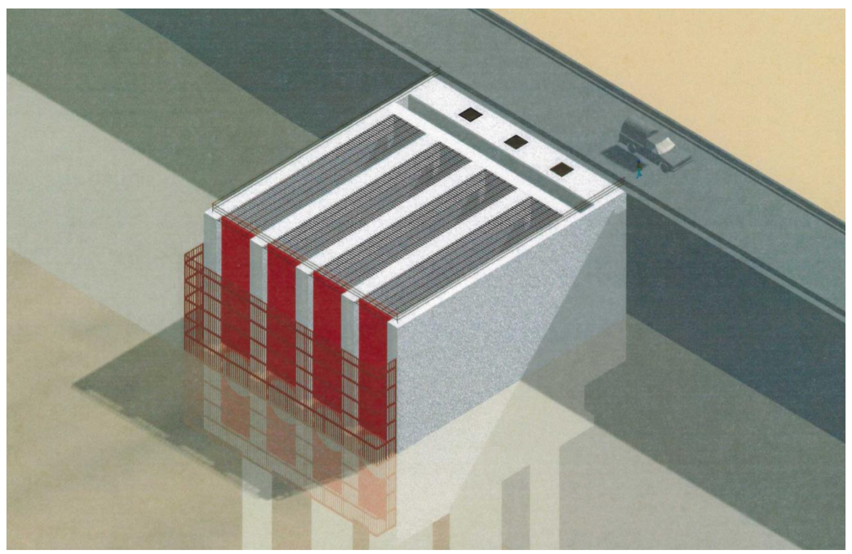
\\Nas\shared projects\1852 Oneida\Drawings\1852-Fig 12.DWG, 3/8/2011 4:15:06 PM

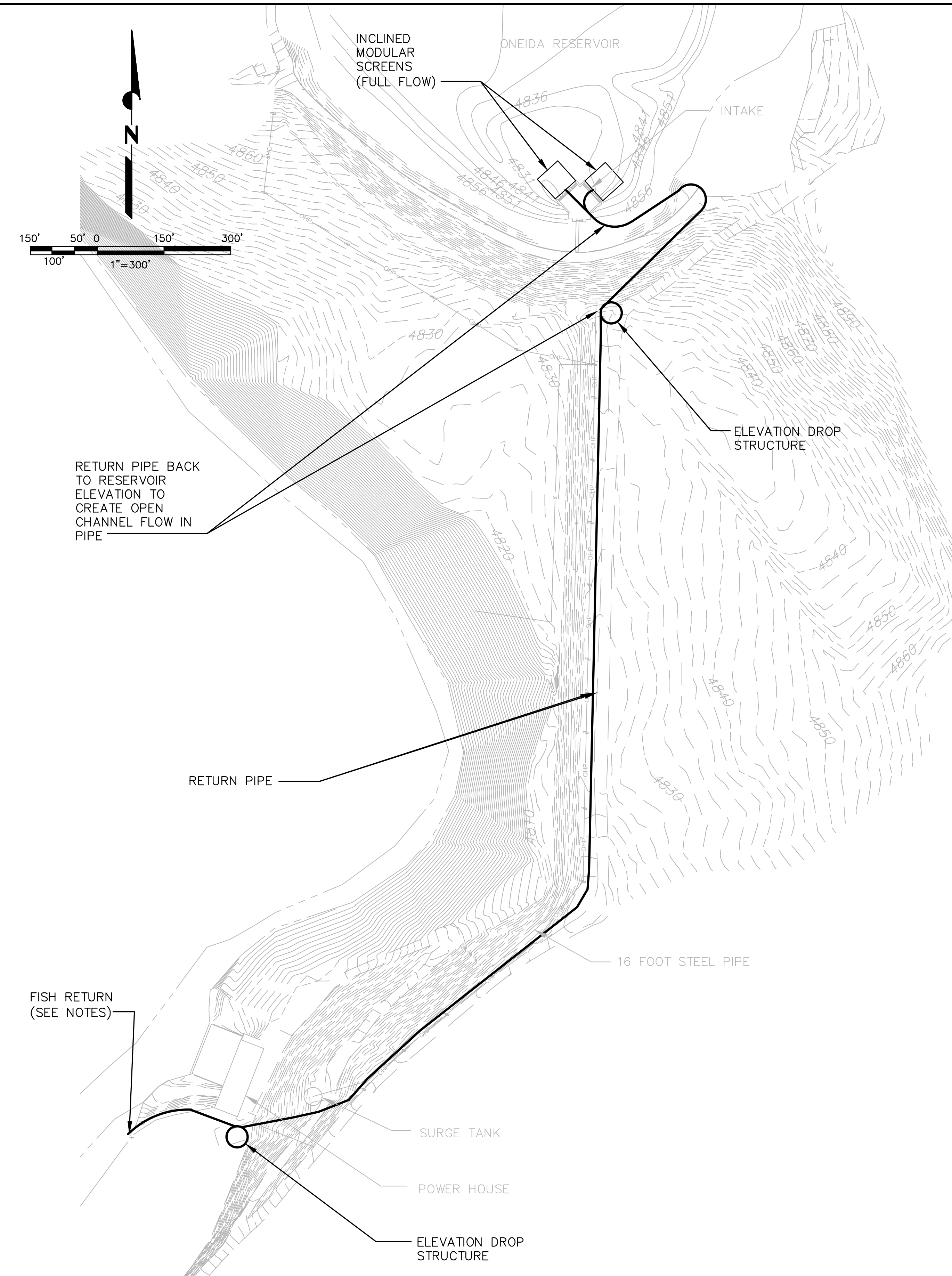


ISOMETRIC OF ARTISTS RENDITION
OF MODULAR INCLINED SCREEN AT
INTAKE (FULL FLOW)

NOTES:

1. FISH RETURN WILL BE LOCATED AT BEST RETURN LOCATION. SHOWN IN CURRENT LOCATION AS AN EXAMPLE DUE TO LACK OF INFORMATION ON BETTER LOCATION AT THIS POINT.

2. ALTERNATIVE SHOWN WITH FISH RETURN PIPE. TRAP AND HAUL COULD ALSO BE USED WITH THIS ALTERNATIVE.



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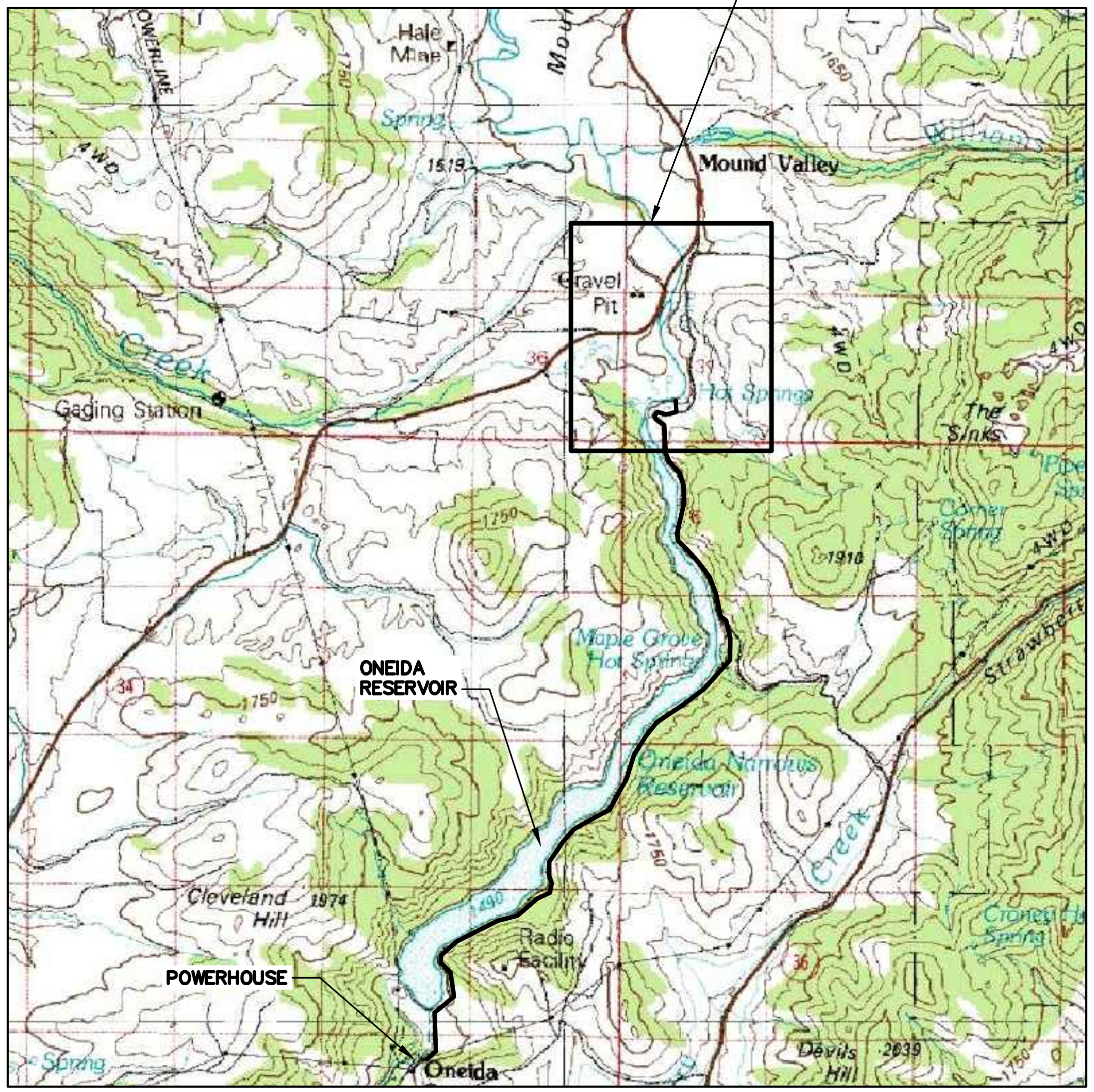
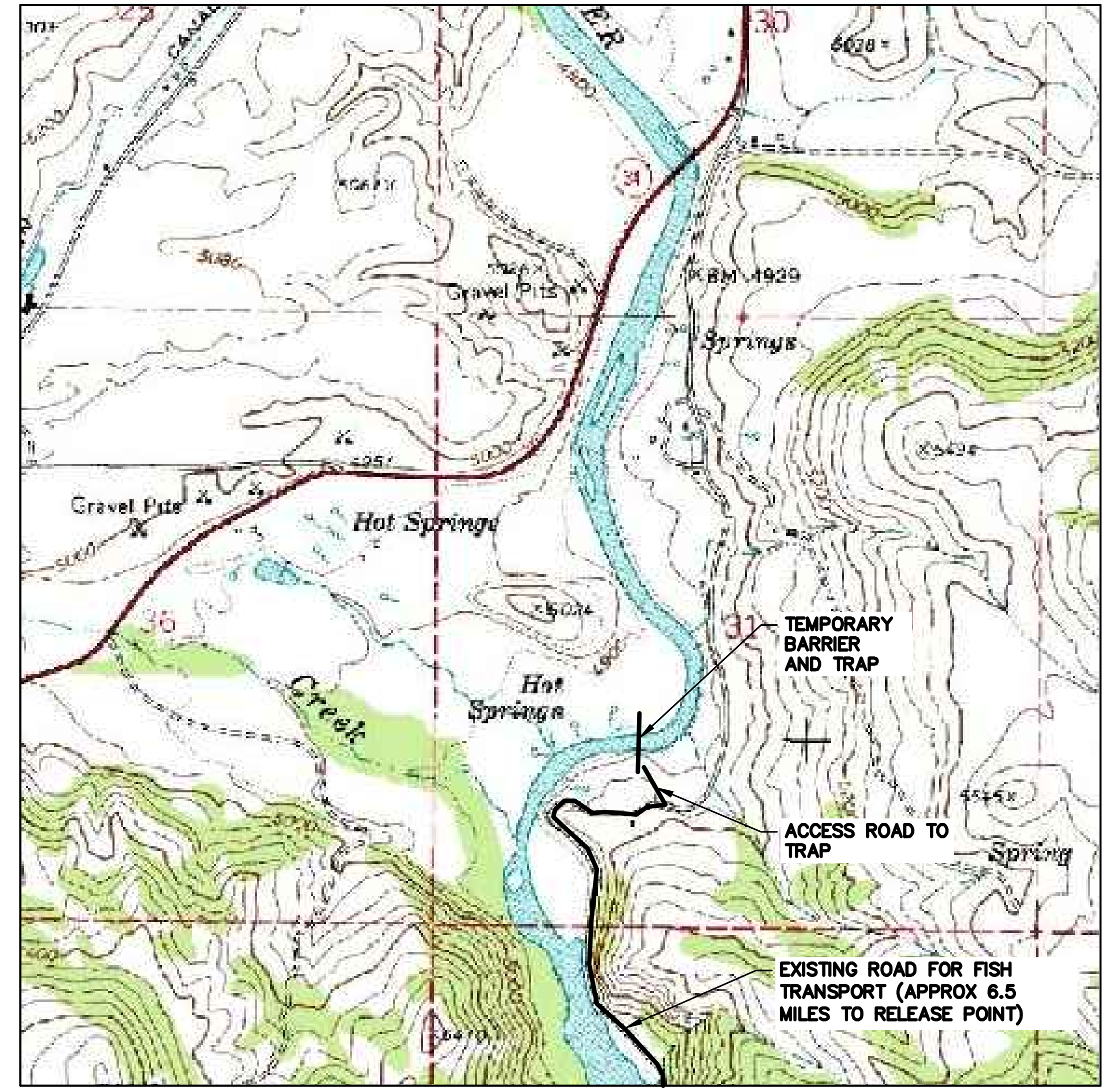
CONCEPTUAL DESIGN FOR FISH PASSAGE AT ONEIDA

ALTERNATIVE D7
FIGURE 13



OVERALL PROJECT AREA



UPSTREAM BARRIER AND TRAP LOCATION

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ALTERNATIVE D7: UPSTREAM CAPTURE
DRAWING 14

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