Annex C

Temporary Fish Passage Plan

Annex C: Temporary Fish Passage Plan

C.1 General

This report explores the range of options considered for maintaining upstream adult fish migration during the entire drawdown construction period and presents the recommended plan of action. Fish passage must continue during the drawdown process even though existing adult fish passage systems will become inoperable shortly after the drawdown process begins at each project. Therefore, temporary adult fish handling facilities must be developed, evaluated, and analyzed for the best alternative that will provide upstream migration.

This report covers conceptual and functional plans in sufficient detail to develop a cost estimate. The option selected for the action plan was based on the information available at this stage of concept development. The final decision concerning the preferred option will depend on results of further investigation into anticipated turbidity and suspended sediment levels during drawdown and it's effect on fish migration. Actual final design, schedule, installation procedures, and operating criteria may change during more detailed design at advanced stages of drawdown implementation.

Adult anadromous fish are in the river system at all times. Chinook and steelhead comprise the majority of migrating adults, although there are a limited number of other species including the endangered sockeye. Summer chinook migrate upstream from July to September. Fall chinook migrate from August to October. Late summer and late fall are periods when steelhead runs are the largest of the year, but there are a number of them migrating year round. From December through March, migration slows since fish tend to hold up when water temperatures are below 4.4 degrees Celsius (40 degrees Fahrenheit).

The period of drawdown construction occurs during a few upstream migrating fish runs containing large numbers of fish. These runs include endangered sockeye and threatened Snake River steelhead and fall chinook. Although steelhead can delay for up to two months without causing great impact to their migration, requiring all fish to delay during the period of construction for both drawdown seasons would greatly impact these and future fish runs. Consequently, adult passage must be maintained during this process.

In the early stages of each drawdown season, the forebay water surface elevation above each project involved in that drawdown season falls below minimum levels required by operating criteria for the fish handling facilities. Depending on river flow, tailwater elevations may fall below elevations required for the fish entrances and for attraction water pump systems to properly function. Worst case is that tailwater elevation would fall below existing minimum operating levels ranging from 2.9 meters (9.5 feet [feet]) to 6.0 meters (19.6 feet), depending on the dam. Tailwater at Ice Harbor Dam is virtually unaffected throughout the process. During the first drawdown season, tailwater at Little Goose is unaffected.

C.2 Overview of Existing Systems

C.2.1 General

Fish passage facilities on the four Snake River dams are similar in design and function. Each dam has a collection system, a fish ladder (or ladders), and an exit into the upstream forebay. The collection systems consist of entrances along the powerhouse with some near either shore of the dams. The entrances tie into a channel that carries the fish to the fish ladder. The fish attraction water pumps pump flow through the channels and out the entrances used to attract the fish. Tailwater is pumped at high volume and low head to attract the adult migrating fish. The ladders are weir- and pool-type ladders that accommodate a total elevation change of roughly 30.5 meters (100 feet). The ladders are fed by forebay water, and a constant flow of 2.12 cubic meters per second (m^3/s) or 2,124 Liters per second (L/s) (75 cubic feet per second [cfs]) is maintained under normal operating conditions. The upstream exits allow the fish to enter the forebay under most normal operating conditions.

C.2.2 Ice Harbor

The fish handling facilities at Ice Harbor consist of independent north and south shore facilities. The north shore facilities include a fish ladder with a counting station, a small collection system, and a pumped attraction water supply system. The collection system includes two downstream entrances and one side entrance from the spillway basin. In normal operation, one downstream entrance is used and the other two entrances are closed. The auxiliary water is supplied by three electric, 200-horsepower (hp) pumps that produce 7.1 m^3/s (250 cfs) each at 1.2 meters (4 feet) total dynamic head (TDH). All three pumps normally are operated.

The south shore facilities are comprised of a fish ladder with a counting station, two south shore entrances, a powerhouse collection system, and a pumped attraction water supply system. The powerhouse collection system includes two downstream entrances and one side entrance from the spillway basin at the north end of the powerhouse, 12 floating orifices, and a common transportation channel. One of the downstream north powerhouse entrances and four of the floating orifices are used during normal operation. Only one south shore entrance is normally used. The attraction water is supplied by eight electric, 250 hp pumps providing 8.5 m^3/s (300 cfs) each at 1.2 meters (4 feet) TDH. Six to eight pumps are normally used to provide the required flows. The excess water from the juvenile fish passage facilities (approximately 5.7 m^3/s [200 cfs]) is routed into the fish pump discharge chamber to provide additional attraction flow.

See Figure C1 for a plan view drawing of the Ice Harbor fish handling facilities.

C.2.3 Lower Monumental

The adult fish handling facilities at Lower Monumental Dam are comprised of north and south shore fish ladders and collection systems with a common attraction water supply. The north shore fish ladder connects to two north shore entrances and to the powerhouse collection system. The powerhouse collection system involves a common transportation channel with two downstream entrances and one side entrance from the spillway basin at the south end of the powerhouse, and 10 floating orifices along the downstream face of the powerhouse. The two north shore entrances, two downstream south powerhouse entrances, and four of the floating orifices are used during normal operation.

The south shore fish ladder has two downstream entrances and a side entrance from the spillway basin. The two downstream entrances are used during normal operation. Again, the attraction water supply is provided from one common pumped system. Fish passage, however, is isolated between the north and south ladder systems.

The attraction water is supplied by three turbine-driven pumps located in the powerhouse on the north side of the river. The turbine drives are powered by head water from the forebay through a 48-inch diameter penstock. Attraction water is pumped into a supply conduit that travels under the powerhouse collection channel, distributing water to the powerhouse diffusers and through the spillway to the diffusers in the south shore collection system. Each turbine-driven pump is capable of producing 23.6 m^3/s (835 cfs) at 1.2 meters (4 feet) TDH. Excess water from the juvenile fish bypass system (approximately 5.7 to 6.8 m^3/s [200 to 240 cfs]) is added to the auxiliary water supply system for the powerhouse collection system.

See Figure C2 for a plan view drawing of the Lower Monumental fish handling facilities.

C.2.4 Little Goose

The fish handling facilities at Little Goose are comprised of one fish ladder on the south shore, two south shore entrances, a powerhouse collection system, north shore entrances with a transportation channel through the spillway to the powerhouse collection system, and attraction water supply system. The powerhouse collection system is comprised of four floating orifices, two downstream entrances, one side entrance from the spillway basin on the north end of the powerhouse, and a common transportation channel. The four floating orifices, two downstream entrances at the north end of the collection system, and the south shore entrances are normally used. The north shore entrances are comprised of two downstream facing entrances and a side entrance from the spillway basin. The two downstream entrances are used normally.

The attraction water is supplied by three turbine-driven pumps that pump water from the tailrace into the distribution system for the diffusers. The turbine drives are powered by head water from the forebay. Each attraction water pump provides 24.0 m^3/s (850 cfs) at 1.2 meters (4 feet) TDH. Additional water (approximately 5.7 m^3/s [200 cfs]) is supplied to the attraction water supply system from the juvenile fish passage facilities primary dewatering structure.

See Figure C3 for a plan view drawing of the Little Goose fish handling facilities.

C.2.5 Lower Granite

The adult fish passage facilities at Lower Granite Dam include one fish ladder on the south shore, two south shore entrances, a powerhouse collection system, north shore entrances with a transportation channel through the spillway to the powerhouse collection system, and an attraction water supply system. The powerhouse collection system is comprised of 10 floating orifices, two downstream entrances, one side entrance from the spillway basin on the north end of the powerhouse, and a common transportation and fish passage channel. Four of the floating orifices, two downstream entrances at the north end of the collection system, and the south shore entrances are normally used. The north shore entrances are made up of two downstream entrances and a side entrance from the spillway basin. The two downstream entrances are used normally.

Three electric pumps that pump water from the tailrace to the diffusers supply the attraction water. Two pumps are normally used to provide the required flows. The pumping system is comprised of one variable speed pump providing 12.7 to 29.7 m^3/s (450 to 1,050 cfs) at 1.2 meters (4 feet) TDH using 350 to 800 hp and two pumps providing 29.7 m^3/s (1,050 cfs) at 1.2 meters (4 feet) TDH using 800 hp each.

See Figure C4 for a plan view drawing of the Lower Granite fish handling facilities.

C.3 Fish Handling Facility Modification Options Considered

This section discusses the possible options considered for temporary fish passage and why they were or were not selected. Anticipated effectiveness of each alternative as evaluated by fish passage experts was the prime criteria for selection. Implementation, construction, logistics, and schedule were also considered. The selection process was based on the assumptions that this was to be a temporary fish passage solution and that the drawdown would be performed at Lower Granite and Little Goose Dams simultaneously during the first season, followed by Lower Monumental and Ice Harbor Dams. If a four-project simultaneous drawdown were to take place, slight modifications would be required to implement the selected alternative. The trap-and-transport option would have to be implemented at Ice Harbor Dam only. Fish would be trapped at Ice Harbor and transported above Lower Granite Dam. This option would require pre-tagging of Tucannon River and Lyons Ferry fish prior to drawdown. Pre-tagging the fish would allow detection and separation during the trap-and-transport process allowing them to be placed in the Lower Monumental reservoir. The options that were considered in the selection of the preferred options are presented in Table C1.

Table C1. Options Considered in the Selection of the Preferred Options

Option Descriptions	Advantages	Disadvantages
Do nothing. This option requires operating the existing systems as long as criteria can be met during the drawdown process. Passage systems would be shut down when water surface elevations reached levels too low to operate the systems. Fish would pause on their upstream migration until the reservoir was evacuated and the embankments were removed.	• This option would be the easiest to implement, requiring no significant modifications.	• Fish runs would be held up during the drawdown period. This would create adverse conditions that are biologically unacceptable. Fall chinook, for instance, might spawn in areas of the reservoirs that could dry up during drawdown, thereby exposing their redds.

Table C1. Options Considered in the Selection of the Preferred Options (continued)

Option Descriptions	Advantages	Disadvantages
Trap adults at each dam and transport from tailrace to forebay. This option consists of installing a new trapping facility in the existing adult migration system at each dam. As fish are trapped they would be transported above the dam and released back into the forebay. Transportation could be by truck or other type of conveyor.	• This option is desirable because it allows fish to migrate at a similar pace as in the past. Lower Granite Dam is already equipped with an adult trapping facility in the fish ladder, which would minimize modifications required at that dam.	• The attraction water systems at each dam (except Ice Harbor) would have to be modified by adding auxiliary pumping plants to provide adequate water flows at the potentially lower tailwater elevations. In the case of Little Goose, an auxiliary pumping plant is required because the existing attraction water pumps are turbine driven causing them to become inoperable during drawdown of the forebay. • Expensive and complex construction is required. • Adult fish entrances would have to be modified (except at Ice Harbor) by extending them with ladders to the lower tailwater elevations. Modifications at Little Goose would be a little less complicated and be comprised primarily of isolating the north shore entrances. • During the drawdown period, adult fish migration numbers can approach 4,000 fish per day. The system would have to be designed for this maximum amount to avoid "stacking up" fish while they wait for transport. • Most of the existing fish trucks are designed for transporting juveniles and would have to be modified to accept both adults and juveniles. Also, given the limited number of adult fish allowed per truck, the logistics of trucking becomes very difficult. • This requires extensive handling of fish, which is undesirable. Each fish would be trapped and transported twice during each drawdown season.

Table C1. Options Considered in the Selection of the Preferred Options (continued)

Option Descriptions	Advantages	Disadvantages
Trap adults at the downstream dam and transport above the next dam upstream in each drawdown season. This option consists of installing a new trapping facility in the existing adult system at Little Goose and Ice Harbor Dams during the first and second seasons of drawdown respectively. As fish are trapped, they would be transported to some point above the next dam upstream and released back into the river system.	• This option is desirable since Little Goose and Ice Harbor Dam's tailwater elevation remains unchanged during their respective drawdown seasons. The adult attraction system would still function up to a point in the fish ladder. Only slight modifications and minimum pumping would be required to install a functioning trap. • One trap-and-haul operation per season minimizes fish handling.	• Most of the existing fish trucks are designed for transporting juveniles and would have to be modified to accept both adults and juveniles. • During each drawdown season adult fish migration numbers can approach 4,000 fish per day. The limited number of fish allowed in one tanker truck makes the logistics of trucking very difficult. • Stray Columbia River fish may get mixed in with the trapped Snake River fish primarily during the second season drawdown while fish are being trapped at Ice Harbor.
Install new and modified fish ladder systems at each dam to maintain upstream migration facilities. Existing ladder systems are designed to elevate fish approximately 30.5 meters (100 feet) and would quit functioning shortly after the drawdown has begun. New systems would be designed to adjust to varying pool elevations in both the forebay and tailrace as required, thereby allowing the fish ladders to function through drawdown.	• Typical fish passage would be maintained during the period of changing river elevations and flow paths. • Pumping requirements could be minimized if the overall lift of the ladders was reduced as the forebay elevations approach the tailwater elevations.	• This option would require almost a completely new adult passage system. Entrances and tailrace passages would be the only key existing items that could be used. • Construction would be extensive and costly. • Scheduling this work would be difficult due to long construction times. The installation would have to be completed prior to drawdown, resulting in extensive in-water work that could disrupt existing adult system operations. • Maintaining existing systems requires lifting the fish the original 30.5 meters (100 feet), which seems impractical as pool elevations approach each other on either side of the dam.

Table C1. Options Considered in the Selection of the Preferred Options (continued)

Option Descriptions	Advantages	Disadvantages
Use existing temporary fish ladders. A number of various temporary fish ladders were constructed to maintain adult fish passage during construction of the dams. The study team researched existing temporary systems to determine the possibility of recommissioning them for use during drawdown.	• Systems already exist and have proven to be effective to some degree.	• The systems were designed for construction of the dams as opposed to the breaching of existing embankments. The differing sequence of events in the drawdown would not allow making the temporary ladders to be functional prior to achieving dam breach. • Most of the existing systems have been filled in with concrete or removed causing recommissioning to be an extensive and, in some cases, perhaps impossible task.
Modify existing systems. This option requires the use of modified fish passage entrances and exits and pumping additional attraction and ladder water to the existing systems to maintain adult fish passage.	• Normal fish handling facility operation is maintained. • Required construction modifications are minor when compared to other options. • Most modifications could be performed without disrupting the existing system operation. • Equipment used during the first drawdown season may be able to be salvaged and reused as applicable in the second season drawdown.	• This option requires extensive in-water and diving work for installation. • Auxiliary pumping systems would be fairly costly to operate. • Entrance and exit conditions are not ideal and may affect fish passage efficiency.
Use existing navigation lock features for fish passage. This option would utilize the navigation lock fill and empty conduits as a temporary method for fish passage.	• The system is already in place and will be taken out of service early in the drawdown process. This permits it to be used for other purposes as feasibility allows.	• Passing flow through this system creates hydraulic conditions not suitable for fish passage without extensive modifications.

C.4 Recommended Options

The migration of adult fish must not be impeded for any extended length of time. Since drawdown activities will render existing fish passage facilities inoperable, alternate means must be provided during this period.

The range of options considered for this alternate means was narrowed to two options by the study team: 1) modify fish entrance, exit, and fish ladders so that fish passage may continue at each project during each drawdown season, and 2) construct a fish trap at both Little Goose and Ice Harbor Dams, collect adults, and truck-transport anesthetized adults to an appropriate discharge point above the next upstream dam during each drawdown season.

The river conditions during drawdown are expected to be very difficult for adult fish migration. Specifically, the concentration of sediment in the water may create both passage problems and health problems for migrating adult fish. This is the primary reason that the option to trap the adults and truck-haul them to a discharge location above the areas most affected is the preferred option. However, other drawdown configurations include drafting all four reservoirs concurrently. In this case the trap and truck-haul option implemented would be to trap adults at Ice Harbor Dam and truck-haul them to a point above Lower Granite Dam. One problem posed with this option is that Tucannon River and Lyons Ferry fish would be encountered. These fish need to be placed in the Lower Monumental reservoir creating further complications with this option. The largest complication is identifying and separating these fish in the Ice Harbor adult trap. Therefore, in a four reservoir concurrent drawdown, modifying existing systems may prove to be the preferred option. Consequently, the study team examined both options in this study.

C.4.1 Option 1 - Modify Each Existing System

System Changes

Because the modifications planned for this option are temporary measures, the study team believed it would be prudent to operate only the most efficient collection system at each dam. Currently, the ladder and attraction systems on the powerhouse side of the dams collect and pass approximately 85 percent of the fish when the dams are not spilling. The shore entrances on this side near the beginning of the ladder currently handle most of the adult fish. These systems should be maintained and operated throughout the drawdown and channelization process. This would result in the following system changes at each dam during their respective drawdown seasons:

- System changes at Ice Harbor Dam would involve shutting down the north shore ladder and attraction system, and operating only the south shore ladder and attraction system.
- System changes at Lower Monumental Dam would involve shutting down the south shore ladder; installing bulkheads to stop water flow through the fish transportation and attraction water conduit to the powerhouse and south shore system; and operating the north shore entrances only.
- System changes at Little Goose Dam would involve installing bulkheads to stop water flow through the fish transportation and attraction water conduit to the north shore system and powerhouse, and operating the south shore entrances only.

- System changes at Lower Granite Dam involve installing bulkheads to stop water flow through the fish transportation and attraction water conduit to the north shore system and powerhouse, and operating the south shore entrances only.

There is no historical data to say how overall efficiency would be affected by operating the powerhouse system only. Operating just one ladder/attraction system maintains adult fish passage while greatly reducing cost and construction required at both Ice Harbor and Lower Monumental dams. It also reduces costs to operate the systems on all four projects during drawdown. By operating the powerhouse systems only, savings can be realized because of fewer entrance modifications, exit modifications, and reduced pumping costs, without greatly affecting passage efficiency. See Figure C10 for a typical overall plan of recommended system modifications.

Entrance Modifications

As previously mentioned, tailwater elevation changes during this process would be a function of river flow and would not be drastic compared to forebay changes. Existing dam tailwater elevations are near natural river flow elevations in the areas of the dams during certain river flow conditions. This makes it feasible to extend the existing fishway entrances out and down to connect with varying tailwater elevations where required.

Existing powerhouse fishway entrances normally used near the beginning of the fish ladder would be the ones operated during drawdown. Existing entrances would be "extended" to reach lowering tailwater elevations using specially designed ladders connected to the entrances. To manage changing tailwater elevations, the ladders would pivot at the connection to the existing entrance with the inlet end of the ladder being buoyant, allowing them to fluctuate with varying tailwater elevations. Two ladder sets would be used at dams having possible tailwater elevation drops greater than 3.0 meters (10 feet) below normal minimum operating elevation. One ladder would be designed for the first half of drawdown, and the other set for the final stages of drawdown. This would keep ladders within the acceptable range of slopes for proper operation. The ladders would be designed to allow a quick change of ladder sets as water level drops below the range of the first ladder set. A schematic representation of a new ladder entrance is shown in Figure C5. Existing adjustable entrances would be dogged off at elevations required for operating the collection systems at minimum flows and depths. This would eliminate any possible variables in operation and minimize the cost of pump installation and operation.

A Denil-type ladder is currently planned for the entrance extensions. The actual type of ladder to be implemented may or may not be a Denil and will require further research and model testing. The Denil ladder is a fishway that consists of a rectangular chute with closely spaced baffles or vanes located along the sides and bottom, as shown in Figure C6. Velocity is varied within the chute by geometry; low at the bottom and higher at the top. Flows within the fishway would be designed to provide adequate attraction velocities.

Based on this overall approach, the following entrance modifications would be made at each of the dams:

- No entrance modifications would be required at Ice Harbor Dam, and tailwater would be unchanged.

- The two north shore entrances at Lower Monumental Dam would be fitted with new Denil ladder entrance extensions. The minimum tailwater possible is about 2.9 meters (9.5 feet) below present minimum operating tailwater. Only one set of ladders would be necessary.
- No entrance modifications would be required at Little Goose Dam. During the first drawdown season the tailwater at Little Goose remains unchanged.
- The two south shore entrances at Lower Granite would be fitted with new Denil ladder entrance extensions. Minimum tailwater possible is about 4.6 meters (15.2 feet) below the current minimum operating tailwater. Two complete sets of ladders would be supplied: one set designed for the first 2.4-meter (8-foot) drop in tailwater, and the other set designed for the remainder.

Attraction Water Modifications

Fishway flows and depths would be operated at current minimum operating conditions. This would allow the most economical functioning of the system. Collection channel velocities must be maintained at 0.6- to 1.2-meters per second (m/s) (2- to 4-feet per second [ft/s]) and fishway depths must be kept at a minimum 1.8 meters (6 feet).

Existing attraction water pumps are not designed to operate at heads greater than about 1.2 meters (4 feet), even if retrofitted with larger drive motors. As the tailwater elevation drops, the existing attraction water pumps at Lower Granite and Lower Monumental will fall below their operating ranges during the first and second season drawdowns, respectively. During this time the pumps cannot provide minimum required flows into the collection systems. In the present condition, collection channel elevation fluctuates up and down with tailwater elevation maintaining constant head across the attraction water pumps. During dam breaching, the head across the attraction water pumps at Lower Granite and Lower Monumental Dams would increase due to a lowering tailwater elevation with constant collection channel elevation. Existing attraction water pump intakes would remain submerged.

The additional head on the system creates a problem. Changing out the attraction water pumps is not feasible because the systems must remain intact up to the point of drawdown. It would be difficult and very costly to install a new pumping system capable of operating in both modes, normal and throughout drawdown. Also, although tailwater remains unchanged at Little Goose Dam during the first drawdown season, the attraction water pumps are turbine driven by forebay head so they will become inoperable as the drawdown begins.

Consequently, the study team recommends adding new pumps to the current systems and tying them into the existing attraction water supply conduits, as shown in Figure C7. The new pumps would provide flows and heads similar to the present systems, allowing them to operate as they currently do. It is possible that these pump systems might be rented, thereby reducing the capital cost. Also, it may be feasible to salvage systems used during the first drawdown season and use them in the second drawdown season. Specifically, the study team proposes the following attraction water modifications at each of the dams:

- The existing attraction water pump system at Ice Harbor Dam would operate as normal. However, there would be no auxiliary flow from the juvenile dewatering system.

- The total attraction water required at Lower Monumental Dam would be 14.2 m^3/s (500 cfs), which is 7.1 m^3/s (250 cfs) for each entrance. Flow numbers would exceed present range of operation for these entrances. Maximum total head on the system, including losses, would be about 4.11 meters (13.5 feet) at minimum river flow. Two 600-hp axial flow pumps would be installed, each producing 7.1 m^3/s (250 cfs) of attraction water flow.
- Total attraction water required at Little Goose Dam would be 28.2 m^3/s (1,000 cfs) to operate the powerhouse and south shore collection systems as they are presently operated. Head on the system would remain unchanged during the first drawdown season. Three 300-hp axial flow pumps would be installed, each producing 9.4 m^3/s (333 cfs) of attraction water flow.
- Total attraction water required at Lower Granite Dam would be 14.2 m^3/s (500 cfs), which is 250 cfs for each entrance. Flow numbers would exceed the current range of operation for these entrances. Maximum total head on the system, including losses, would be about 5.85 meters (19.2 feet) at minimum river flow. Three 600-hp axial flow pumps would be installed, each producing 4.7 m^3/s (167 cfs) of attraction water flow.

Fish Ladder Flow

Fish exit and auxiliary fish ladder flow is typically provided by gravity-fed forebay head water. Fish ladder flows, both auxiliary supply and fish exit flows, will drop off and discontinue shortly after the drawdown has begun. Ladder flows must be maintained at current minimum levels to provide adequate depths and velocities for fish passage.

Where applicable, existing forebay intakes for the ladder flows would be closed or isolated.

Water supply for both the fishway exit and auxiliary supply to the ladder would be provided by adding a series of pumps in the forebay and plumbing them in together to supply these features. These pumps might also be rented in order to reduce overall cost of this modification. Also, it may be feasible to salvage systems used during the first drawdown season and use them in the second drawdown season. A number of pumps would be provided so they can be "staged" as the reservoir drops, providing the required constant fish ladder flow at varying forebay elevations. Also, a throttling valve will be placed in the system to create required head loss keeping the pumps operating on the proper areas of the pump curves as water surface elevations vary. The pumps would be mounted on a platform on the upstream face of the dam, as shown in Figure C8.

The specific fish ladder flow modifications required at each dam are as follows:

- At Ice Harbor Dam, 2.7 m^3/s (96 cfs) would be provided to the false weir and auxiliary fish ladder flow system. Present minimum forebay elevation is 133 meters (437 feet). Drawdown elevation would be approximately 103 meters (338 feet). Four vertical turbine pumps capable of producing 0.68 m^3/s (24 cfs) each at a TDH of about 34 meters (110 feet) would be required. Each pump would be driven by a 450 hp electric motor.
- The Lower Monumental north shore fish ladder would have 2.1 m^3/s (75 cfs) provided to the false weir and auxiliary ladder flow system. Current minimum forebay elevation is 164 meters (537 feet). Drawdown elevation will be approximately 130 meters (427.5 feet) at minimum river flow. Four vertical turbine pumps capable of producing 0.53 m^3/s (18.75 cfs) each at a TDH of about 37 meters (120 feet) would be required. Each pump would be driven by a 400 hp electric motor.

- The fish ladder at Little Goose would have 2.1 m^3/s (75 cfs) provided to the false weir and auxiliary ladder flow system. Current minimum forebay elevation is 193 meters (633.0 feet). Drawdown elevation would be approximately 158 meters (517.4 feet) at minimum river flow. Four vertical turbine pumps capable of producing 0.53 m^3/s (18.75 cfs) each at a TDH of about 38 meters (125 feet) would be required. Each pump would be driven by a 400 hp electric motor.
- The fish ladder at Lower Granite would have 2.1 m^3/s (75 cfs) provided to the false weir and auxiliary ladder flow system. The current minimum forebay elevation is 223 meters (733.0 feet). Drawdown elevation will be approximately 188 meters (617.8 feet) at minimum river flow. Four vertical turbine pumps capable of producing 0.53 m^3/s (18.75 cfs) each at a TDH of about 38 meters (125 feet) would be required. Each pump would be driven by a 400 hp electric motor.

Exit Modifications

Since the forebay water surface elevations will fall below the fishway exits soon after drawdown begins, a system to safely transport the fish from the top of the ladder into the lowering forebay will need to be provided.

A system similar to the alternate fish ladder exit that currently exists at Lower Granite Dam would be retrofitted to the fish handling systems. This system consists of a false weir and a release flume system that will work in conjunction with the pumped ladder flow mentioned earlier. The pumped ladder flow supplies the false weir with attraction water to help attract the fish into the exit flume and also provides flow down the ladder and flow down the exit flume to help flush the adult fish.

The false weir would be fit to the existing fish ladder exit with a transition into a 450-millimeter (18-inch) wide by 700-millimeter (27.5-inch) tall round bottom fiberglass flume system dropping at a 20 percent slope. The flume system would be located near the exits and extend down in a series of straight lengths and long radius bends so it can be supported off the face of the dam. The flume would have an open top allowing the transported fish to exit the system at any water surface elevation, as shown in Figure C9. The false weir and exit flume system would be installed at all four dams.

Schedule

Current systems would be operated in their normal mode as long as possible through the beginning stages of each drawdown season. Ice Harbor and Lower Monumental Dams would operate as they normally do during the first drawdown season. Lower Granite and Little Goose Dams would be breached and have free flowing river during the second drawdown season and adult systems would not be required. Affected adult fish exits would become inoperable within the first couple of days of drawdown. Attraction water systems and fishway entrances, however, may operate for quite some time throughout the drawdown process in their normal modes, except for the turbine-driven attraction water pumps at Lower Monumental and Little Goose Dams. River flow at the time of the drawdown would govern when the new temporary systems will have to be employed.

New ladders would be fabricated prior to drawdown. All pivoting and flexible seal connections to the existing structure would have to be performed in the wet using dive crews prior to drawdown. When tailwater elevation falls below that required for normal entrance operation, the portion of system not to be used would be bulkheaded off, and new ladder entrances attached.

New attraction water pumping systems would have to be installed and electrically connected prior to beginning river drawdown. Pump supports, pumps, shafting, valving, and taps into the attraction water supply conduit would have to be done in the wet using dive crews. Taps into existing attraction water supply conduits would have to be performed during a normal adult passage system outage the year prior to drawdown. Motor supports, drive motors, and electrical connections would be assembled and installed on the tailrace deck.

The attraction water conduits and fish passage conduits would have to be modified for isolation bulkheads during a normal system outage a year prior to drawdown.

New exit flume systems and an upwell and false weir caisson connection to existing fishway exit would have to be installed in the wet prior to beginning drawdown using dive crews. The upwell and false weir caisson would have to be designed for "drop-in" type connection to existing fishway exits, to new exit flume system, and to ladder water supply piping providing a quick installation of the system as drawdown progresses past the point of normal operation.

Fish ladder flow pumping stations would have to be installed and functional prior to beginning drawdown. Pumps, discharge piping, header pipe, throttling valve and pipe and pump column supports would have to be installed in the wet using dive crews. Motors and electrical connections would be installed on the top decks.

C.4.2 Option 2 - Trap Adults at the Downstream Dam and Transport Above the Next Dam Upstream in each Drawdown Season

General

This option involves trapping all migrating adult fish at Little Goose Dam and transporting them above Lower Granite Dam for release during the first drawdown season. During the second drawdown season, migrating adult fish would be trapped at Ice Harbor Dam and transported above Lower Monumental Dam and released back into the river system.

Enough fish trucks and personnel would have to be available to handle the peak load of migrating fish, approximately 3,000 fish per day. Assuming 50 fish per truck, a 6-hour turnaround time for transport and release, and round-the-clock operation, a minimum of 13 trucks would be required. It may be possible to borrow fish hauling trucks from other agencies or quickly retrofit used tankers for fish hauling purposes. This study team assumed that there would be ten existing trucks available and three that must be bought and modified to suit fish hauling. All new and modified trucks would be designed to haul both juvenile and adult fish so that the tankers could be better utilized.

Required Modifications to Existing Systems

To accomplish this option, the following modifications would need to be made to Little Goose Dam for the first drawdown season:

- The north shore fish attraction system would be isolated as in Option 1. The south shore attraction and fishway entrance system would be operated as it currently is. Tailwater elevations would remain the same.

- Since the attraction water pumps are turbine driven, they would become inoperable as the forebay drawdown began. Three 300-hp axial flow pumps would be installed to supply the required attraction water similar to Option 1.
- The first bend in the fish ladder would be fitted with a diversion screen. The diversion screen would be designed to deploy into place when the trap is ready to operate. Slots would be cut into the ladder walls in this area for the placement of a false weir for fish attraction, similar to that shown in the plan view in Figure C12.
- To operate the new trap and supply ladder attraction water, 2,406 L/s (85 cfs) of pumped flow will have to be provided. As the drawdown begins flow from the top end of the ladder would cease. The current minimum forebay elevation is 193 meters (633 feet). The drawdown elevation would be approximately 158 meters (517.4 feet). About 1,841 L/s (65 cfs) would be supplied into the top of the fish ladder, with 566 L/s (20 cfs) being piped down to the new fish trap. Approximately 283 L/s (10 cfs) of the fish trap supply will enter the fish ladder through the new false weir at the trap, providing a total ladder flow in the lower reaches of 2,124 L/s (75 cfs) as currently required. The pumping system would be similar to Option 1 for fish ladder flow. In this case, four vertical turbine pumps capable of producing 602 L/s (21.25 cfs) each at a TDH of about 36.6 meters (120 feet) would be required. Each pump would be driven by a 450-hp electric motor. Figure C8 shows a similar arrangement to accomplish the auxiliary flow.

To accomplish this option, the following modifications would need to be made to Ice Harbor Dam for the second drawdown season:

- The north shore fish ladder would be taken out of service. The south shore attraction and fishway entrance system would be operated as it currently is. Tailwater elevations would remain the same.
- The return bend at floor elevation 121 meters (397.0 feet) of Section No. 1 of the fish ladder would be fitted with a diversion screen. The diversion screen would be designed to deploy into place when the trap is ready to operate. Slots would be cut into the ladder walls in this area for the placement of a false weir for fish attraction, as shown in the plan view in Figure C12.
- To operate the new trap and supply ladder attraction water, 3,002 L/s (106 cfs) of pumped flow will have to be provided. As the drawdown begins, the fish ladder water supply diffusers operated by the attraction water pumps would remain in service, but the flow from the top end of the ladder would cease. The current minimum forebay elevation is 133 meters (437 feet). The drawdown elevation would be approximately 103 meters (338 feet). About 2,435 L/s (86 cfs) would be supplied into the top of the fish ladder, with 566 L/s (20 cfs) being piped down to the new fish trap. Approximately 283 L/s (10 cfs) of the fish trap supply will enter the fish ladder through the new false weir at the trap, providing a total ladder flow in the lower reaches of 2,718 L/s (96 cfs) as currently required. The pumping system would be similar to Option 1 for fish ladder flow. In this case, five vertical turbine pumps capable of producing 600 L/s (21.2 cfs) each at a TDH of about 33.5 meters (110 feet) would be required. Each pump would be driven by a 400-hp electric motor. Figure C8 shows a similar arrangement to accomplish the auxiliary flow.

New Trap System Features

The new trap systems would have a flume starting in the fish ladder wall at a bend in the ladder system with a false weir to attract the adults into the system. The flume would have a PIT tag detector to allow for any desired monitoring that the biologists may want to perform. A switch gate to switch between two holding tanks would be installed. Two holding tanks allows continuation of the trapping function as a fish hauling truck is being loaded.

The individual holding tanks would be fitted with vertical crowders for quick release of the fish. Tanks would be arranged so that the crowders can be operated by a single, strategically located, mobile crane. This would eliminate excessive mechanical equipment, saving costs and maintenance.

Water supply for a variety of purposes, including the false weirs, flume flushing, holding tanks, fish release auxiliary water, and truck loading, will be piped down from the pumped fish ladder water supply system previously mentioned. Flow required is 85 L/s (3 cfs) per holding tank, 28 L/s (1 cfs) per flume flushing point, 28 L/s (1 cfs) per truck loading chute, and 283 L/s (10 cfs) per false weir, with the truck loading water assumed to be incidental. This is a total water supply per system of 566 L/s (20 cfs). About 283 L/s (10 cfs) of the total would enter the ladder system through the false weir and would supplement the total ladder attraction flow required. Tank drains would be discharged into the lower regions of the ladders but really cannot be counted on as ladder flow due to the distance down the ladder that they must discharge into. Therefore, 283 L/s (10 cfs) of addition pumped water needs to be supplied beyond the total ladder flow.

See Figures 11 and 12 for arrangement of the new adult trap features.

Schedules

The false weirs and the diversion screen would have to be installed during the fish ladder outage the year prior to the drawdown season. The diversion screen would be designed to not obstruct normal ladder operation when not deployed.

The water supply pumping station would have to be installed and functional prior to beginning drawdown. Pumps, discharge piping, header pipe, throttling valve, and pipe and pump column supports would have to be installed in the wet using dive crews. Motors and electrical connections would be installed on the top decks. Piping down to the new trap could be installed at anytime prior to drawdown.

Everything downstream of the new false weir could be constructed at any time prior to beginning drawdown.

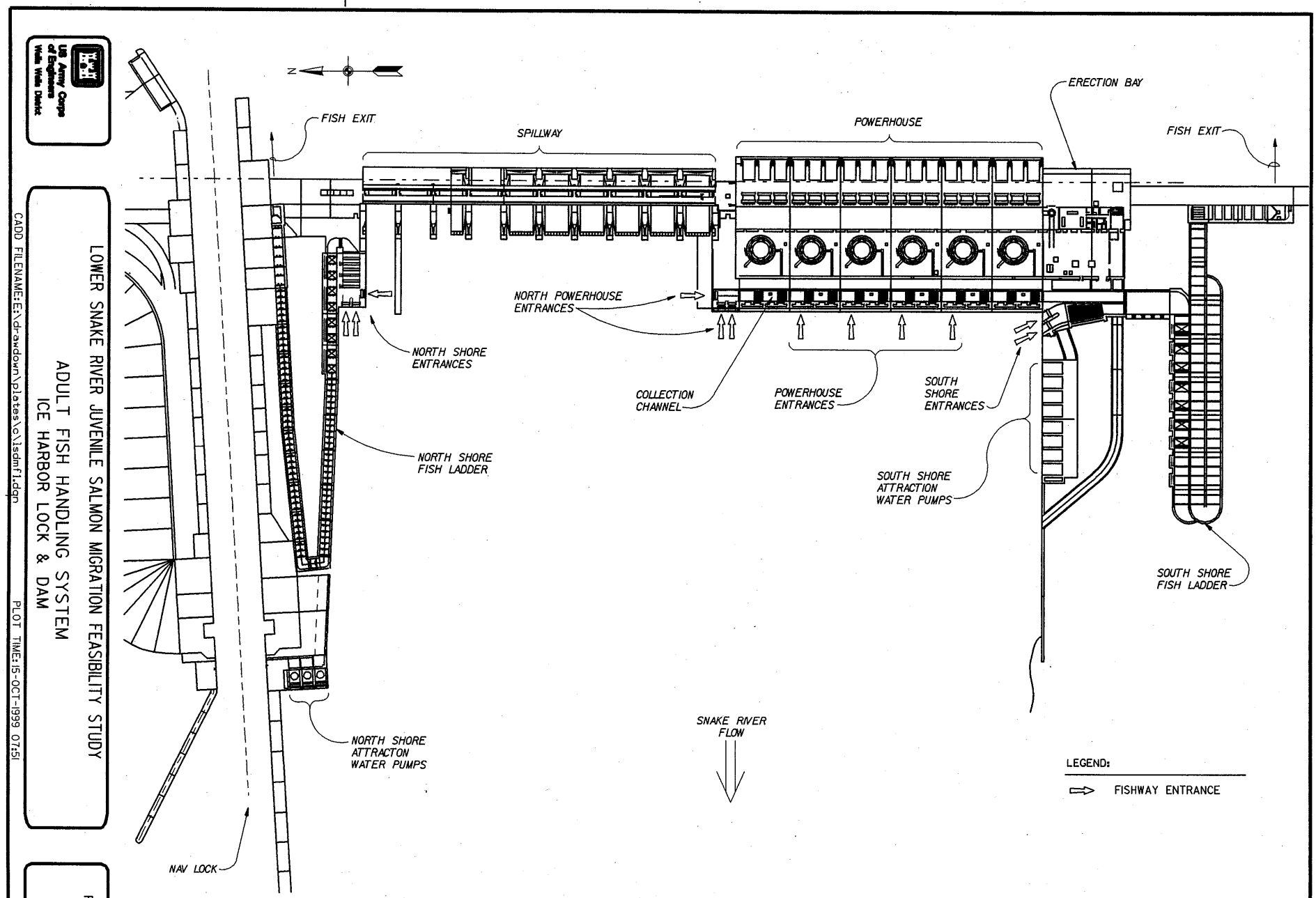
Electrical power for new attraction water, fish ladder pumping systems, and adult trap supply would have to be back fed from the nearby power substations. Actual switchgear and circuitry requirements for the pump stations have not been considered in this report and will require detail description and design in any subsequent work.

C.5 Conclusion

The relative advantages and disadvantages of these temporary fish passage measures were discussed at the Fish Facilities Design Review Work Group. The primary concern was with implementing

modifications to each project to allow the fish to migrate upriver. The water quality of the river during the initial drawdown may be heavily silt laden and may severely impede the migration of fish. The group was unanimous in recommending that trapping and hauling adult fish, while not a good option, was a better option.

The study team selected the trap and haul option as the preferred option for a temporary means to facilitate the migration of adult fish. This is based on the uncertainty of sediment loads in the river and the difficulty in achieving effective fish ladder modifications.



ADULT FISH HANDLING SYSTEM - ICE HARBOR LOCK & DAM

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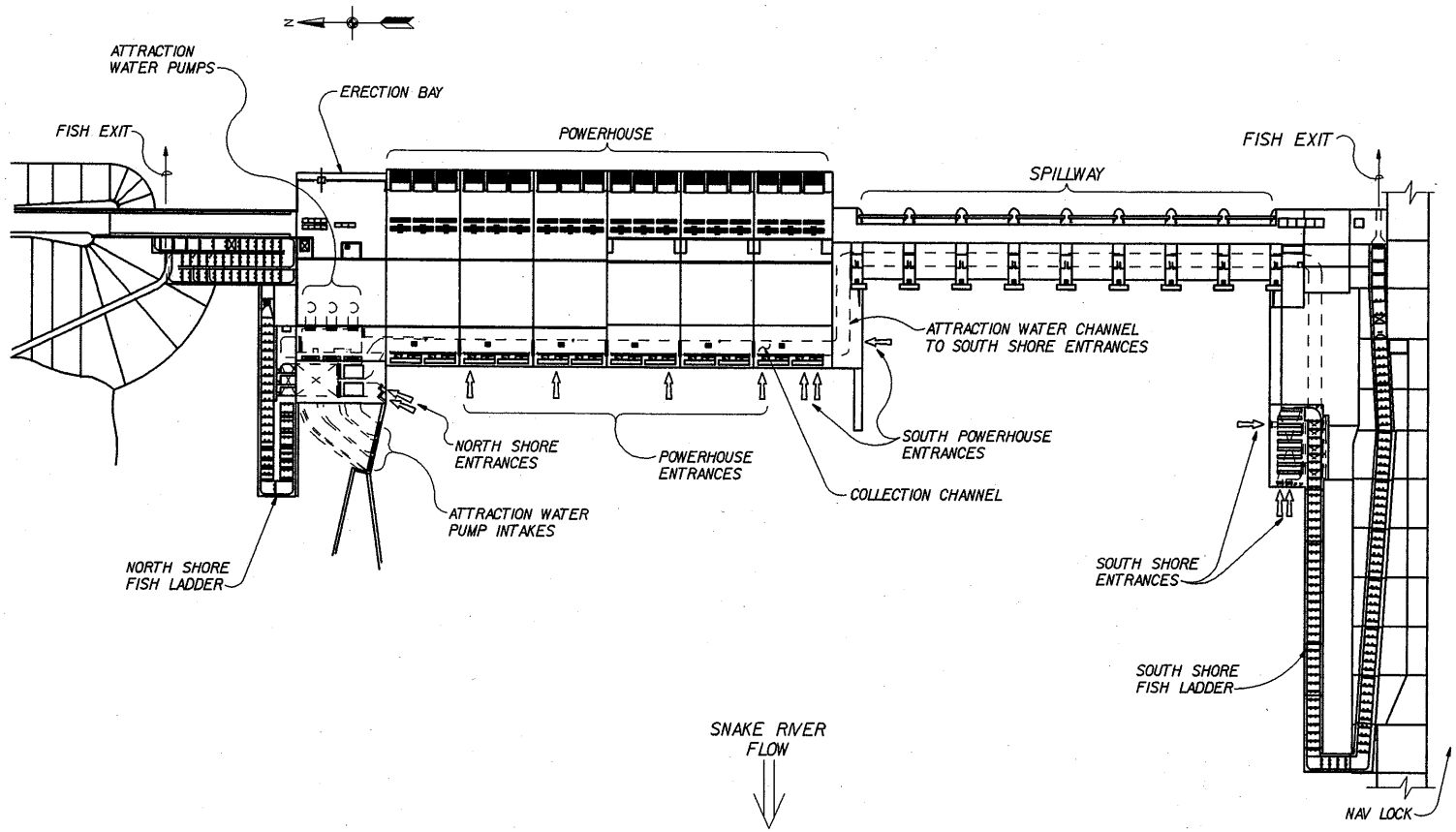
SHEET MAIN SCALE:

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

ADULT FISH HANDLING SYSTEM
LOWER MONUMENTAL LOCK & DAM

Figure:
C2



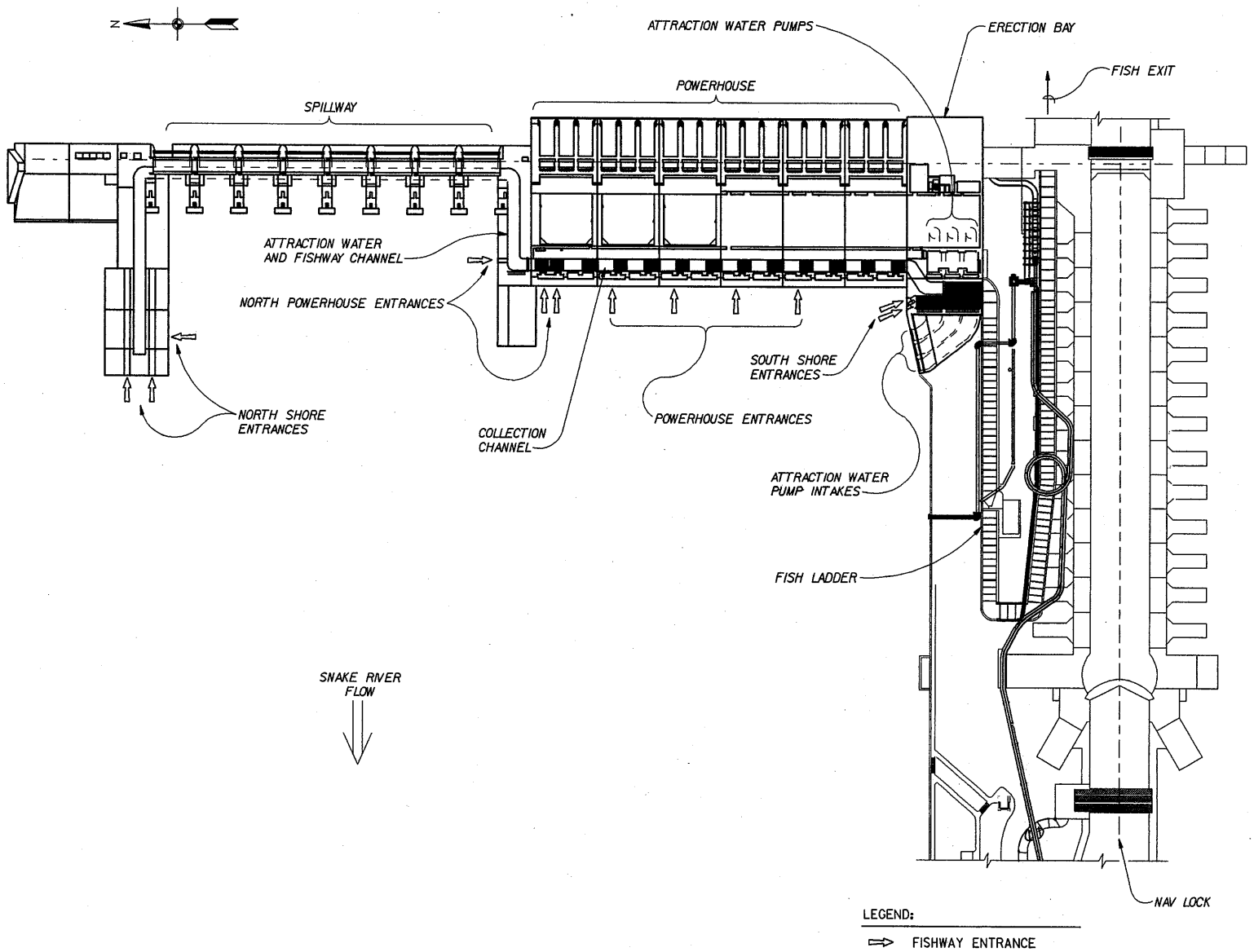
ADULT FISH HANDLING SYSTEM - LOWER MONUMENTAL LOCK & DAM

US Army Corps of Engineers
Walla Walla District

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

ADULT FISH HANDLING SYSTEM
LITTLE GOOSE LOCK & DAM

Figure:
C3



ADULT FISH HANDLING SYSTEM - LITTLE GOOSE LOCK & DAM

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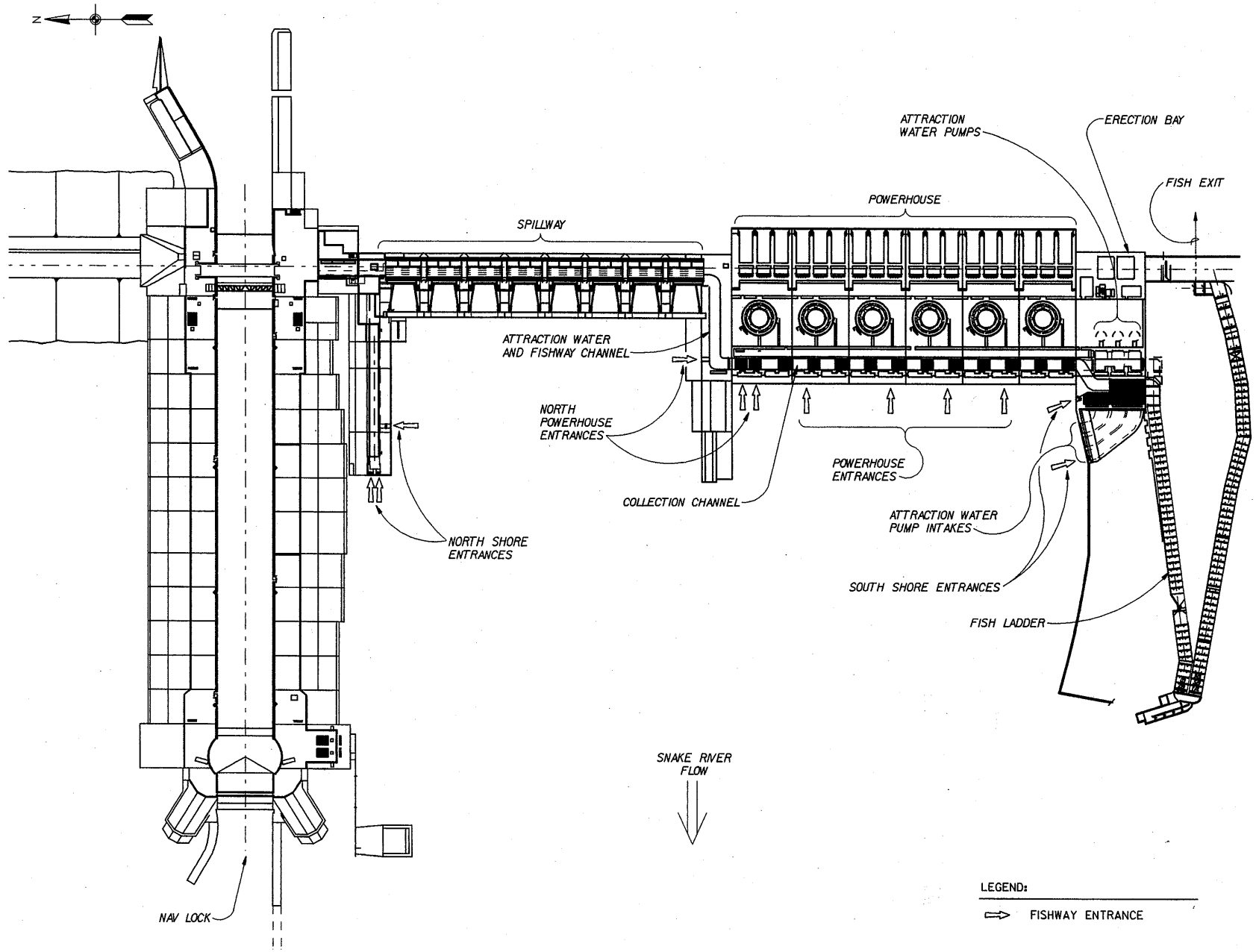

ADULT FISH HANDLING SYSTEM - LOWER GRANITE LOCK & DAM

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LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

ADULT FISH HANDLING SYSTEM
LOWER GRANITE LOCK & DAM

Figure: C4

CADD FILENAME: E:\drawdown\plates\c\lsdmf4.dgn

PLOT TIME: 15-OCT-1999 08:00

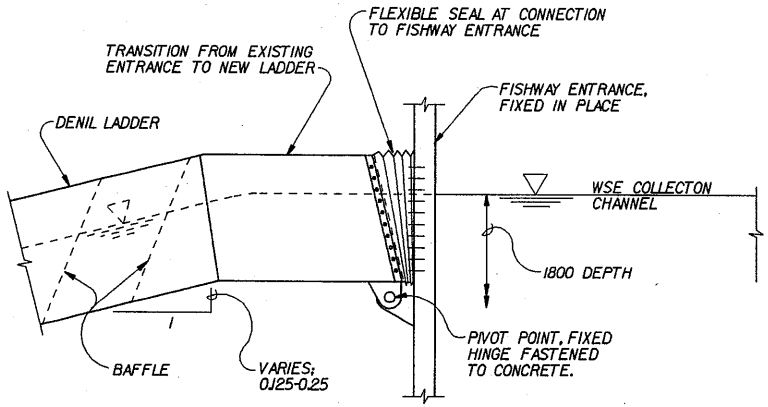
SHEET MAIN SCALE:

US Army Corps of Engineers
Walla Walla District

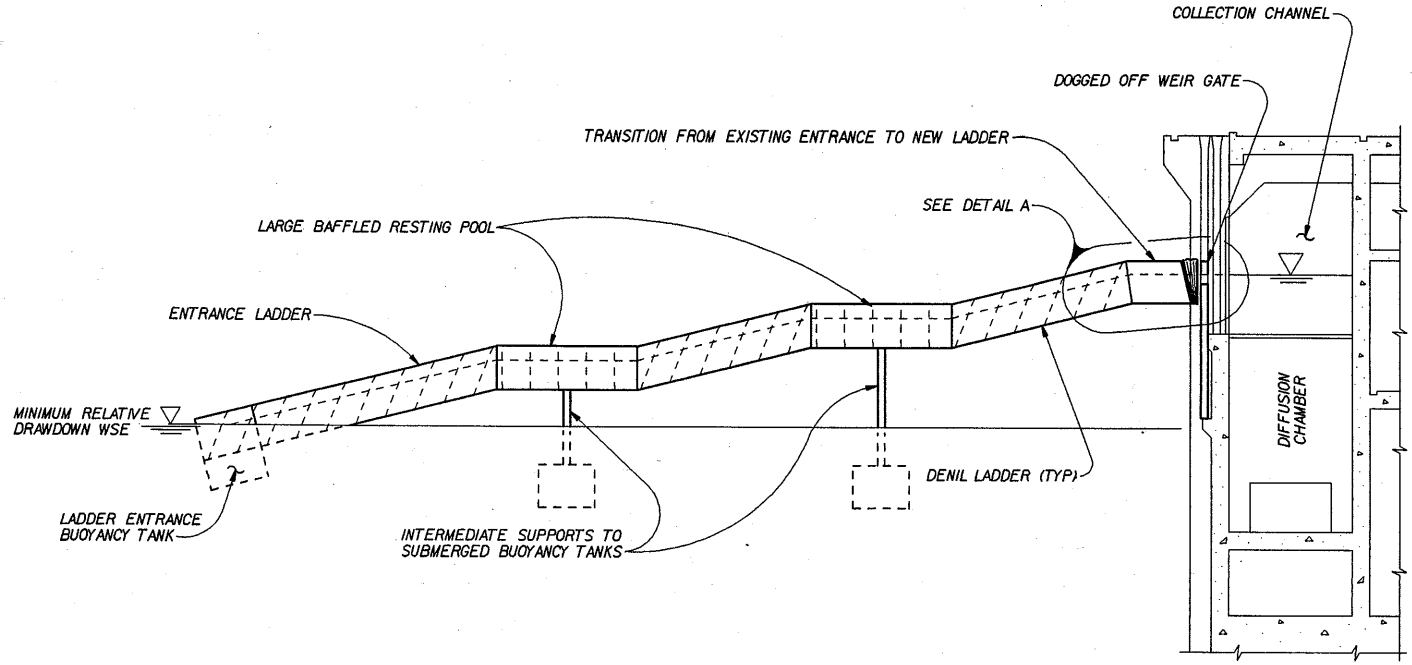
LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

SECTION AT COLLECTION / ENTRANCE
SHOWING LADDER ENTRANCE EXTENSION

Figure:
C5



DETAIL A



SECTION AT COLLECTION/ENTRANCE SHOWING LADDER ENTRANCE EXTENSION

NOTE:
1. UNLESS OTHERWISE NOTED, DIMENSIONS ARE SHOWN IN MILLIMETERS.

SHEET MAIN SCALE:

US Army Corps of Engineers
Walla Walla District

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

DENIL FISH LADDER
PLAIN DENIL FISHWAY

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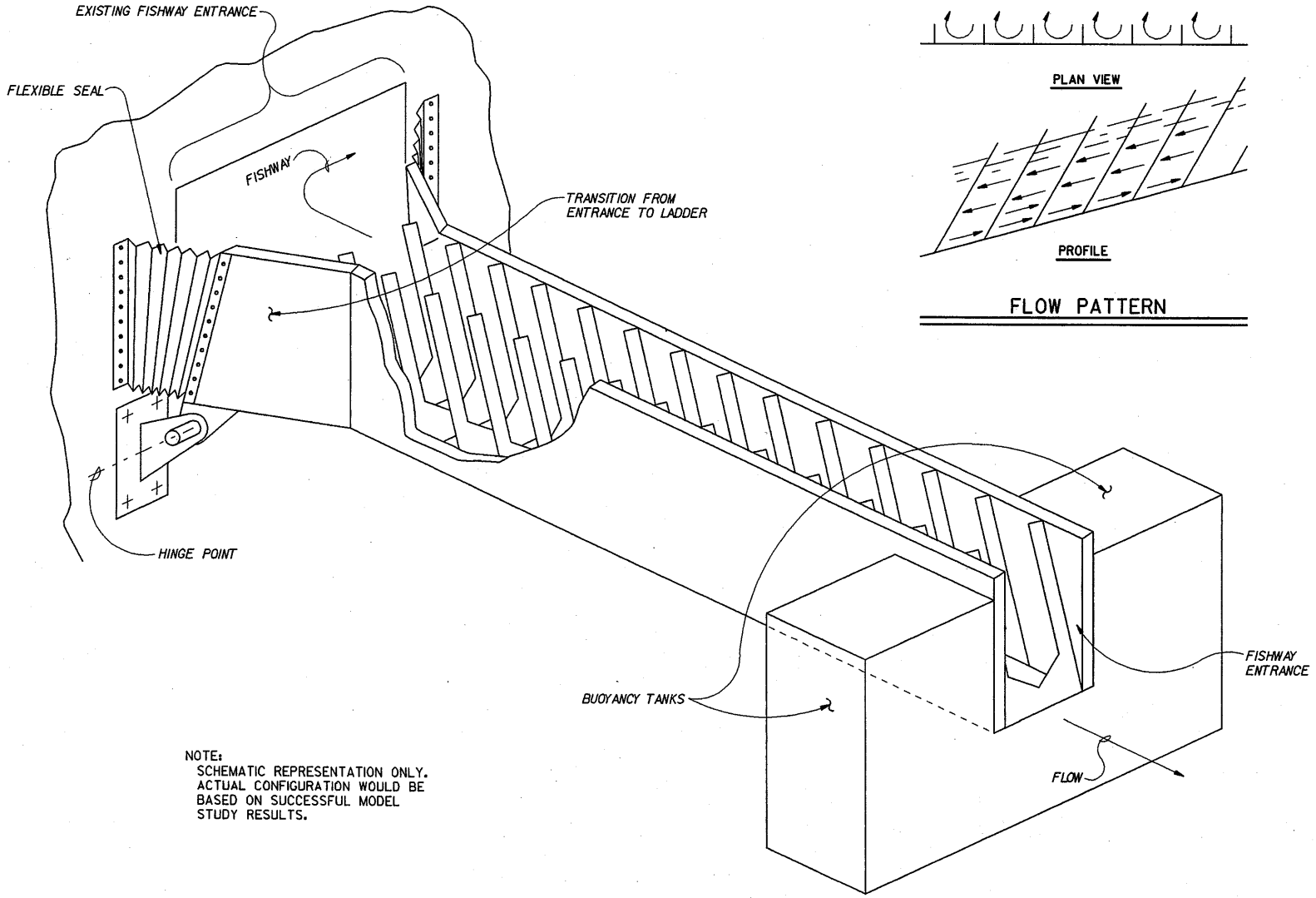
Figure: C6



NOTE:
SCHEMATIC REPRESENTATION ONLY. ACTUAL CONFIGURATION WOULD BE BASED ON SUCCESSFUL MODEL STUDY RESULTS.

FLOW PATTERN

- SLOPE: 10-25%
- RESTING POOLS ARE REQUIRED BETWEEN LONG SEGMENTS, NOT SHOWN.

PLAIN DENIL FISHWAY

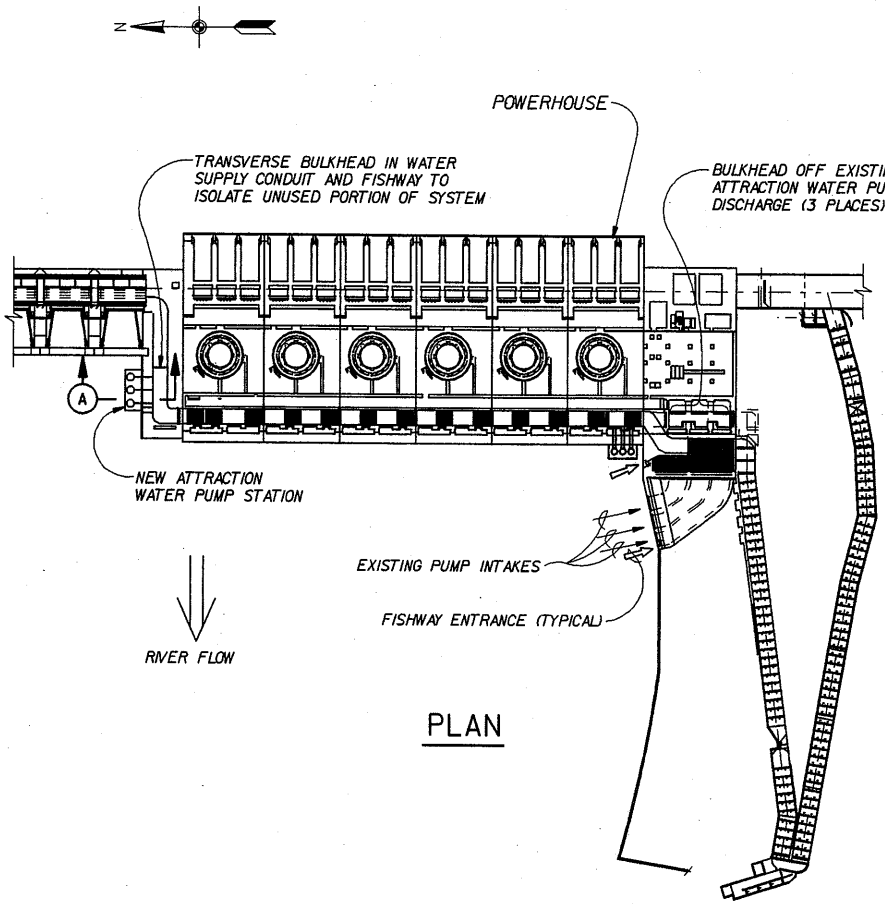
40il

US Army Corps of Engineers Walla Walla District

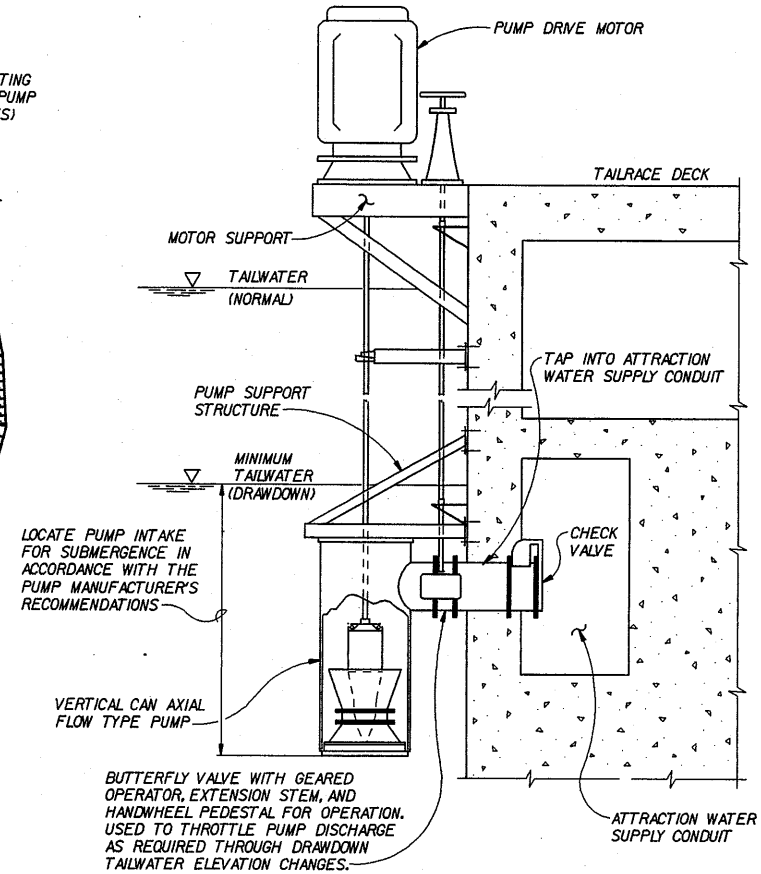
LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

ATTRACTION WATER PUMPS

Figure: C7



PLAN



SECTION A

Pump Capacity Chart

PROJECT	NO. PUMPS REQUIRED	CAPACITY EACH (CMS)	TOTAL CAPACITY (CMS)	MOTOR (HP) *
ICE HARBOR	N/A	N/A	N/A	N/A
L. MONUMENTAL	2	7.1	14.2	600
L. GOOSE	3	9.4	28.2	300
L. GRANITE	3	4.7	14.2	600

* HP PER MOTOR

EXISTING PUMPS AT ICE HARBOR WILL CONTINUE TO FUNCTION.

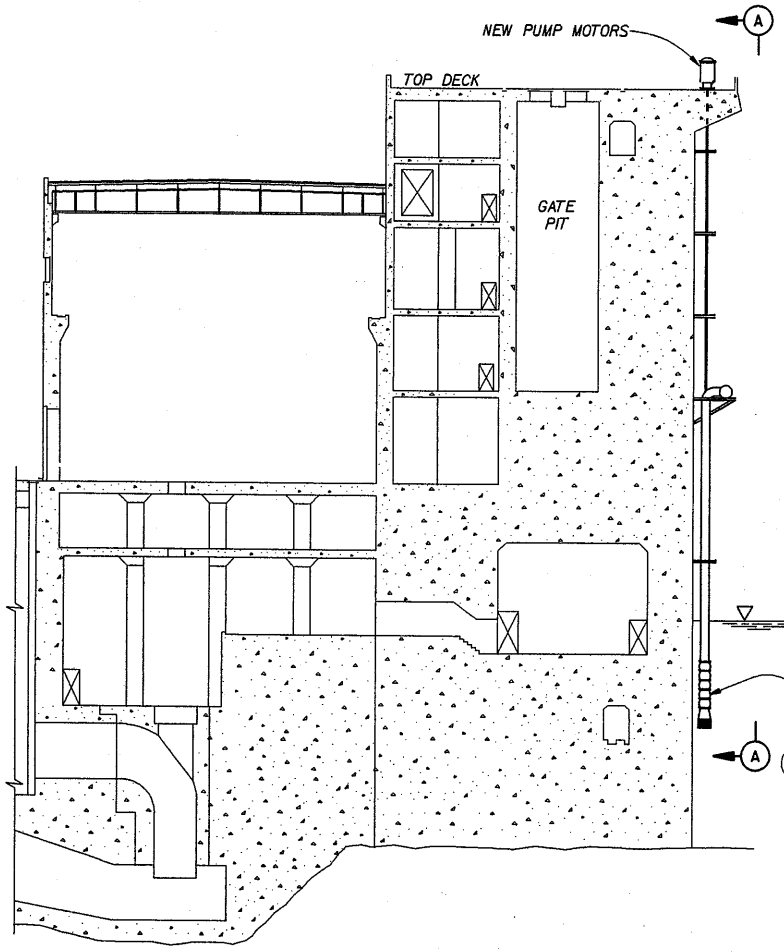
NORMAL TAILWATER DURING FIRST DRAWDOWN SEASON. EXISTING TURBINE DRIVEN PUMPS BECOME INOPERATIVE HOWEVER DURING FOREBAY DRAWDOWN. POWERHOUSE AND SOUTH SHORE ENTRANCES TO OPERATE AS ORIGINALLY DESIGNED. ISOLATE NORTH SHORE.

NOTE:
1. CMS - CUBIC METERS PER SECOND

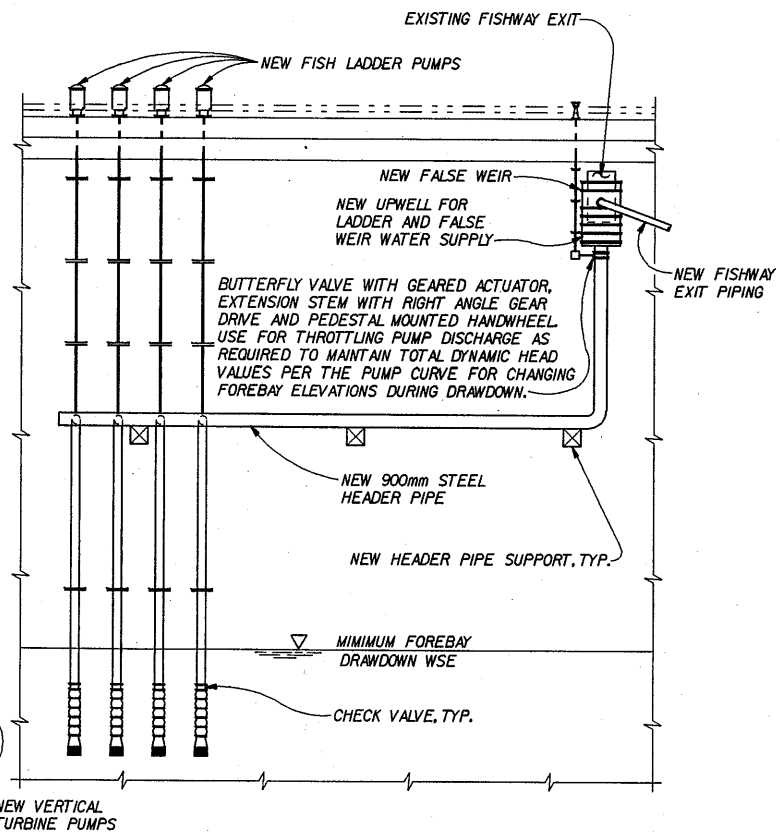
LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

FISH LADDER PUMPS

Figure: C8



SECTION THRU ERECTION BAY



SECTION A

Pump Capacity Chart			
PROJECT	CAPACITY EACH (CMS)	TOTAL CAPACITY (CMS)	MOTOR (HP)
ICE HARBOR	0.68	2.7	450
L. MONUMENTAL	0.53	2.1	400
L. GOOSE	0.53	2.1	400
L. GRANITE	0.53	2.1	400

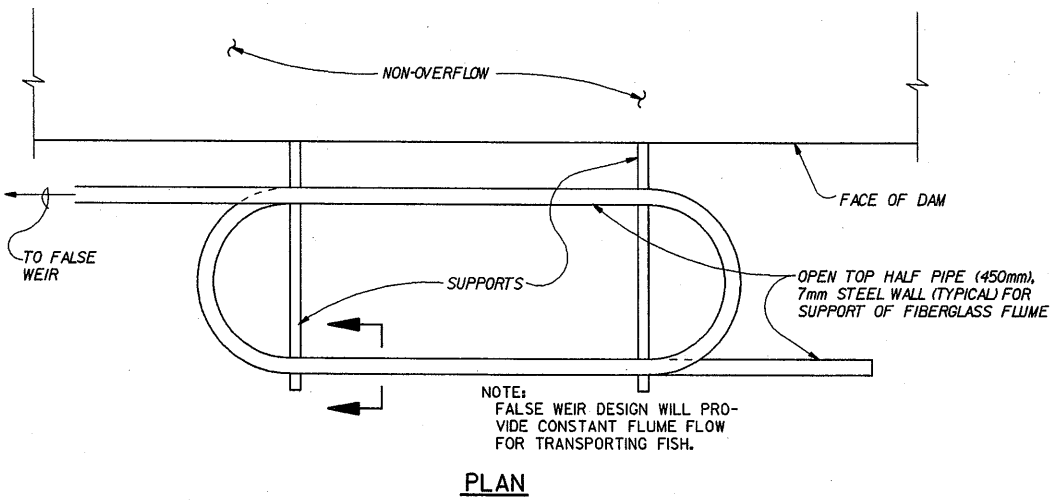
NOTE:
1. CMS - CUBIC METERS PER SECOND

U.S. Army Corps of Engineers
Walla Walla District

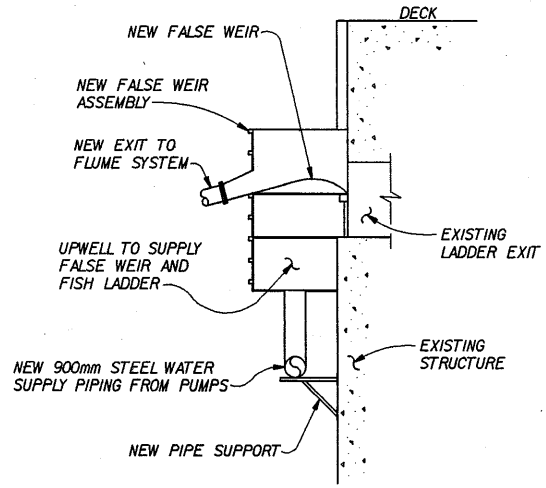
LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

LADDER EXIT MODIFICATIONS

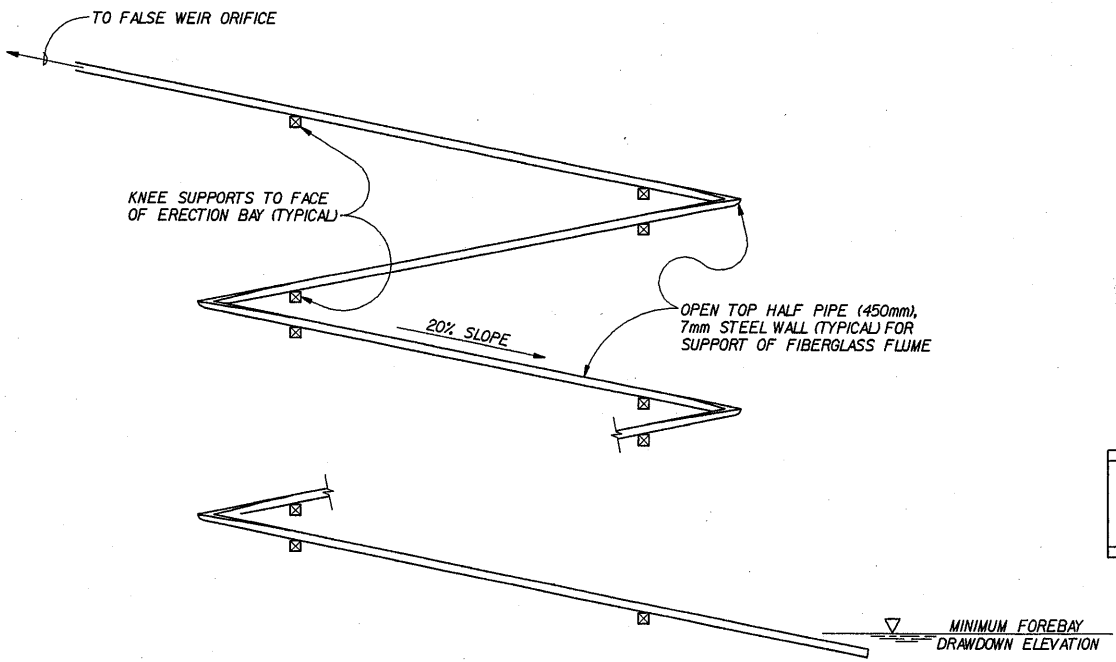
Figure: C9



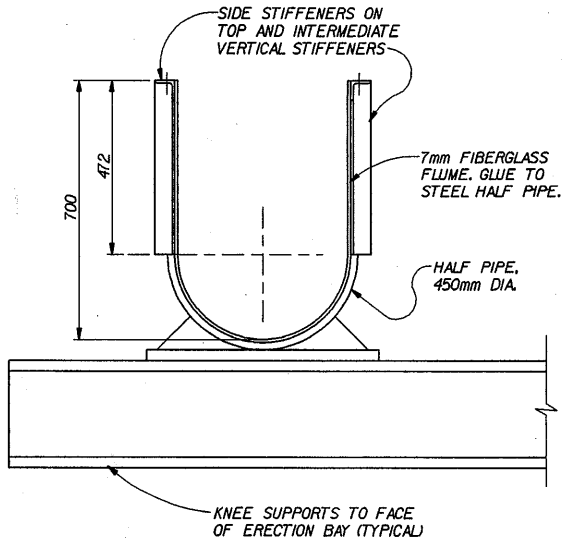
PLAN



SECTIONAL ELEVATION
ADULT EXIT CAISSON



ELEVATION



TYPICAL SECTION

NOTE:
1. UNLESS OTHERWISE NOTED, DIMENSIONS ARE SHOWN IN MILLIMETERS.

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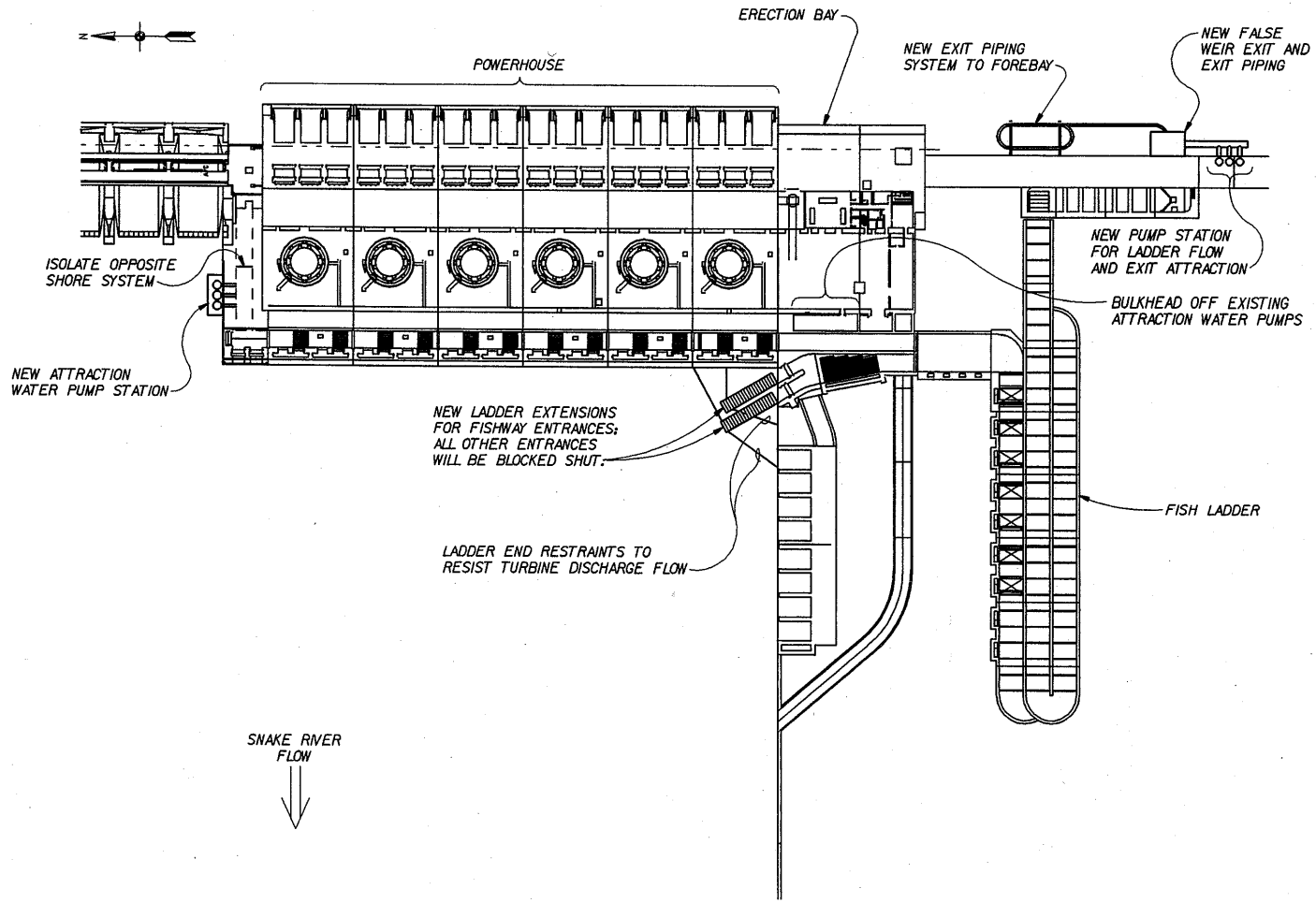
LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

ADULT FISH HANDLING SYSTEM MODIFICATIONS

PLAN

Figure: C10



PLAN

US Army Corps of Engineers Walla Walla District

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

ADULT TRAP SYSTEM
OVERALL PLAN - ICE HARBOR LOCK AND DAM

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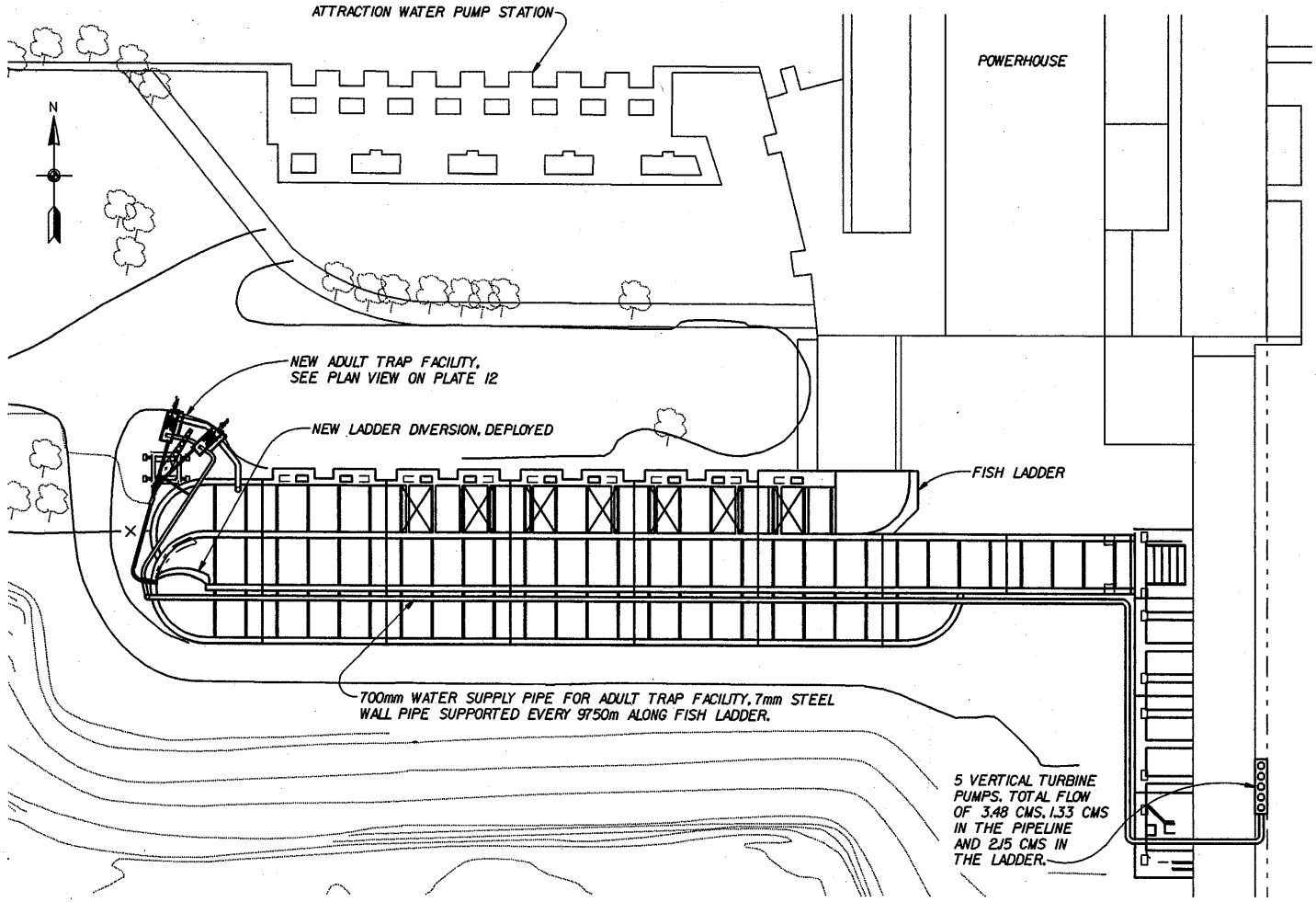
Figure: C11



ADULT TRAP SYSTEM: OVERALL PLAN - ICE HARBOR LOCK AND DAM

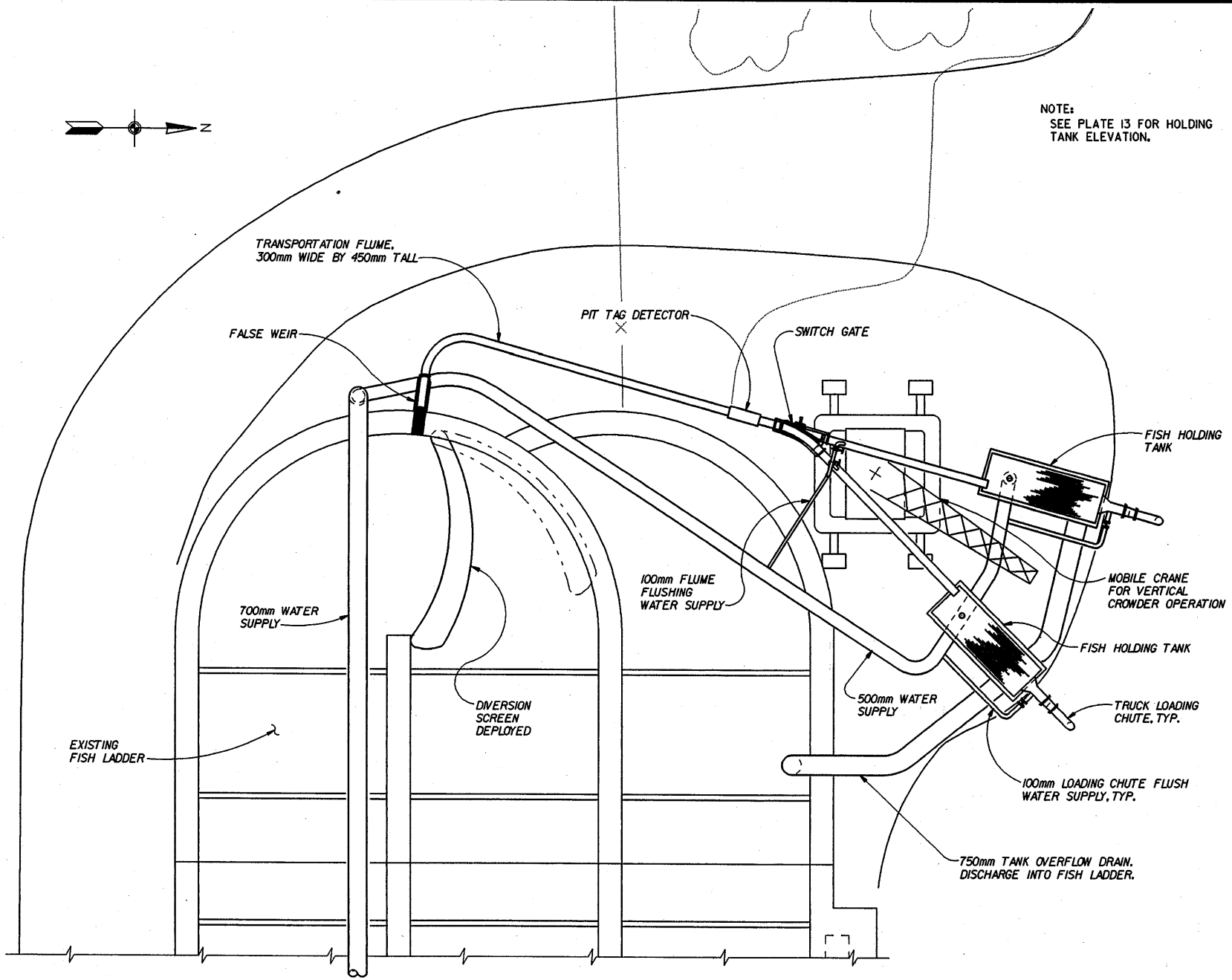
(NOTE: ICE HARBOR SHOWN; LITTLE GOOSE SIMILAR)

US Army Corps of Engineers Walla Walla District

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY

ADULT TRAP SYSTEM
PLAN - ICE HARBOR LOCK AND DAM

Figure: C12



ADULT TRAP SYSTEM: PLAN - ICE HARBOR LOCK AND DAM
(NOTE: ICE HARBOR SHOWN; LITTLE GOOSE SIMILAR)

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SHEET MAIN SCALE:

US Army Corps
of Engineers
Walla Walla District

LOWER SNAKE RIVER JUVENILE SALMON MIGRATION FEASIBILITY STUDY
ADULT TRAP SYSTEM
HOLDING TANK ELEVATION - ICE HARBOR AND LITTLE GOOSE LOCK & DAM

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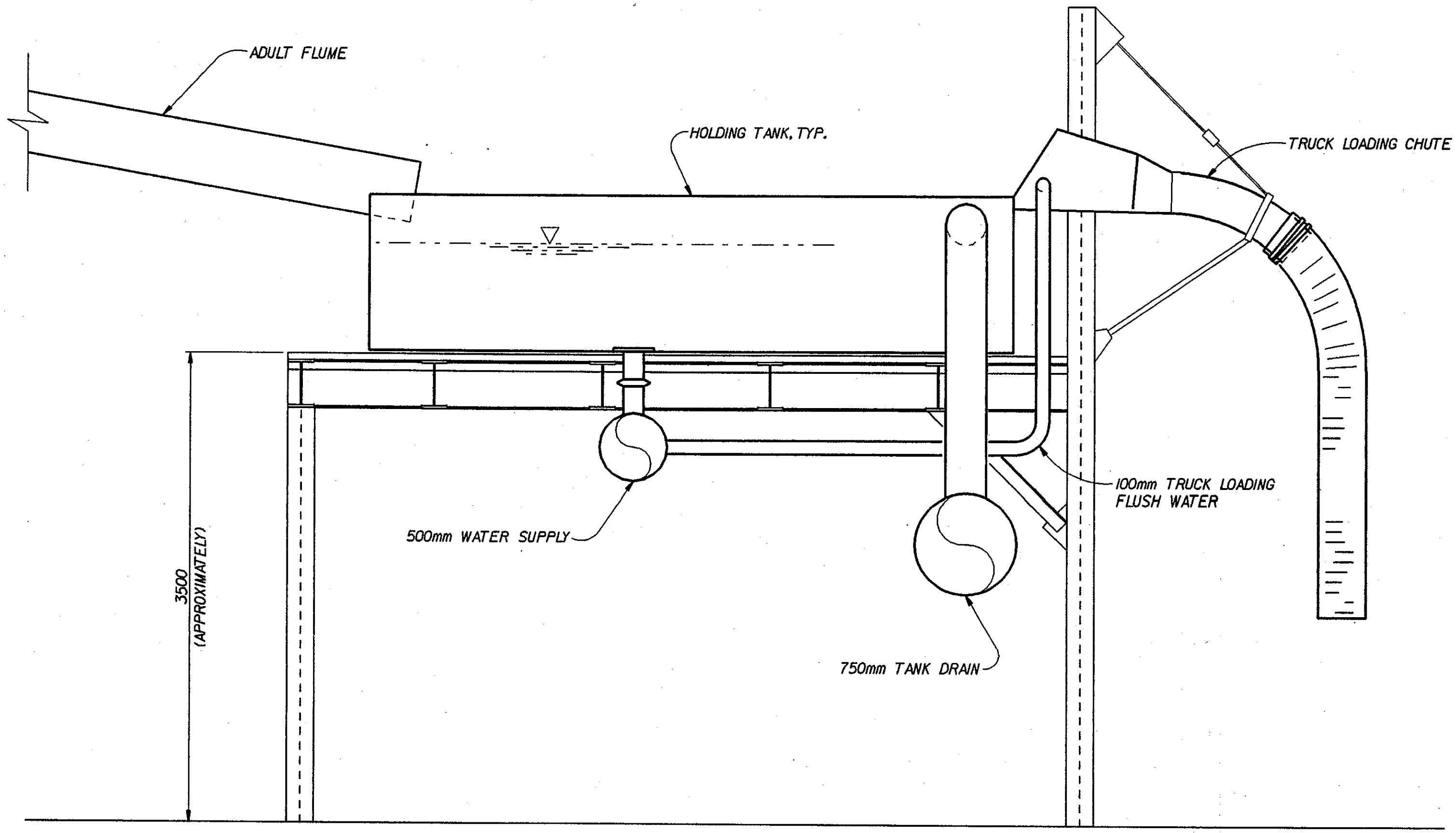
Figure:
C13



ADULT TRAP SYSTEM: HOLDING TANK ELEVATION - ICE HARBOR AND LITTLE GOOSE LOCK AND DAM

NOTE:
1. UNLESS OTHERWISE NOTED, DIMENSIONS ARE SHOWN IN MILLIMETERS.