Lower Yellowstone Intake Diversion Dam Fish Passage Project, Montana

APPENDIX B – COST ENGINEERING

Lower Yellowstone Intake Fish Passage EIS

OCTOBER 2016

Contents

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ATTACHMENTS

1.0 Alternative Construction Cost Estimates

This appendix accounts for the development of five, comparable alternative construction cost estimates. These estimates have all been developed using the Micro-Computer Aided Cost Estimating System (MCACES) software in order to develop detailed unit prices. The estimates have been prepared by various estimators and all estimating assumptions are discussed in detail in subsequent sections of this appendix.

1.1 General

This project is located on the Yellowstone River approximately 17 miles northeast of Glendive, Montana. There is currently an Intake Diversion Dam and Diversion Headworks that provides water for the Lower Yellowstone Irrigation Project's (LYIP) main canal. This canal diverts water on the north side of the river and continues for approximately 71.6 miles delivering water primarily for agricultural use.

The existing diversion dam is presumed to be a complete barrier to the endangered pallid sturgeon, due to the increased turbulence and velocities associated with the rock that forms the dam and the boulder field found immediately downstream of the dam. Monitoring of the pallid sturgeon has indicated that they are unable to move upstream beyond the existing intake dam.

Each of the five proposed action alternatives aim to improve fish passage for the endangered pallid sturgeon and other native fish as well as reduce entrainment of fish into the LYIP main canal. Each of the construction alternatives would contribute to recovery of the pallid sturgeon by increasing access to an additional 165 miles of habitat along the Yellowstone River for migration, spawning and development.

1.2 Purpose

The purpose of this work is to develop total project cost estimates – consistent with the conceptual level designs - for the five construction alternatives.

1.3 Design Alternatives

The project includes five action alternatives and the no action plan. As noted, each of the action alternatives are designed to provide improved fish passage through and/or around the existing Intake Diversion Dam location. The following is a brief description of the alternatives. Subsequent sections of this appendix will discuss in greater detail the construction elements and assumptions for each alternative.

- **No Action –** This alternative does not assume any new construction would be completed. The existing Intake Diversion Dam would remain in place without any modifications.

- **Rock Ramp –** This alternative would replace the existing rock and timber crib structure of the existing intake diversion dam with a concrete weir and a shallow-sloped, un-grouted boulder and cobble rock ramp.

- **Bypass Channel** - This alternative would construct a new bypass channel on Joe's Island, south of the existing Intake Diversion Dam. This alternative would also include replacing the Intake Diversion Dam with a concrete weir.

- **Modified Side Channel –** This alternative would create a fish bypass channel using the existing 'high flow channel' that runs south of the existing Intake Diversion Dam. The existing channel would be modified to allow for more frequent flows to pass through. The existing Intake Diversion Dam would remain in place.

- **Multiple Pump** - This alternative would remove the existing Intake Diversion Dam and construct five pump stations on the Yellowstone River to deliver water to the Lower Yellowstone Irrigation Project main canal. The pump stations would be designed to provide the same amount of water as is currently being diverted by the dam.

- **Multiple Pumps with Conservation Measures** - This alternative would include several new construction components that would allow for the removal of the existing Intake Diversion Dam along with conservation measures to lessen the water required to be diverted. These construction components include implementation of water conservation measures, shallow ground water pumping, gravity diversions and use of wind energy to offset pumping costs. The conservation measures would consist of installing new check structures, flow measuring devices, modifying existing laterals to pipes, center pivot sprinkler installation, lining the main canal, control over checking and groundwater pumping.

1.4 Alternative Design Levels

Two of the proposed alternatives have been initially designed and estimated by the Omaha District prior to this current study. These alternatives include the Rock Ramp and Bypass Channel. The Rock Ramp alternative has been designed to a conceptual level while the Bypass Channel has previously been designed and estimated to the 100% design level. Thus the Bypass Channel has much more certainty and has far less chance of future changes, if any.

The remaining three expanded alternatives have been designed only to a conceptual level. These alternatives still have many investigations outstanding that could change many of the assumptions used in both the designs and estimates. Moving into future design phases with any of these alternatives would allow for development of more integrated hydraulic, geotechnical and other technical studies such that many assumptions here within would be modified as necessary.

1.5 Estimates for Comparison Purposes

Given that some of the estimates have been previously completed and/or designed to different levels of detail, each of the five proposed alternative estimates have been newly developed or updated in order for the total project costs to be comparable. These modifications include the updating of price levels based on USACE Civil Works escalation factors, modifying contingencies to reflect associated risks at the estimates' current design levels, and attempting to maintain similar assumptions across all five alternatives. The following sections discuss each of these items in more detail as they relate to each of the five alternatives.

2.0 Initial Alternatives

This section discusses the changes made to the cost estimates of the two initial alternatives such that they would be comparable with three newly proposed alternatives. The two previously estimated alternatives, Rock Ramp and Bypass Channel, were developed by USACE, Omaha District (NWO). For this current study, the primary modifications to these two estimates is to escalate the total costs per the Civil Works Construction Cost Index System (CWCCIS) found in EM 1110-2-1304, and to incorporate an updated abbreviated risk analysis contingency mark-up. The following section is a discussion of these two alternatives and the assumptions made to complete the necessary price level updates for inclusion into a Total Project Cost Summary (TPCS).

2.1 Detailed Alternative Descriptions

2.1.1 Rock Ramp

The Rock Ramp alternative would replace the existing rock and timber crib structure at the Intake Diversion Dam with a concrete weir and a shallow-sloped, un-grouted boulder and cobble rock ramp. The rock ramp would be designed to mimic natural river function and would have reduced velocities and turbulence so that migrating fish could pass over the dam, thereby improving fish passage and contributing to ecosystem restoration.

The replacement concrete weir would approximately 40 feet upstream of the existing weir, and would create sufficient water height to divert 1,374 cfs into the main canal. The cast-in-place reinforced concrete weir would replace the existing timber and rock-filled dam and would provide long-term durability that is lacking in the current structure. The weir crest would vary in elevation, including at least one low-flow channel for fish passage. The historic headworks would be preserved in placed and would serve as a weir abutment on the north bank, while a concrete abutment would be constructed on the south bank. The downstream side of the weir would tie directly into the rock ramp to provide a seamless transition and unimpeded fish passage.

The rock ramp would be constructed downstream of the replacement weir by placing rock and fill material in the river channel to shape the ramp, followed by placement of rock riprap. The new ramp would be constructed over the site of the existing Intake Diversion Dam, preserving most of the historic dam in place. The new ramp would include at least one low flow channel in conjunction with the low flow channel on the weir crest. The rocks in the ramp would be sized to withstand high flows and ice jams and would range from 1 – 4 feet in diameter. The rock would be purchased from commercial quarries in either Wyoming or Minnesota and likely delivered by train to Glendive before being trucked to the project site.

Staging and rock stockpile areas would be located downstream of the headworks and another construction zone would be located on the Joe’s Island side of the dam. Haul roads and a temporary crossing over the main canal would need to be constructed to prevent damage to the existing county bridge.

2.1.2 Bypass Channel

The Bypass Channel alternative would construct a bypass channel on Joe's Island from the inlet of the existing high flow chute to just downstream of the existing dam and rubble field. It would also replace the existing Intake Diversion Dam with a concrete weir. The placement of the bypass channel is thought to allow fish better access to the channel and increase their abilities to migrate upstream of the intake dam.

The bypass channel would be designed to divert approximately 13-15% of total Yellowstone River flows. Significant quantities of excavation would be required to create the channel. The excavated material is assumed to be disposed of all within Joe's Island, and therefore no material would be required to be hauled off-site. Sheet pile cofferdams would be required to complete the channel construction. Two vertical control structures would be constructed within the bypass channel. These structures would consist of riprap and would give the appearance of a seamless channel invert while providing stability during extreme events. The bypass channel would also require stone placement for bank protection and on the channel bed to minimize the risk of erosion. The riprap for the bank protection would be purchased from acceptable quarries and transported to the project site, while the bedding stone is assumed to be screened from the excavation of the bypass channel.

The concrete weir would be constructed approximately 40 feet upstream of the existing dam. The new weir would provide adequate water surface elevations for splitting the river flow into the new bypass channel and also ensuring delivery of irrigation water. The weir would consist of a cantilevered structural wall created by a deep foundation of either driven piles or drilled shafts with a concrete cap. Fill would be placed between the new weir and the existing rock weir, and the new crest would contain at least one low-flow channel for fish passage.

2.2 Basis of Estimates

2.2.1 Rock Ramp

The MCACES construction cost estimate was completed by the NWO during previous alternatives analysis for this project. The MCACES estimate provided by the NWO for use in this current study was completed in April 2011. For inclusion in the economic analysis, the estimate has been escalated to a current pricing date of April 2016. The Civil Works Construction Cost Index System (CWCCIS) escalation factors were used in the escalation of the construction costs. The CWCCIS factors calculate to an approximate 8.25% increase to each feature account. The original MCACES costs along with the escalation factors and current total costs are provided in Table 2-1.

Table 2.1 Rock Ramp Escalation Factors and Cost Updates

Feature Account	Item Description from MCACES	Original Costs (3Q11)	CWCCIS Factor (3Q11)	CWCCIS Factor (3Q16)	Current Costs
06	Coffer Dam	$3,850,361	740.70	801.79	$4,167,924
06	Rock Ramp	$42,351,677	740.70	801.79	$45,844,675
06	Remaining Site Work	$939,069	740.70	801.79	$1,016,520
15	Concrete Crest Structure	$8,268,256	740.70	801.79	$8,950,189
				Total Construction Cost:	$59,979,308
				Total Escalation Percent:	8.25%

2.2.2 Bypass Channel

A MCACES construction cost estimate developed in accordance with final design plans has been developed by NWO. However, this estimate was set up in accordance with the bid schedule, and therefore did not include sorting into CWCCIS feature accounts. Therefore it was decided that the 90% estimate, which still contained costs sorted into feature accounts, would be used for the purposes of completing the analysis for this study.

This 90% MCACES construction cost estimate was prepared in February 2015 by NWO. For inclusion in the current economic analysis, the estimate has been escalated to a current pricing date of April 2016. The CWCCIS escalation factors were used in the escalation of the construction costs. The CWCCIS factors calculate to an approximate 1.93% increase on total construction costs. The original MCACES costs along with the escalation factors and current total costs are provided in Table 2-2.

Table 2.2 Bypass Channel Escalation Factors and Cost Updates

Feature Account	Item Description from MCACES	Original Costs (2Q15)	CWCCIS Factor (2Q15)	CWCCIS Factor (3Q16)	Current Costs
09	Bypass Channel	$17,707,099	845.53	861.75	$18,046,778
15	Intake Weir	$12,065,928	788.66	801.79	$12,266,807
16	Bank Stabilization Rock	$18,714,085	837.55	855.31	$19,110,912
				Total Construction Cost:	$49,424,497
				Total Escalation Percent:	1.93%

2.3 Total Project Cost Summary (TPCS)

The escalated costs have been input into the latest version of the TPCS Excel spreadsheet provided by the USACE, Walla Walla District. The TPCS incorporates the projects constructions costs, project markups, and functional costs. The escalated prices shown in the Table 2-1 and Table 2-2 have been input into the TPCS and have been escalated to both the program year (FY17) and the midpoint of construction per the project schedule. The TPCS spreadsheets are provided in Attachment B.1.

2.4 Project Schedules

The durations used for the construction components are based on discussions and schedules previously developed. These discussions and scheduling information are from the following documents.

- Intake Diversion Dam Modification, Lower Yellowstone Project, Final EA (2010).
- Intake Diversion Dam Modification Project, Cost Appendix, Summary of Fish Passage Design Features (2012).

From the discussion and information within these two reports, simplified project schedules have been developed for use in this study. The tentative project schedules are provided in Attachment B.2 and are based on the following assumptions:

- The Bypass Channel alternative does not include a design phase, as this alternative has already been fully designed. Thus construction could begin much sooner than the other alternatives.
- Assumes design phase of the Rock Ramp alternative would begin in May of 2016.
- Construction would begin in May of 2016 for the Bypass Channel, and May of 2018 for the Rock Ramp alternative.

2.5 Functional Costs

2.5.1 01 Account – Lands and Damages

There are currently no costs assumed for this account, as the NWO did not include real estate costs in their original analysis. However, based on estimated real estate costs developed for other alternatives in this current study, it is not likely that real estate costs would be significant. Therefore, no costs for this account have been added.

2.5.2 02 Account – Relocations

No relocations items were included in the original NWO estimates for either alternative. Therefore no costs are included in either estimate for this feature account.

2.5.3 06 Account – Fish and Wildlife Facilities

In addition to the construction costs, costs for monitoring and adaptive management during construction have been included in the TPCS. These costs are currently estimated at 1.0% of total construction costs.

2.5.4 30 Account – Planning, Engineering and Design (PED)

Costs for this account were estimated as percentages of construction costs for the various feature accounts. This account covers planning, engineering and design including; preparation of plans, specifications, and engineering during construction. The current estimate assumes 9.0% of construction costs for this account for the Rock Ramp alternative. This value is the same percentage used by the NWO in previous analysis on this project.

No PED markup is included for the Bypass Channel alternative. This is due to this alternative already having 100% design plans developed. Thus, no further PED expenditures would be required for this alternative to proceed to construction.

2.5.5 31 Account – Construction Management (CM)

Costs for this account were estimated as percentages of construction costs of the various feature accounts. This costs is assumed to cover construction management during the construction phase. The current estimate assumes 6.0% of construction costs for this account. This value is the same percentage used by the NWO in previous analysis on this project.

2.6 Project Markups

2.6.1 Escalation

After the MCACES construction costs for both alternatives have been escalated to current prices (3Q16), the costs have been escalated to the program year (1Q17) as well as to the midpoints of construction to estimate the fully funded project cost. The appropriate escalation cost factors for each date and for each feature account have been calculated within the Total Project Cost Summary.

2.6.2 Contingency

An Abbreviated Risk Analysis (ARA) was completed in order to develop the contingency percent used for each alternative. The separate calculated contingencies for construction, PED and CM were used within the TPCS for both alternatives. The ARA documents for these alternatives are found in Attachment B.3.

The overall project contingency for the Rock Ramp is currently 31.0% and the overall project contingency for the Bypass Channel is 8.8%. The Bypass Channel contingency is significantly lower due to the fact that the estimate is based on 90% design plans. Therefore, at this level of design, most risks have been mitigated in the design, and funding streams are already in place.

3.0 Expanded Alternatives

This section discusses the three alternatives that have recently been designed and estimated for use in this study. Each of these three alternatives (Modified Side Channel, Multiple Pump Stations, and Multiple Pumps with Conservation Measures) have been designed to a conceptual level and estimated by Tetra Tech. The following sections discuss each alternative and the assumptions used in the development of MCACES construction cost estimates and TPCS documents such that they are comparable to the Initial Alternatives.

3.1 Detailed Alternative Descriptions

3.1.1 Modified Side Channel

The Modified Side Channel alternative would improve fish passage by creating a fish bypass using the existing "high flow channel." Pallid sturgeon have been documented to pass through the existing high flow channel in previous years. Therefore if the existing channel is constructed to allow for additional and more frequent flows, then it would also provide greater fish passage.

The construction required to allow for additional flow would require the creation of approximately 6,000 feet of new channel. The new channel sections would cutoff several existing bends and create new backwater areas. The entire high flow channel would be lowered significantly and would require bank protection in several areas as well as five grade control structures.

3.1.2 Multiple Pump

The Multiple Pump alternative proposes removing the Intake Diversion Dam, using the existing headworks when there is sufficient flow in the Yellowstone River to gravity divert the required flows, and constructing five pumping stations along the banks of the Yellowstone River to deliver water to the Lower Yellowstone Irrigation Project to be operated when gravity flows are insufficient. The pumping plants would be constructed at various locations along the Lower Yellowstone River between Intake Dam and Savage. The intakes would be screened to minimize fish entrainment and would discharge into existing canals to supply the irrigation districts. Because the irrigation canal system was designed for gravity flow of water primarily from a single water source at Intake, this alternative would require some restructuring of the Lower Yellowstone Irrigation Project canal system to accommodate a water supply from multiple points along the canal.

The pumping stations would be designed for a total diversion capacity of 1,374 cfs when the flow in the Yellowstone River is 3,000 cfs at the upper most point of diversion. Each of the five pumping stations would be designed for a capacity of 275 cfs. Water would be drawn from the river through a feeder canal to a fish screen structure, located at the edge of the channel migration zone. The motors and electrical equipment in both the fish screen structure and the pump station would be located above the 100-year flood elevation. Fish would be screened out and returned to the river through a fish return pipe and irrigation water would pass through the fish screen and flow into the pumping station. Discharge pipes would convey the irrigation water to the main irrigation canal.

3.1.3 Multiple Pumps with Conservation Measures

The Multiple Pumps with Conservation Measures alternative includes four primary components including the implementation of water conservation measures, pumping, gravity diversions through the existing headworks and use of wind energy to offset pumping costs. The removal of the dam would allow passage on the Yellowstone River, and other components would provide a continued water source to the Lower Yellowstone Irrigation District.

The conservation measures are proposed to reduce the amount of water needed by the project by reducing inefficiency losses in the delivery system and on the farms. The proposed level of conservation is assumed to be completed by installing/completing the following:

- Installation of check structures to provide water control along the canal as a means of maintaining water levels high enough to allow match between water needs and water diversions
- Installation of flow measuring devices on the main canal and laterals to measure water flows in areas where there is no monitoring currently.
- Converting existing laterals from open ditches to pipes to reduce losses from evaporation, seepage, bank vegetation consumption and spillage.
- Convert farms from flood irrigation to sprinkler irrigation to provide more efficient water use to certain farms.
- Lining of the main canal with 3-inches of shotcrete over a geomembrane layer to lessen losses in the canal from seepage.
- Control of over checking to avoid higher than necessary water levels. Over checking can exacerbate the seepage losses on unlined canals.
- Installing groundwater pumps to provide water for irrigation when needed.

This alternative would also require the installation of Ranney Wells to provide water to the main canal after removal of the existing Intake Diversion Dam. The Ranney Well pumping stations would be installed at seven sites along the Yellowstone River and would the wells would pump water directly into the canal. The energy needed to operate the numerous Ranney Wells is assumed to be off-set by the construction of a wind turbine at a pre-existing wind farm. Once built, the LYIP is assumed to obtain a banking agreement such that the energy costs to operate the wells would be zero.

3.2 MCACES Construction Cost Estimates

The three new alternatives were estimated using MCACES 2nd Generation (MII) cost estimating software in accordance with guidance contained in ER 1110-2-1302, Civil Works Cost Engineering.

3.3 Basis of Estimate

3.3.1 Basis of Design

The available design documents for these three alternatives can all be found in Attachments A-1, A-2 and A-3 of the Lower Yellowstone Intake Diversion Dam Fish Passage Project, Montana, Draft Environmental Impact Statement (EIS) (2016). These sections of the EIS contain detailed discussions of the design development and contain all conceptual level design drawings that were used in the estimating process.

3.3.2 Basis of Quantities

The cost estimates are based on project quantity take-offs that have been calculated in accordance with the attachments referenced in the EIS. A quantity summary and detailed quantity take-offs that correspond to the three expanded alternative MCACES cost estimates are found in Attachment B.4.

3.4 Project Schedules

Simplified tentative project schedules have been developed for each of these three construction alternatives. The durations for each of the alternatives have been used in the cost estimates to determine costs for the contractor to maintain field facilities and provide construction supervision. The simplified tentative project schedules are presented in Attachment B.2. These schedules have been developed with the following assumptions:

- Assumes design phase would begin in May of 2016
- Assumes contractor would try and avoid major construction activities that could interrupt the water supply during the irrigation season, which is assumed to be from the middle of April through September.
- Assumes crews would work 10 hours per day and 6 days per week.

3.5 Acquisition Plan

Each cost estimate currently assumes that the projects would be let out in an unrestricted bid process and are expected to have a competitive bidding market. Due to the size of the proposed projects, no small business contracts are assumed. Each estimate has prime and subcontracting assumptions based on an alternative by alternative basis. A brief discussion of the assumptions used in the estimate are below.

- Modified Side Channel – The cost estimate is based on one contract being awarded to a prime contractor to complete the work. The estimate currently assumes that there would be subcontractors required for concrete, landscape and pile driving work. The prime contractor would be responsible for all the preparatory work, and placing all associated site work as well as overseeing the subcontractors' efforts.

- Multiple Pump Stations - The cost estimate is based on two contracts being awarded to a prime contractor. The first contract would be let out for the installation of all five pump stations. The prime contractor for this is currently assumed to be able to handle all the earthwork, but is assumed to require subcontractors for the concrete, pile driving, electrical and pump installation work. The second contract is assumed to be awarded to a prime contractor that would have the capabilities to complete all aspects of the existing dam removal.

- Multiple Pumps with Conservation Measures - The cost estimate is based on six contracts being awarded to a prime contractor to complete. These six contracts, in no particular order) would account for the following: 1) Removal of the existing Intake Diversion Dam, 2) Lining the main canal and converting laterals into pipes, 3) Installing check structures and flow measuring devices, 4) Converting farms to center pivot sprinklers, 5) Erecting a 2 megawatt wind turbine, and 6) Installing the Ranney Wells.

3.6 Project Construction

The following is a brief summary of the key construction elements and the estimated construction methodology for each alternative.

3.6.1 Modified Side Channel

This alternative would require three staging areas and a gravel construction access road installed along the north and east side of the high flow channel. The staging areas and access roads would require the placement of gravel. A single span access bridge would also need to be placed across the high flow channel to allow for access to both sides of the channel. A cofferdam would then be required to facilitate channel excavation at both the upstream and downstream tie-in locations.

The cofferdams would consist of sheet piles to reduce seepage with an earthen embankment placed over them. The embankment would have bank protection stone placed on the slopes.

Channel excavation would be completed to construct three bend cutoffs and to lower and widen the existing channel. Approximately one third of the material excavated would be used as fill that would be placed in existing bends in order to cut those sections off. The remaining excavated material would be disposed of at the proposed spoil area located on Joe's Island. The disposal location would require some sediment and erosion control measures. Lastly the newly formed high flow channel would have bank protection installed. This bank protection consist of a bedding layer beneath riprap.

3.6.2 Multiple Pump Stations

This alternative includes the construction of five pump stations along the Yellowstone River. Each of the stations would require the construction of a staging area and access roads that would be cleared, graded, and have gravel placed. The excavation for the pump station would begin first. After the excavation is complete the placement of the reinforced concrete floors, walls and top slab would be completed. Upon completion of the concrete work all pump station items including pumps, motors, piping, and steel structure would be completed.

A feeder canal would also need to be constructed leading to the pump station. The feeder canal would require the installation of sheet piling for dewatering purposes. The canal area would be cleared prior to be being excavated. A steel trash rack would be installed in the feeder canal as well.

To prevent fish from entering the irrigation pumps, a fish screen structure would also be constructed. The fish screen would require clearing and excavation. Then reinforced concrete foundations, floors, footings and walls would be installed. The fish screen steel supports, screen and deadplates would be installed next. A return pump and pipes would be installed to return fish to the river.

After the pump stations are complete and operational, then the existing Intake Diversion Dam would be removed. The removal of the dam would likely occur in two phases. The initial phase would require steel sheet piles placed just upstream of the dam and downstream of the boulder field. An earthen embankment would be placed, in lieu of sheet piles, over the boulder field to connect the two sheet pile walls. An earthen embankment was assumed because of the uncertain and risk associated with attempting to drive sheet piles through the existing rock dam and boulder field.

After construction of the initial phase cofferdam, a portion of the existing dam and boulder field would be removed. It is assumed that the rock removed would be hauled locally on Joe's Island for stockpiling such that the stone could be reused in the future. After the rock and dam removal is complete, a new sheet pile cofferdam could be driven and the earthen embankment removed. Then the cofferdam would be extended across the remaining portion of the dam and boulder field to allow for the removal of the remaining section of the dam.

3.6.3 Multiple Pumps with Conservation Measures

This alternative has numerous components with some taking multiple years to place due to the scope of the project and/or due to possible narrow work windows that may be required to avoid impacting the irrigation season and the extreme cold weather months. Therefore the following is more a general discussion of each of the components and the assumptions for work required to complete that were used in the estimate, and not necessarily a detailed sequencing of all work.

- Convert Laterals from Ditches to Pipe – This work assumes replacing existing earthen ditches, primarily in the most downstream reaches, to reinforced concrete pipe. Based on the existing dimensions of the laterals, it has been assumed that the pipe sizes required would vary from 18 inches to 72 inches. Some laterals would require far greater pipe sizes, and even double or triple barrel piping. Thus it was assumed after 72 inches the lateral would be lined with shotcrete with same procedures as the lining of the main canal.

The new pipes would be placed in the existing laterals on top of a base layer. Once the pipes are laid the pipe, and remaining area of the lateral, would be backfilled.

- Line Main Canal – To reduce seepage losses it is proposed that the entire main canal would be lined with shotcrete placed on top of a geomembrane liner. Prior to placing the shotcrete, the channel would need to be filled to approximately half the current volume due to the significant decrease in flows. The fill material for this is assumed to come from a borrow site within the study region, and therefore would not be purchased. After filling and grading the canal a geomembrane liner would be placed beneath a 3 inch layer of fiber reinforced shotcrete.

- Check Structures – Nine new check structures are anticipated to be constructed within the main canal. These check structures would require earthwork prior to placing the reinforced concrete structures. The check structures would also have hydraulic gates installed for controlling flows. Lastly, riprap erosion protection would be placed.

- Flow Measuring Devices – Numerous flow measuring devices are proposed to be installed at various locations throughout the study region. There are two types of measuring devices proposed, Cipolletti weir and Parshall flumes. These are both concrete structures and can vary in size. Each of the measuring device types would require some earthwork along with reinforced cast-in-place concrete.

- Convert Fields from Flood Irrigation to Sprinklers - Approximately 5,000 acres of flood irrigated farmland is assumed to be converted to sprinkler irrigation. It is assumed that center pivot sprinklers would be installed, and these sprinklers would require pumps for pressurization. The cost estimate also includes costs of installing power lines to the sprinkler systems.

- Renewable Energy Resources – The estimate includes the cost to install a 2 megawatt (MW) wind turbine and a pre-existing windfarm. The construction of the turbine is assumed to offset the cost of the Ranney Well operations.

- Ranney Wells – The Ranney Wells are required to have test drilling and pumping tests. Once finalized, the pumps would be manufactured and the pump station constructed. The Ranney Wells would also require discharge and collector pipelines. Access roads to the pump station would also be built.

3.7 Effective Dates for Labor, Equipment and Material Pricing

The labor, equipment, and material pricing were developed using the MCACES 2012 English Unit Cost Library, 2016 Richland County Labor Library (see Attachment B.5 for Davis-Bacon wages used), and the 2014 Equipment Library (Region IV) for the base cost estimates. The index pricing data has been prepared in April 2016 dollars.

The cost estimate has been updated with current quoted fuel prices of $1.66/gal for off-road diesel, $1.94/gal for on-road diesel and $1.95/gal for gasoline in the Glendive, MT area.

3.8 Estimated Construction Durations

The estimate contains many user created cost items that were developed outside of the MCACES Unit Cost Library. These developed cost items have had crews and production rates created in order to accurately calculate unit costs. See Attachment B.6 for the estimated production rates and duration estimates for these construction items.

3.9 Direct and Contractor Markups

3.9.1 Direct Markups

The cost estimate for each alternative includes a direct markup for crews and equipment working overtime. The markup is calculated in MCACES and is based on the assumption that crews would be working 10 hours per day and 6 days per week. The markup percentage used in the estimate is 16.67 percent.

3.9.2 Contractor Markups

The prime contractor Job Office Overhead (JOOH) markup for each alternative is based on a calculated percentage within MCACES. The JOOH calculation is based off the estimated duration for all construction components. A running percentage has been used in the estimate for the prime contractor Home Office Overhead (HOOH) markup. Profit is included for the prime contractor and is calculated using the profit weighted guideline calculation within MCACES. Bonding has also been included for the prime and sub-contractors.

3.10 Functional Costs

3.10.1 01 Account – Lands and Damages

Real Estate costs have been estimated for these three alternatives. The alternative footprints were overlaid onto parcel data in order to determine the area required to be purchased. Then a value of $10,000 per acre was assumed to be used for purchasing these lands. This value was provided by the Bureau of Reclamation, and was based on reasonable land purchases by the Bureau on other recent projects.

For this project the following acres and costs were included in the TPCS, with an assumed 25% contingency.

Table 3.1 Summary of Assumed Real Estate Costs

Alternative	Acres to be Purchased	Cost per Acre	Total Cost*
Modified Side Channel	22 acres	$10,000	$220,000
Multiple Pump Stations	44.3 acres	$10,000	$443,300
Multiple Pumps with Conservation	280 acres	$10,000	$2,800,000
* Note: Costs do not contain contingency			

3.10.2 02 Account – Relocations

Current analysis for each of the three expanded alternatives shows no relocations within the project extent. Therefore, at this time, no relocation costs are included in any of these three alternatives.

3.10.3 06 Account – Fish and Wildlife Facilities

In addition to the construction costs, costs for adaptive management during construction have been included in the TPCS. These costs are currently estimated at 1.0% of total construction costs.

3.10.4 30 Account – Planning, Engineering and Design (PED)

Costs for this account were estimated as percentages of construction costs for the various feature accounts. This account covers the planning, engineering and design including; preparation of plans, specifications, and engineering during construction. The current estimate assumes 9.0% of construction costs for this account. This value is the same percentage used by the NWO in previous analysis on this project.

3.10.5 31 Account – Construction Management (CM)

Costs for this account were estimated as percentages of construction costs of the various feature accounts. This costs is assumed to cover construction management during the construction phase. The current estimate assumes 6.0% of construction costs for this account. This value is the same percentage used by the NWO in previous analysis on this project.

3.11 Project Markups

3.11.1 Escalation

Each alternative construction cost has been escalated to the program year (1Q17) as well as to the midpoints of construction to calculate the fully funded project cost. The appropriate escalation cost factors for each date and for each feature account have been calculated within the Total Project Cost Summary spreadsheets.

3.11.2 Contingency

An Abbreviated Risk Analysis (ARA) has been completed in order to develop the contingency values for each alternative. The calculated contingencies reflect the uncertainty in designs and other aspects of the alternatives. However, the contingencies are primarily weighted towards the levels of uncertainty in the significant cost drivers of the MCACES estimates. Alternatively stated, the alternatives with less risk of cost increases to these significant cost drivers, in relation to the total cost, are likely to have lower contingencies. The ARA documents are provided in Attachment B.3, and the overall project contingencies for each alternative are as follows:

- Modified Side Channel – 33.7%
- Multiple Pump Stations – 35.4%
- Multiple Pumps with Conservation Measures – 31.6%

3.12 Total Project Cost Summary (TPCS)

A TPCS has been prepared for each alternative using the latest TPCS Excel spreadsheet provided by the USACE, Walla Walla District. The TPCS incorporates the projects construction costs, project markups, and functional costs. The TPCS uses these current price level costs and further escalates to the program year and estimated midpoint of construction for each alternative. The TPCS for each alternative is presented in Attachment B.1.

3.13 MCACES Construction Cost Estimate Summaries

Summary printouts of the MCACES cost estimates can be found in Attachment B.7. The costs shown in these summaries is for construction work only, and does not include PED, CM, escalation or contingencies.

4.0 First Cost Summaries

This section provides summary tables of each of the action alternatives' project costs. These summaries are broken out by work breakdown structure and include the current MCACES costs, functional costs, and estimated contingencies from the risk analysis documents. The costs in the following tables are in third quarter 2016 prices (3Q16), and the tables do not include escalation. The values match the rounded values from the "Estimated Cost" column in the TPCS sheets found in Attachment B.1.

Table 4.1 Rock Ramp Alternative First Cost Summary

Work Breakdown Structure Feature Account	Cost	Contingency	Total Cost
01 - Real Estate (LERRDs)	-	25.00%	-
06 - Fish and Wildlife Facilities (Adaptive Mgmt.)	$600,000	32.70%	$796,000
06 - Fish and Wildlife Facilities	$51,029,000	32.70%	$67,715,000
15 - Floodway Control & Diversion Structure	$8,950,000	32.70%	$11,877,000
30 - Planning, Engineering & Design (PED)	$5,453,000	18.84%	$6,480,000
31 - Construction Management (CM)	$3,635,000	20.55%	$4,382,000
		Total Estimated Cost:	**$91,250,000**

Table 4.2 Bypass Channel Alternative First Cost Summary

Work Breakdown Structure Feature Account	Cost	Contingency	Total Cost
01 - Real Estate (LERRDs)	-	25.00%	-
06 - Fish and Wildlife Facilities (Adaptive Mgmt.)	$494,000	8.82%	$538,000
09 - Channels and Canals	$18,047,000	8.82%	$19,639,000
15 - Floodway Control & Diversion Structure	$12,267,000	8.82%	$13,349,000
16 - Bank Stabilization	$19,111,000	8.82%	$20,797,000
30 - Planning, Engineering & Design (PED)	-	8.82%	-
		Total Estimated Cost:	**$57,582,000**

Table 4.3 Modified Side Channel Alternative First Cost Summary

Work Breakdown Structure Feature Account	Cost	Contingency	Total Cost
01 - Real Estate (LERRDs)	$220,000	25.00%	$275,000
06 - Fish and Wildlife Facilities (Adaptive Mgmt.)	$352,000	35.18%	$476,000
08 - Roads, Railroads and Bridges	$1,042,000	35.18%	$1,408,000
09 - Channels and Canals	$16,703,000	35.18%	$22,579,000
16 - Bank Stabilization	$17,436,000	35.18%	$23,570,000
30 - Planning, Engineering & Design (PED)	$3,201,000	23.21%	$3,944,000
31 - Construction Management (CM)	$2,133,000	24.93%	$2,665,000
		Total Estimated Cost:	**$54,916,000**

Table 4.4 Multiple Pump Stations Alternative First Cost Summary

Work Breakdown Structure Feature Account	Cost	Contingency	Total Cost
01 - Real Estate (LERRDs)	$443,000	25.00%	$554,000
04 - Dams	$6,600,000	36.83%	$9,030,000
06 - Fish and Wildlife Facilities (Adaptive Mgmt.)	$843,000	36.83%	$1,153,000
19 - Buildings Grounds and Utilities	$77,678,000	36.83%	$106,284,000
30 - Planning, Engineering & Design (PED)	$7,664,000	26.52%	$9,697,000
31 - Construction Management (CM)	$5,108,000	26.52%	$6,463,000
		Total Estimated Cost:	**$133,180,000**

Table 4.5 Multiple Pumps with Conservation Measures Alternative First Cost Summary

Work Breakdown Structure Feature Account	Cost	Contingency	Total Cost
01 - Real Estate (LERRDs)	$2,800,000	25.00%	$3,500,000
04 - Dams	$7,037,000	32.38%	$9,315,000
06 - Fish and Wildlife Facilities (Adaptive Mgmt.)	$3,131,000	32.38%	$4,144,000
09 - Channels and Canals	$195,853,000	32.38%	$259,261,000
19 - Buildings, Grounds and Utilities	$18,703,000	32.38%	$24,758,000
20 - Permanent Operating Equipment	$91,468,000	32.38%	$121,082,000
30 - Planning, Engineering & Design (PED)	$28,458,000	26.52%	$36,006,000
31 - Construction Management (CM)	$18,972,000	26.52%	$24,004,000
		Total Estimated Cost:	**$482,069,000**

5.0 Operations, Maintenance and Repairs

Cost estimates have been developed for the No Action alternative as well as each of the construction alternatives for the anticipated costs for operations, maintenance and repairs (OM&R) over the life cycle of the project (assumed to be 50-years). These estimates are conceptual level estimates for each of the five construction alternatives and have been calculated for comparison purposes only.

5.1 OM&R Development

In order to estimate the OM&R costs for each alternative, general assumptions had to be made to determine how much costs would be spent each and every year over the lifespan of the project. This was completed in spreadsheet format where a list of assumptions was developed that noted the OM&R item, the assumed annual cost, and the assumed number of occurrences over a 50 year project life. From there a matrix was developed to display the costs for each year and which OM&R item occurs in any given year. These OM&R calculation spreadsheets are provided in Attachment B.8.

Information and costs were gathered from the Lower Yellowstone Irrigation Project (LYIP), the Bureau of Reclamation, and the USACE for use in the OM&R estimates. The current costs have been reviewed by staff from these entities, and updates to the estimates have been developed by BOR, but are still subject to change as the project progresses. Table 5-1 shows the current net present value of OM&R costs over the 50 year project life as well as the average annual costs for OM&R after discounting.

Discounting of the OM&R costs is completed in order to compare benefits and costs that are in different time scales. Thus, discounting is used to express the future OM&R costs in today's equivalent values. The current Federal discount rate of 3.125% has been used to calculate the discount factors for each and every year over the O&M timeframe. These factors are shown in the annual O&M tables found in Attachment B.8.

Table 5.1 Summary of Annual OM&R Costs

Alternative	Net Present Value of OM&R	Average Annual OM&R[1]
No Action	$66,419,873	$2,643,043
Rock Ramp	$71,370,121	$2,840,028
Bypass Channel	$70,333,034	$2,798,759
Modified Side Channel	$73,045,804	$2,906,708
Multiple Pump Stations	$124,394,601	$4,950,029
Multiple Pumps with Conservation	$114,768,141	$4,566,963

1. Average Annual OM&R is based on 50-year period of analysis and 3.125% Federal discount rate

6.0 References

US Army Corps of Engineers (USACE). 1993. “ER 1110-1-1300: Engineering and Design Cost Engineering Policy and General Requirements.” Washington D.C.

US Army Corps of Engineers (USACE). 1999. “ER 1110-2-1150: Engineering and Design for Civil Works Projects.” Washington D.C.

US Army Corps of Engineers (USACE). 2008a. “ER 1110-2-1302: Civil Works Cost Engineering.” Washington D.C.

US Army Corps of Engineers (USACE). 2008b. “ETL 1110-2-573: Construction Cost Estimating Guide for Civil Works.” Washington D.C.

US Army Corps of Engineers (USACE). 2010. “EM 1110-2-1304: Civil Works Construction Cost Index System (CWCCIS).” Washington D.C.

US Army Corps of Engineers (USACE). 2012. “Intake Diversion Dam Modification Project Cost Appendix, Summary of Fish Passage Design Features Concepts and Cost Implications.” Omaha, NE.

U.S. Bureau of Reclamation (Reclamation) and U.S. Army Corps of Engineers (USACE). 2010. Intake Diversion Dam Modification, Lower Yellowstone Project, Montana, Final Environmental Assessment. Report and Appendixes.

U.S. Bureau of Reclamation (Reclamation) and U.S. Army Corps of Engineers (USACE). 2015. Intake Diversion Dam Modification, Lower Yellowstone Project, Montana, Final Supplement to the 2010 Environmental Assessment. Including all attachments.

Attachment B.1
Total Project Cost Summary (TPCS) Spreadsheets

Rock Ramp TPCS

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: **Yellowstone River - Rock Ramp Alternative**
PROJECT NO: 0
LOCATION: Yellowstone River, MT and ND

DISTRICT: Omaha (NWO) **PREPARED: 5/19/2016**
POC: CHIEF, COST ENGINEERING, xxx

This Estimate reflects the scope and schedule in report; Lower Yellowstone River Intake Diversion Dam Modification Project, Eng. Appx.

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**						**TOTAL PROJECT COST (FULLY FUNDED)**			
						Program Year (Budget EC): 2017 Effective Price Level Date: 1 OCT 16									
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	**TOTAL ($K)** *J*	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K) *K*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
06	FISH & WILDLIFE FACILITIES	$51,029	$16,686	32.7%	$67,715	1.8%	$51,931	$16,981	$68,912	$0	$68,912	5.4%	$54,750	$17,903	$72,653
06	FISH & WILDLIFE FACILITIES (Monitoring & Adaptive Mgmt.)	$600	$196	32.7%	$796	1.8%	$610	$200	$810	$0	$810	5.4%	$644	$210	$854
15	FLOODWAY CONTROL & DIVERSION STRUCTURE	$8,950	$2,927	32.7%	$11,877	1.8%	$9,108	$2,978	$12,087	$0	$12,087	5.4%	$9,603	$3,140	$12,743
	CONSTRUCTION ESTIMATE TOTALS:	$60,579	$19,809		$80,388	1.8%	$61,650	$20,159	$81,809	$0	$81,809	5.4%	$64,997	$21,253	$86,250
01	LANDS AND DAMAGES	$0	$0 -		$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN	$5,453	$1,027	18.8%	$6,480	3.6%	$5,650	$1,064	$6,714	$0	$6,714	3.0%	$5,821	$1,096	$6,917
31	CONSTRUCTION MANAGEMENT	$3,635	$747	20.6%	$4,382	3.6%	$3,766	$774	$4,540	$0	$4,540	11.4%	$4,195	$862	$5,058
	PROJECT COST TOTALS:	$69,667	$21,583	31.0%	$91,250		$71,066	$21,997	**$93,063**	$0	**$93,063**	5.5%	$75,013	$23,212	$98,225

______________________ **CHIEF, COST ENGINEERING, xxx**

______________________ **PROJECT MANAGER, xxx**

______________________ **CHIEF, REAL ESTATE, xxx**

______________________ **CHIEF, PLANNING,xxx**

______________________ **CHIEF, ENGINEERING, xxx**

______________________ **CHIEF, OPERATIONS, xxx**

______________________ **CHIEF, CONSTRUCTION, xxx**

______________________ **CHIEF, CONTRACTING,xxx**

______________________ **CHIEF, PM-PB, xxxx**

______________________ **CHIEF, DPM, xxx**

ESTIMATED FEDERAL COST:	**100%**	**$98,225**
ESTIMATED NON-FEDERAL COST:	**0%**	**$0**
ESTIMATED TOTAL PROJECT COST:		**$98,225**

**** TOTAL PROJECT COST SUMMARY ****

CONTRACT 1

**** CONTRACT COST SUMMARY ****

PROJECT: Yellowstone River - Rock Ramp Alternative
LOCATION: Yellowstone River, MT and ND
This Estimate reflects the scope and schedule in report; Lower Yellowstone River Intake Diversion Dam Modification Project, Eng. Appx.

DISTRICT: Omaha (NWO)
POC: CHIEF, COST ENGINEERING, xxx
PREPARED: 5/19/2016

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			13-Apr-11	Program Year (Budget EC):			2017					
		Effective Price Level:			1-Oct-15	Effective Price Level Date:			1 OCT 16					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 1													
06	FISH & WILDLIFE FACILITIES	$51,029	$16,686	32.7%	$67,715	1.8%	$51,931	$16,981	$68,912	2019Q4	5.4%	$54,750	$17,903	$72,653
06	FISH & WILDLIFE FACILITIES (Monitoring & Adaptive Mgmt.)	$600	$196	32.7%	$796	1.8%	$610	$200	$810	2019Q4	5.4%	$644	$210	$854
15	FLOODWAY CONTROL & DIVERSION STRUCTURE	$8,950	$2,927	32.7%	$11,877	1.8%	$9,108	$2,978	$12,087	2019Q4	5.4%	$9,603	$3,140	$12,743
	CONSTRUCTION ESTIMATE TOTALS:	$60,579	$19,809	32.7%	**$80,388**		$61,650	$20,159	$81,809			$64,997	$21,253	$86,250
01	LANDS AND DAMAGES	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$303	$57	18.8%	$360	3.6%	$314	$59	$373	2017Q3	2.0%	$320	$60	$380
0.5%	Planning & Environmental Compliance	$303	$57	18.8%	$360	3.6%	$314	$59	$373	2017Q3	2.0%	$320	$60	$380
5.0%	Engineering & Design	$3,029	$571	18.8%	$3,600	3.6%	$3,138	$591	$3,729	2017Q3	2.0%	$3,200	$603	$3,803
0.5%	Reviews, ATRs, IEPRs, VE	$303	$57	18.8%	$360	3.6%	$314	$59	$373	2017Q3	2.0%	$320	$60	$380
0.5%	Life Cycle Updates (cost, schedule, risks)	$303	$57	18.8%	$360	3.6%	$314	$59	$373	2017Q3	2.0%	$320	$60	$380
0.5%	Contracting & Reprographics	$303	$57	18.8%	$360	3.6%	$314	$59	$373	2017Q3	2.0%	$320	$60	$380
0.5%	Engineering During Construction	$303	$57	18.8%	$360	3.6%	$314	$59	$373	2019Q4	11.4%	$350	$66	$416
0.5%	Planning During Construction	$303	$57	18.8%	$360	3.6%	$314	$59	$373	2019Q4	11.4%	$350	$66	$416
0.5%	Project Operations	$303	$57	18.8%	$360	3.6%	$314	$59	$373	2017Q3	2.0%	$320	$60	$380
31	CONSTRUCTION MANAGEMENT													
5.0%	Construction Management	$3,029	$623	20.6%	$3,652	3.6%	$3,138	$645	$3,783	2019Q4	11.4%	$3,496	$719	$4,214
0.5%	Project Operation:	$303	$62	20.6%	$365	3.6%	$314	$65	$378	2019Q4	11.4%	$350	$72	$422
0.5%	Project Management	$303	$62	20.6%	$365	3.6%	$314	$65	$378	2019Q4	11.4%	$350	$72	$422
	CONTRACT COST TOTALS:	$69,667	$21,583		$91,250		$71,066	$21,997	$93,063			$75,013	$23,212	$98,225

Bypass Channel TPCS

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **Yellowstone River - Bypass Channel Alternative**
PROJECT NO: 0
LOCATION: Yellowstone River, MT and ND

DISTRICT: Omaha (NWO)
POC: CHIEF, COST ENGINEERING, xxx

PREPARED: 5/19/2016

This Estimate reflects the scope and schedule in report; Lower Yellowstone River Intake Diversion Dam Modification Project, Eng. Appx.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2017; Effective Price Level Date: 1 OCT 16									
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	TOTAL ($K) J	Spent Thru: 10/1/2015 ($K)	TOTAL FIRST COST ($K) K	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
06	FISH & WILDLIFE FACILITIES (Adaptive Mgmt.)	$494	$44	8.8%	$538	1.8%	$503	$44	$547	$0	$547	1.4%	$510	$45	$555
09	CHANNELS & CANALS	$18,047	$1,592	8.8%	$19,639	1.8%	$18,366	$1,620	$19,985	$0	$19,985	1.4%	$18,615	$1,642	$20,257
15	FLOODWAY CONTROL & DIVERSION STRUCTURE	$12,267	$1,082	8.8%	$13,349	1.8%	$12,484	$1,101	$13,585	$0	$13,585	1.4%	$12,653	$1,116	$13,769
16	BANK STABILIZATION	$19,111	$1,686	8.8%	$20,797	1.8%	$19,449	$1,715	$21,164	$0	$21,164	1.4%	$19,713	$1,739	$21,452
	CONSTRUCTION ESTIMATE TOTALS:	$49,919	$4,403		$54,322	1.8%	$50,801	$4,481	$55,282	$0	$55,282	1.4%	$51,491	$4,542	$56,033
01	LANDS AND DAMAGES	$0	$0	-	$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN	$0	$0	0.0%	$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
31	CONSTRUCTION MANAGEMENT	$2,996	$264	8.8%	$3,260	3.6%	$3,104	$274	$3,378	$0	$3,378	3.0%	$3,197	$282	$3,479
	PROJECT COST TOTALS:	$52,915	$4,667	8.8%	$57,582		$53,905	$4,755	**$58,660**	$0	**$58,660**	1.5%	$54,688	$4,824	$59,512

CHIEF, COST ENGINEERING, xxx

PROJECT MANAGER, xxx

CHIEF, REAL ESTATE, xxx

CHIEF, PLANNING,xxx

CHIEF, ENGINEERING, xxx

CHIEF, OPERATIONS, xxx

CHIEF, CONSTRUCTION, xxx

CHIEF, CONTRACTING,xxx

CHIEF, PM-PB, xxxx

CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:	**100%**	**$59,512**
ESTIMATED NON-FEDERAL COST:	**0%**	**$0**
ESTIMATED TOTAL PROJECT COST:		**$59,512**

****** TOTAL PROJECT COST SUMMARY ******

CONTRACT 1

****** CONTRACT COST SUMMARY ******

PROJECT: Yellowstone River - Bypass Channel Alternative
LOCATION: Yellowstone River, MT and ND
This Estimate reflects the scope and schedule in report; Lower Yellowstone River Intake Diversion Dam Modification Project, Eng. Appx.

DISTRICT: Omaha (NWO)
POC: CHIEF, COST ENGINEERING, xxx

PREPARED: 5/19/2016

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**13-Mar-15**	Program Year (Budget EC):			2017					
		Effective Price Level:			1-Oct-15	Effective Price Level Date:			1 OCT 16					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	CONTRACT 1													
06	FISH & WILDLIFE FACILITIES (Adaptive Mgmt.)	$494	$44	8.8%	$538	1.8%	$503	$44	$547	2017Q4	1.4%	$510	$45	$555
09	CHANNELS & CANALS	$18,047	$1,592	8.8%	$19,639	1.8%	$18,366	$1,620	$19,985	2017Q4	1.4%	$18,615	$1,642	$20,257
15	FLOODWAY CONTROL & DIVERSION STRUCTURE	$12,267	$1,082	8.8%	$13,349	1.8%	$12,484	$1,101	$13,585	2017Q4	1.4%	$12,653	$1,116	$13,769
16	BANK STABILIZATION	$19,111	$1,686	8.8%	$20,797	1.8%	$19,449	$1,715	$21,164	2017Q4	1.4%	$19,713	$1,739	$21,452
	CONSTRUCTION ESTIMATE TOTALS:	$49,919	$4,403	8.8%	**$54,322**		$50,801	$4,481	$55,282			$51,491	$4,542	$56,033
01	LANDS AND DAMAGES	$0	$0	0.0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN													
0.0%	Project Management	$0	$0	8.8%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning & Environmental Compliance	$0	$0	8.8%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Engineering & Design	$0	$0	8.8%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Reviews, ATRs, IEPRs, VE	$0	$0	8.8%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Life Cycle Updates (cost, schedule, risks)	$0	$0	8.8%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Contracting & Reprographics	$0	$0	8.8%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Engineering During Construction	$0	$0	8.8%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Planning During Construction	$0	$0	8.8%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	8.8%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
5.0%	Construction Management	$2,496	$220	8.8%	$2,716	3.6%	$2,586	$228	$2,814	2017Q4	3.0%	$2,663	$235	$2,898
0.5%	Project Operation:	$250	$22	8.8%	$272	3.6%	$259	$23	$282	2017Q4	3.0%	$267	$24	$290
0.5%	Project Management	$250	$22	8.8%	$272	3.6%	$259	$23	$282	2017Q4	3.0%	$267	$24	$290
	CONTRACT COST TOTALS:	$52,915	$4,667		$57,582		$53,905	$4,755	$58,660			$54,688	$4,824	$59,512

Modified Side Channel TPCS

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **Yellowstone River - Modified Side Channel Alternative**
PROJECT NO: 0
LOCATION: Yellowstone River, MT and ND

DISTRICT: Omaha (NWO)
POC: CHIEF, COST ENGINEERING, xxx

PREPARED: 5/19/2016

This Estimate reflects the scope and schedule in report; Lower Yellowstone River Intake Diversion Dam Modification Project, Eng. Appx.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis) Program Year (Budget EC): 2017 Effective Price Level Date: 1 OCT 16						TOTAL PROJECT COST (FULLY FUNDED)			
WBS NUMBER A	Civil Works Feature & Sub-Feature Description B	COST ($K) C	CNTG ($K) D	CNTG (%) E	TOTAL ($K) F	ESC (%) G	COST ($K) H	CNTG ($K) I	**TOTAL ($K) J**	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K) K	INFLATED (%) L	COST ($K) M	CNTG ($K) N	FULL ($K) O
06	FISH & WILDLIFE FACILITIES (Monitoring & Adaptive Mgmt.)	$352	$124	35.2%	$476	1.8%	$358	$126	$484	$0	$484	3.9%	$372	$131	$503
08	ROADS, RAILROADS & BRIDGES	$1,042	$367	35.2%	$1,408	1.8%	$1,060	$373	$1,433	$0	$1,433	3.9%	$1,101	$387	$1,489
09	CHANNELS & CANALS	$16,703	$5,876	35.2%	$22,579	1.8%	$16,998	$5,980	$22,978	$0	$22,978	3.9%	$17,654	$6,210	$23,864
16	BANK STABILIZATION	$17,436	$6,134	35.2%	$23,570	1.8%	$17,744	$6,242	$23,986	$0	$23,986	3.9%	$18,429	$6,483	$24,912
	CONSTRUCTION ESTIMATE TOTALS:	$35,532	$12,500		$48,032	1.8%	$36,160	$12,721	$48,881	$0	$48,881	3.9%	$37,556	$13,212	$50,767
01	LANDS AND DAMAGES	$220	$55	25.0%	$275	1.8%	$224	$56	$280	$0	$280	0.9%	$226	$56	$282
30	PLANNING, ENGINEERING & DESIGN	$3,201	$743	23.2%	$3,944	3.6%	$3,316	$770	$4,086	$0	$4,086	2.7%	$3,405	$790	$4,195
31	CONSTRUCTION MANAGEMENT	$2,133	$532	24.9%	$2,665	3.6%	$2,210	$551	$2,761	$0	$2,761	8.2%	$2,390	$596	$2,986
	PROJECT COST TOTALS:	$41,086	$13,829	33.7%	$54,916		$41,910	$14,097	**$56,008**	$0	**$56,008**	4.0%	$43,577	$14,654	$58,231

CHIEF, COST ENGINEERING, xxx

PROJECT MANAGER, xxx

CHIEF, REAL ESTATE, xxx

CHIEF, PLANNING,xxx

CHIEF, ENGINEERING, xxx

CHIEF, OPERATIONS, xxx

CHIEF, CONSTRUCTION, xxx

CHIEF, CONTRACTING,xxx

CHIEF, PM-PB, xxxx

CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:	**100%**	**$58,231**
ESTIMATED NON-FEDERAL COST:	**0%**	**$0**
ESTIMATED TOTAL PROJECT COST:		**$58,231**

**** TOTAL PROJECT COST SUMMARY ****

CONTRACT 1

**** CONTRACT COST SUMMARY ****

PROJECT: Yellowstone River - Modified Side Channel Alternative
LOCATION: Yellowstone River, MT and ND
This Estimate reflects the scope and schedule in report; Lower Yellowstone River Intake Diversion Dam Modification Project, Eng. Appx.

DISTRICT: Omaha (NWO)
POC: CHIEF, COST ENGINEERING, xxx

PREPARED: 5/19/2016

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			19-May-16	Program Year (Budget EC):			2017					
		Effective Price Level:			1-Oct-15	Effective Price Level Date:			1 OCT 16					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 1													
06	FISH & WILDLIFE FACILITIES (Monitoring & Adaptive Mgmt.)	$352	$124	35.2%	$476	1.8%	$358	$126	$484	2019Q1	3.9%	$372	$131	$503
08	ROADS, RAILROADS & BRIDGES	$1,042	$367	35.2%	$1,408	1.8%	$1,060	$373	$1,433	2019Q1	3.9%	$1,101	$387	$1,489
09	CHANNELS & CANALS	$16,703	$5,876	35.2%	$22,579	1.8%	$16,998	$5,980	$22,978	2019Q1	3.9%	$17,654	$6,210	$23,864
16	BANK STABILIZATION	$17,436	$6,134	35.2%	$23,570	1.8%	$17,744	$6,242	$23,986	2019Q1	3.9%	$18,429	$6,483	$24,912
	CONSTRUCTION ESTIMATE TOTALS:	$35,532	$12,500	35.2%	**$48,032**		$36,160	$12,721	$48,881			$37,556	$13,212	$50,767
01	LANDS AND DAMAGES	$220	$55	25.0%	$275	1.8%	$224	$56	$280	2017Q3	0.9%	$226	$56	$282
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$178	$41	23.2%	$219	3.6%	$184	$43	$227	2017Q3	2.0%	$188	$44	$232
0.5%	Planning & Environmental Compliance	$178	$41	23.2%	$219	3.6%	$184	$43	$227	2017Q3	2.0%	$188	$44	$232
5.0%	Engineering & Design	$1,777	$412	23.2%	$2,189	3.6%	$1,841	$427	$2,268	2017Q3	2.0%	$1,878	$436	$2,313
0.5%	Reviews, ATRs, IEPRs, VE	$178	$41	23.2%	$219	3.6%	$184	$43	$227	2017Q3	2.0%	$188	$44	$232
0.5%	Life Cycle Updates (cost, schedule, risks)	$178	$41	23.2%	$219	3.6%	$184	$43	$227	2017Q3	2.0%	$188	$44	$232
0.5%	Contracting & Reprographics	$178	$41	23.2%	$219	3.6%	$184	$43	$227	2017Q3	2.0%	$188	$44	$232
0.5%	Engineering During Construction	$178	$41	23.2%	$219	3.6%	$184	$43	$227	2019Q1	8.2%	$199	$46	$246
0.5%	Planning During Construction	$178	$41	23.2%	$219	3.6%	$184	$43	$227	2019Q1	8.2%	$199	$46	$246
0.5%	Project Operations	$178	$41	23.2%	$219	3.6%	$184	$43	$227	2017Q3	2.0%	$188	$44	$232
31	CONSTRUCTION MANAGEMENT													
5.0%	Construction Management	$1,777	$443	24.9%	$2,220	3.6%	$1,841	$459	$2,300	2019Q1	8.2%	$1,991	$496	$2,488
0.5%	Project Operation:	$178	$44	24.9%	$222	3.6%	$184	$46	$230	2019Q1	8.2%	$199	$50	$249
0.5%	Project Management	$178	$44	24.9%	$222	3.6%	$184	$46	$230	2019Q1	8.2%	$199	$50	$249
	CONTRACT COST TOTALS:	$41,086	$13,829		$54,916		$41,910	$14,097	$56,008			$43,577	$14,654	$58,231

Multiple Pump TPCS

****** TOTAL PROJECT COST SUMMARY ******

PROJECT: **Yellowstone River - Multiple Pump Alternative**
PROJECT NO: 0
LOCATION: Yellowstone River, MT and ND

DISTRICT: Omaha (NWO)
POC: CHIEF, COST ENGINEERING, xxx

PREPARED: 5/19/2016

This Estimate reflects the scope and schedule in report; Lower Yellowstone River Intake Diversion Dam Modification Project, Eng. Appx.

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis) Program Year (Budget EC): 2017; Effective Price Level Date: 1 OCT 16						TOTAL PROJECT COST (FULLY FUNDED)			
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	**TOTAL ($K)** *J*	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K) *K*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
04	DAMS	$6,600	$2,430	36.8%	$9,030	1.8%	$6,716	$2,473	$9,190	$0	$9,190	12.4%	$7,551	$2,781	$10,331
06	FISH & WILDLIFE FACILITIES (Monitoring & Adaptive Mgmt.)	$843	$310	36.8%	$1,153	1.8%	$858	$316	$1,174	$0	$1,174	7.0%	$918	$338	$1,256
19	BUILDINGS, GROUNDS & UTILITIES	$77,678	$28,606	36.8%	$106,284	1.8%	$79,049	$29,111	$108,161	$0	$108,161	6.5%	$84,164	$30,995	$115,159
	CONSTRUCTION ESTIMATE TOTALS:	$85,120	$31,347		$116,467	1.8%	$86,623	$31,901	$118,524	$0	$118,524	6.9%	$92,633	$34,114	$126,746
01	LANDS AND DAMAGES	$443	$111	25.0%	$554	1.8%	$451	$113	$564	$0	$564	0.9%	$455	$114	$569
30	PLANNING, ENGINEERING & DESIGN	$7,664	$2,033	26.5%	$9,697	3.6%	$7,940	$2,106	$10,047	$0	$10,047	3.4%	$8,210	$2,178	$10,388
31	CONSTRUCTION MANAGEMENT	$5,108	$1,355	26.5%	$6,463	3.6%	$5,292	$1,404	$6,696	$0	$6,696	14.7%	$6,071	$1,610	$7,681
	PROJECT COST TOTALS:	$98,335	$34,846	35.4%	$133,181		$100,307	$35,523	**$135,831**	$0	**$135,831**	7.0%	$107,369	$38,015	$145,384

CHIEF, COST ENGINEERING, xxx

PROJECT MANAGER, xxx

CHIEF, REAL ESTATE, xxx

CHIEF, PLANNING,xxx

CHIEF, ENGINEERING, xxx

CHIEF, OPERATIONS, xxx

CHIEF, CONSTRUCTION, xxx

CHIEF, CONTRACTING,xxx

CHIEF, PM-PB, xxxx

CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:	**100%**	**$145,384**
ESTIMATED NON-FEDERAL COST:	**0%**	**$0**
ESTIMATED TOTAL PROJECT COST:		**$145,384**

**** TOTAL PROJECT COST SUMMARY ****

MULTIPLE PUMP STATIONS

**** CONTRACT COST SUMMARY ****

PROJECT: Yellowstone River - Multiple Pump Alternative
LOCATION: Yellowstone River, MT and ND
This Estimate reflects the scope and schedule in report; Lower Yellowstone River Intake Diversion Dam Modification Project, Eng. Appx.

DISTRICT: Omaha (NWO)
POC: CHIEF, COST ENGINEERING, xxx

PREPARED: 5/19/2016

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			**19-May-16**	Program Year (Budget EC):			2017					
		Effective Price Level:			1-Oct-15	Effective Price Level Date:			1 OCT 16					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	MULTIPLE PUMP STATIONS													
04	DAMS	$6,600	$2,430	36.8%	$9,030	1.8%	$6,716	$2,473	$9,190	2023Q1	12.4%	$7,551	$2,781	$10,331
06	FISH & WILDLIFE FACILITIES (Monitoring & Adaptive Mgmt.)	$843	$310	36.8%	$1,153	1.8%	$858	$316	$1,174	2020Q3	7.0%	$918	$338	$1,256
19	BUILDINGS, GROUNDS & UTILITIES	$77,678	$28,606	36.8%	$106,284	1.8%	$79,049	$29,111	$108,161	2020Q2	6.5%	$84,164	$30,995	$115,159
	CONSTRUCTION ESTIMATE TOTALS:	$85,120	$31,347	36.8%	**$116,467**		$86,623	$31,901	$118,524			$92,633	$34,114	$126,746
01	LANDS AND DAMAGES	$443	$111	25.0%	$554	1.8%	$451	$113	$564	2017Q3	0.9%	$455	$114	$569
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$426	$113	26.5%	$539	3.6%	$441	$117	$558	2017Q3	2.0%	$450	$119	$569
0.5%	Planning & Environmental Compliance	$426	$113	26.5%	$539	3.6%	$441	$117	$558	2017Q3	2.0%	$450	$119	$569
5.0%	Engineering & Design	$4,256	$1,129	26.5%	$5,385	3.6%	$4,410	$1,170	$5,579	2017Q3	2.0%	$4,497	$1,193	$5,690
0.5%	Reviews, ATRs, IEPRs, VE	$426	$113	26.5%	$539	3.6%	$441	$117	$558	2017Q3	2.0%	$450	$119	$569
0.5%	Life Cycle Updates (cost, schedule, risks)	$426	$113	26.5%	$539	3.6%	$441	$117	$558	2017Q3	2.0%	$450	$119	$569
0.5%	Contracting & Reprographics	$426	$113	26.5%	$539	3.6%	$441	$117	$558	2017Q3	2.0%	$450	$119	$569
0.5%	Engineering During Construction	$426	$113	26.5%	$539	3.6%	$441	$117	$558	2020Q3	14.7%	$506	$134	$641
0.5%	Planning During Construction	$426	$113	26.5%	$539	3.6%	$441	$117	$558	2020Q3	14.7%	$506	$134	$641
0.5%	Project Operations	$426	$113	26.5%	$539	3.6%	$441	$117	$558	2017Q3	2.0%	$450	$119	$569
31	CONSTRUCTION MANAGEMENT													
5.0%	Construction Management	$4,256	$1,129	26.5%	$5,385	3.6%	$4,410	$1,170	$5,579	2020Q3	14.7%	$5,058	$1,342	$6,400
0.5%	Project Operation:	$426	$113	26.5%	$539	3.6%	$441	$117	$558	2020Q3	14.7%	$506	$134	$641
0.5%	Project Management	$426	$113	26.5%	$539	3.6%	$441	$117	$558	2020Q3	14.7%	$506	$134	$641
	CONTRACT COST TOTALS:	$98,335	$34,846		$133,181		$100,307	$35,523	$135,831			$107,369	$38,015	$145,384

Filename: 04 Yellowstone River_Multiple Pump Stations_TPCS_WORKING
TPCS

Multiple Pumps with Conservation Measures TPCS

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **Yellowstone River - Multiple Pumps with Conservation Measures**
PROJECT NO: 0
LOCATION: Yellowstone River, MT and ND

DISTRICT: Omaha (NWO)
POC: CHIEF, COST ENGINEERING, xxx

PREPARED: 5/19/2016

This Estimate reflects the scope and schedule in report; Lower Yellowstone River Intake Diversion Dam Modification Project, Eng. Appx.

Program Year (Budget EC): 2017
Effective Price Level Date: 1 OCT 16

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**						**TOTAL PROJECT COST (FULLY FUNDED)**			
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	**TOTAL ($K)** *J*	Spent Thru: **10/1/2015** ($K)	**TOTAL FIRST COST** ($K) *K*	INFLATED (%) *L*	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
04	DAMS	$7,037	$2,278	32.4%	$9,315	1.8%	$7,161	$2,318	$9,479	$0	$9,479	7.0%	$7,662	$2,481	$10,143
06	FISH & WILDLIFE FACILITIES (Monitoring & Adaptive Mgmt.)	$3,131	$1,014	32.4%	$4,144	1.8%	$3,186	$1,031	$4,217	$0	$4,217	7.0%	$3,409	$1,104	$4,513
09	CHANNELS & CANALS	$195,853	$63,408	32.4%	$259,261	1.8%	$199,312	$64,528	$263,840	$0	$263,840	7.0%	$213,271	$69,048	$282,319
19	BUILDINGS, GROUNDS & UTILITIES	$18,703	$6,055	32.4%	$24,758	1.8%	$19,033	$6,162	$25,195	$0	$25,195	7.0%	$20,366	$6,594	$26,960
20	PERMANENT OPERATING EQUIPMENT	$91,468	$29,613	32.4%	$121,082	1.8%	$93,084	$30,136	$123,220	$0	$123,220	0.0%	$93,084	$30,136	$123,220
	CONSTRUCTION ESTIMATE TOTALS:	$316,191	$102,369		$418,559	1.8%	$321,775	$104,177	$425,952	$0	$425,952	5.0%	$337,793	$109,362	$447,155
01	LANDS AND DAMAGES	$2,800	$700	25.0%	$3,500	1.8%	$2,849	$712	$3,562	$0	$3,562	5.9%	$3,019	$755	$3,773
30	PLANNING, ENGINEERING & DESIGN	$28,458	$7,548	26.5%	$36,006	3.6%	$29,485	$7,820	$37,305	$0	$37,305	5.2%	$31,015	$8,226	$39,241
31	CONSTRUCTION MANAGEMENT	$18,972	$5,032	26.5%	$24,004	3.6%	$19,656	$5,214	$24,870	$0	$24,870	14.7%	$22,549	$5,981	$28,529
	PROJECT COST TOTALS:	$366,421	$115,649	31.6%	$482,069		$373,765	$117,923	**$491,688**	$0	**$491,688**	5.5%	$394,375	$124,324	$518,699

CHIEF, COST ENGINEERING, xxx

PROJECT MANAGER, xxx

CHIEF, REAL ESTATE, xxx

CHIEF, PLANNING,xxx

CHIEF, ENGINEERING, xxx

CHIEF, OPERATIONS, xxx

CHIEF, CONSTRUCTION, xxx

CHIEF, CONTRACTING,xxx

CHIEF, PM-PB, xxxx

CHIEF, DPM, xxx

ESTIMATED FEDERAL COST: **100%** **$518,699**
ESTIMATED NON-FEDERAL COST: **0%** **$0**

ESTIMATED TOTAL PROJECT COST: **$518,699**

Filename: 05 Yellowstone River_Ranney Wells_TPCS_WORKING
TPCS

**** TOTAL PROJECT COST SUMMARY ****

CONTRACT 1

**** CONTRACT COST SUMMARY ****

PROJECT: Yellowstone River - Multiple Pumps with Conservation Measures
LOCATION: Yellowstone River, MT and ND
This Estimate reflects the scope and schedule in report; Lower Yellowstone River Intake Diversion Dam Modification Project, Eng. Appx.

DISTRICT: Omaha (NWO)
POC: CHIEF, COST ENGINEERING, xxx

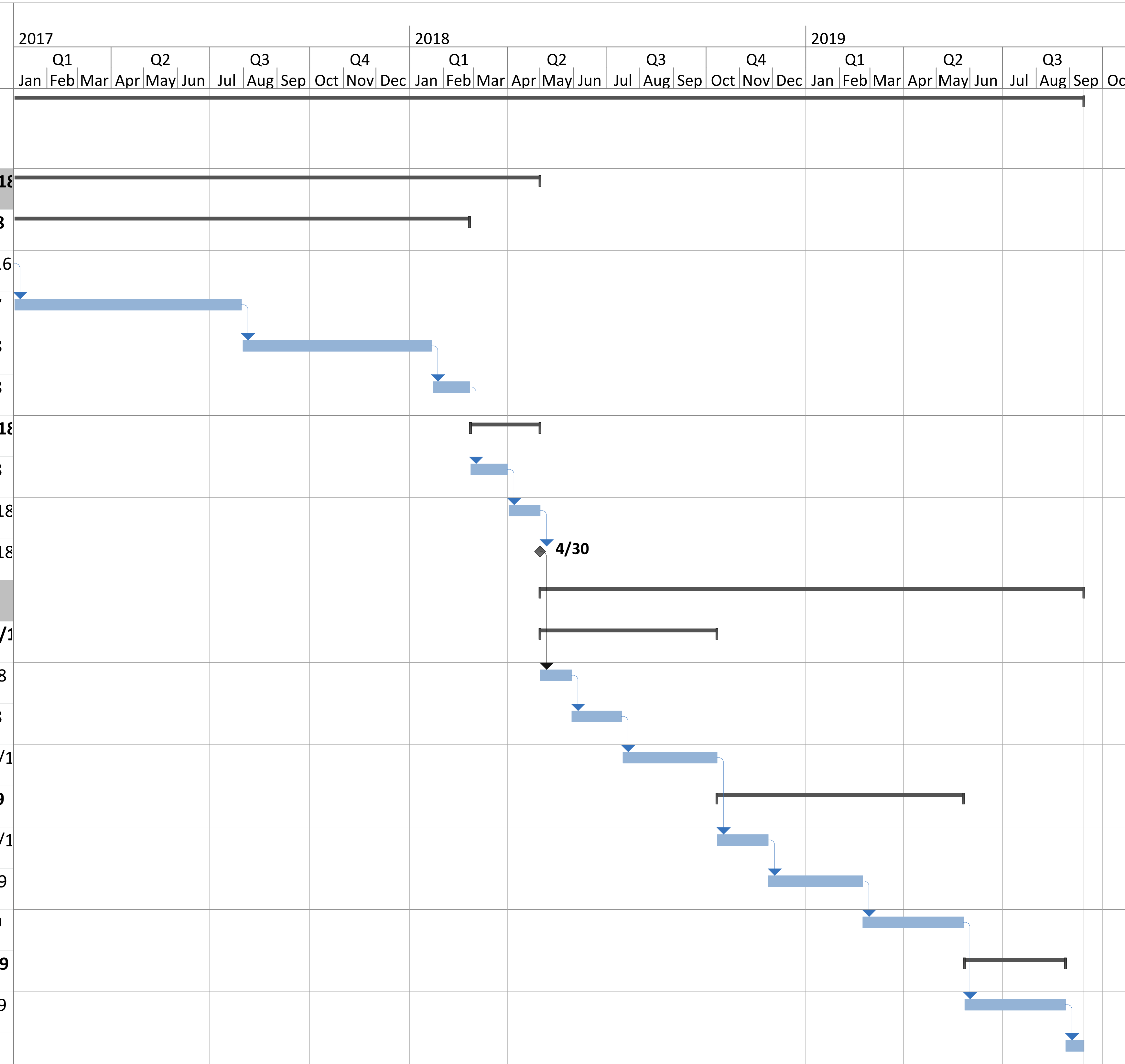
PREPARED: 5/19/2016

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared:			19-May-16	Program Year (Budget EC):			2017					
		Effective Price Level:			1-Oct-15	Effective Price Level Date:			1 OCT 16					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 1													
04	DAMS	$7,037	$2,278	32.4%	$9,315	1.8%	$7,161	$2,318	$9,479	2020Q3	7.0%	$7,662	$2,481	$10,143
06	FISH & WILDLIFE FACILITIES (Monitoring & Adaptive Mgmt.)	$3,131	$1,014	32.4%	$4,144	1.8%	$3,186	$1,031	$4,217	2020Q3	7.0%	$3,409	$1,104	$4,513
09	CHANNELS & CANALS	$195,853	$63,408	32.4%	$259,261	1.8%	$199,312	$64,528	$263,840	2020Q3	7.0%	$213,271	$69,048	$282,319
19	BUILDINGS, GROUNDS & UTILITIES	$18,703	$6,055	32.4%	$24,758	1.8%	$19,033	$6,162	$25,195	2020Q3	7.0%	$20,366	$6,594	$26,960
20	PERMANENT OPERATING EQUIPMENT	$91,468	$29,613	32.4%	$121,082	1.8%	$93,084	$30,136	$123,220	2017Q1	0.0%	$93,084	$30,136	$123,220
	CONSTRUCTION ESTIMATE TOTALS:	$316,191	$102,369	32.4%	**$418,559**		$321,775	$104,177	$425,952			$337,793	$109,362	$447,155
01	LANDS AND DAMAGES	$2,800	$700	25.0%	$3,500	1.8%	$2,849	$712	$3,562	2020Q1	5.9%	$3,019	$755	$3,773
30	PLANNING, ENGINEERING & DESIGN													
0.5%	Project Management	$1,581	$419	26.5%	$2,000	3.6%	$1,638	$434	$2,072	2018Q1	4.0%	$1,704	$452	$2,155
0.5%	Planning & Environmental Compliance	$1,581	$419	26.5%	$2,000	3.6%	$1,638	$434	$2,072	2018Q1	4.0%	$1,704	$452	$2,155
5.0%	Engineering & Design	$15,810	$4,193	26.5%	$20,003	3.6%	$16,380	$4,345	$20,725	2018Q1	4.0%	$17,035	$4,518	$21,554
0.5%	Reviews, ATRs, IEPRs, VE	$1,581	$419	26.5%	$2,000	3.6%	$1,638	$434	$2,072	2018Q1	4.0%	$1,704	$452	$2,155
0.5%	Life Cycle Updates (cost, schedule, risks)	$1,581	$419	26.5%	$2,000	3.6%	$1,638	$434	$2,072	2018Q1	4.0%	$1,704	$452	$2,155
0.5%	Contracting & Reprographics	$1,581	$419	26.5%	$2,000	3.6%	$1,638	$434	$2,072	2018Q1	4.0%	$1,704	$452	$2,155
0.5%	Engineering During Construction	$1,581	$419	26.5%	$2,000	3.6%	$1,638	$434	$2,072	2020Q3	14.7%	$1,879	$498	$2,377
0.5%	Planning During Construction	$1,581	$419	26.5%	$2,000	3.6%	$1,638	$434	$2,072	2020Q3	14.7%	$1,879	$498	$2,377
0.5%	Project Operations	$1,581	$419	26.5%	$2,000	3.6%	$1,638	$434	$2,072	2018Q1	4.0%	$1,704	$452	$2,155
31	CONSTRUCTION MANAGEMENT													
5.0%	Construction Management	$15,810	$4,193	26.5%	$20,003	3.6%	$16,380	$4,345	$20,725	2020Q3	14.7%	$18,791	$4,984	$23,774
0.5%	Project Operation:	$1,581	$419	26.5%	$2,000	3.6%	$1,638	$434	$2,072	2020Q3	14.7%	$1,879	$498	$2,377
0.5%	Project Management	$1,581	$419	26.5%	$2,000	3.6%	$1,638	$434	$2,072	2020Q3	14.7%	$1,879	$498	$2,377
	CONTRACT COST TOTALS:	$366,421	$115,649		$482,069		$373,765	$117,923	$491,688			$394,375	$124,324	$518,699

Attachment B.2
Tentative Project Schedules

Rock Ramp Project Schedule

ID	Task Name	Duration	Start	Finish
1	**LOWER YELLOWSTONE IRRIGATION PROJECT - ROCK RAMP ALTERNATIVE**	**1055 days**	**Mon 5/2/16**	**Fri 9/13/19**
2	**PRE-CONSTRUCTION AWARD**	**625 days**	**Mon 5/2/16**	**Mon 4/30/18**
3	**Plans & Specifications**	**570 days**	**Mon 5/2/16**	**Sat 2/24/18**
4	30% Design	210 days	Mon 5/2/16	Sat 12/31/16
5	60% Design	180 days	Mon 1/2/17	Sat 7/29/17
6	90% Design	150 days	Mon 7/31/17	Sat 1/20/18
7	BCOE	30 days	Mon 1/22/18	Sat 2/24/18
8	**Procurement & Award**	**55 days**	**Mon 2/26/18**	**Mon 4/30/18**
9	Advertise	30 days	Mon 2/26/18	Sat 3/31/18
10	Award	25 days	Mon 4/2/18	Mon 4/30/18
11	NTP	0 days	Mon 4/30/18	Mon 4/30/18
12	**CONSTRUCTION**	**430 days**	**Tue 5/1/18**	**Fri 9/13/19**
13	**Phase 1 Construction**	**140 days**	**Tue 5/1/18**	**Wed 10/10/1**
14	Mobilization and Site Preparation	25 days	Tue 5/1/18	Tue 5/29/18
15	Place Cofferdam (South Bank to Center of Existing Dam)	40 days	Wed 5/30/18	Sat 7/14/18
16	Place Concrete Weir (South Half)	75 days	Mon 7/16/18	Wed 10/10/1
17	**Phase 2 Construction**	**195 days**	**Thu 10/11/1**	**Sat 5/25/19**
18	Place Cofferdam (Headworks to End of New Weir)	40 days	Thu 10/11/18	Mon 11/26/1
19	Place Concrete Weir (North Half)	75 days	Tue 11/27/18	Thu 2/21/19
20	Place Rock Ramp (North Half)	80 days	Fri 2/22/19	Sat 5/25/19
21	**Phase 3 Construction**	**80 days**	**Mon 5/27/19**	**Tue 8/27/19**
22	Place Rock Ramp (South Half)	80 days	Mon 5/27/19	Tue 8/27/19
23	Demobilization	15 days	Wed 8/28/19	Fri 9/13/19

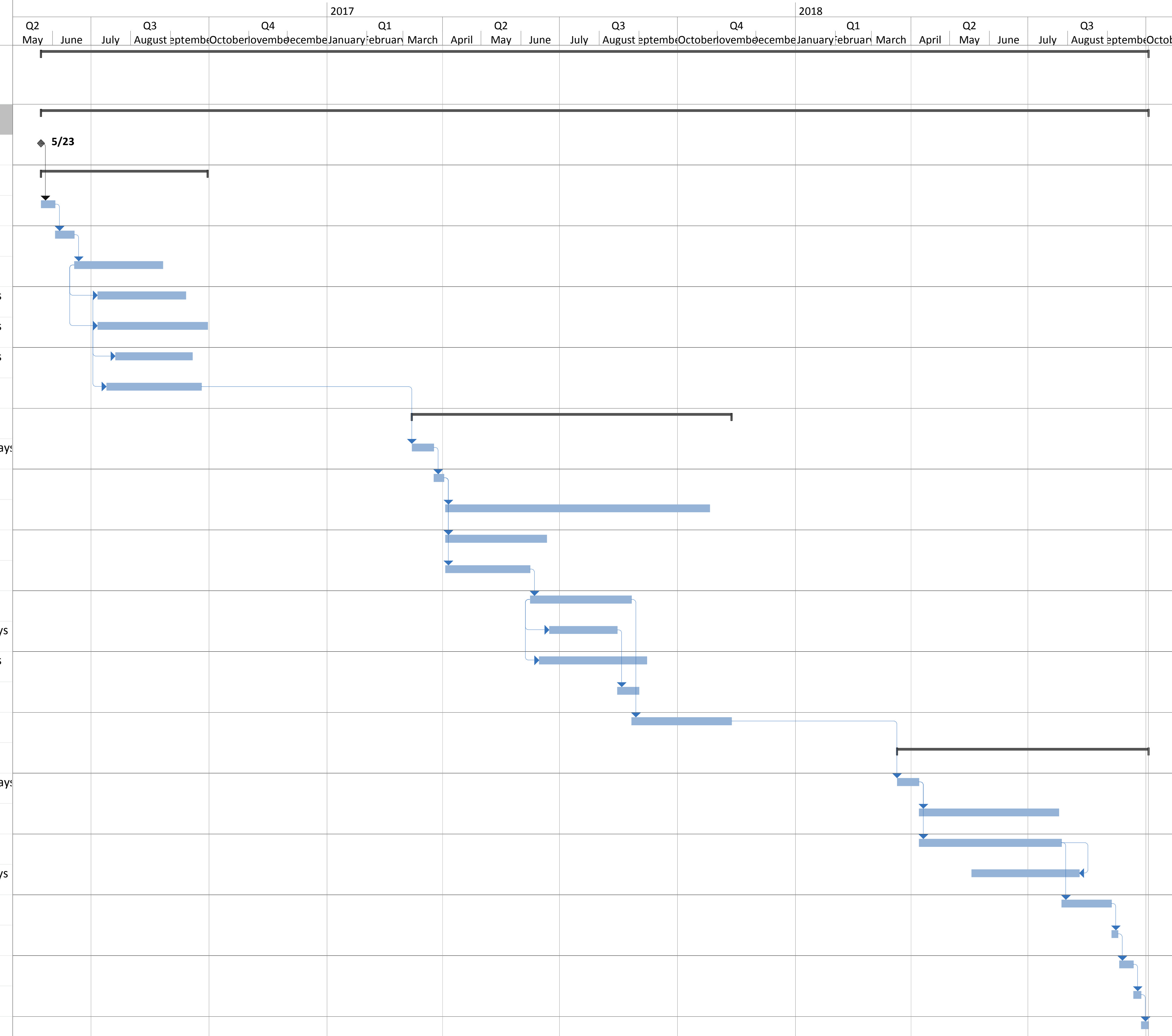


Project: LA River_Project Schedule
Date: Wed 4/20/16

Task	Project Summary	Inactive Milestone	Manual Summary	Progress
Split	External Tasks	Inactive Summary	Start-only	Manual Progress
Milestone	External Milestone	Duration-only	Finish-only	
Summary	Inactive Task	Manual Summary Rollup	Deadline	

Bypass Channel Project Schedule

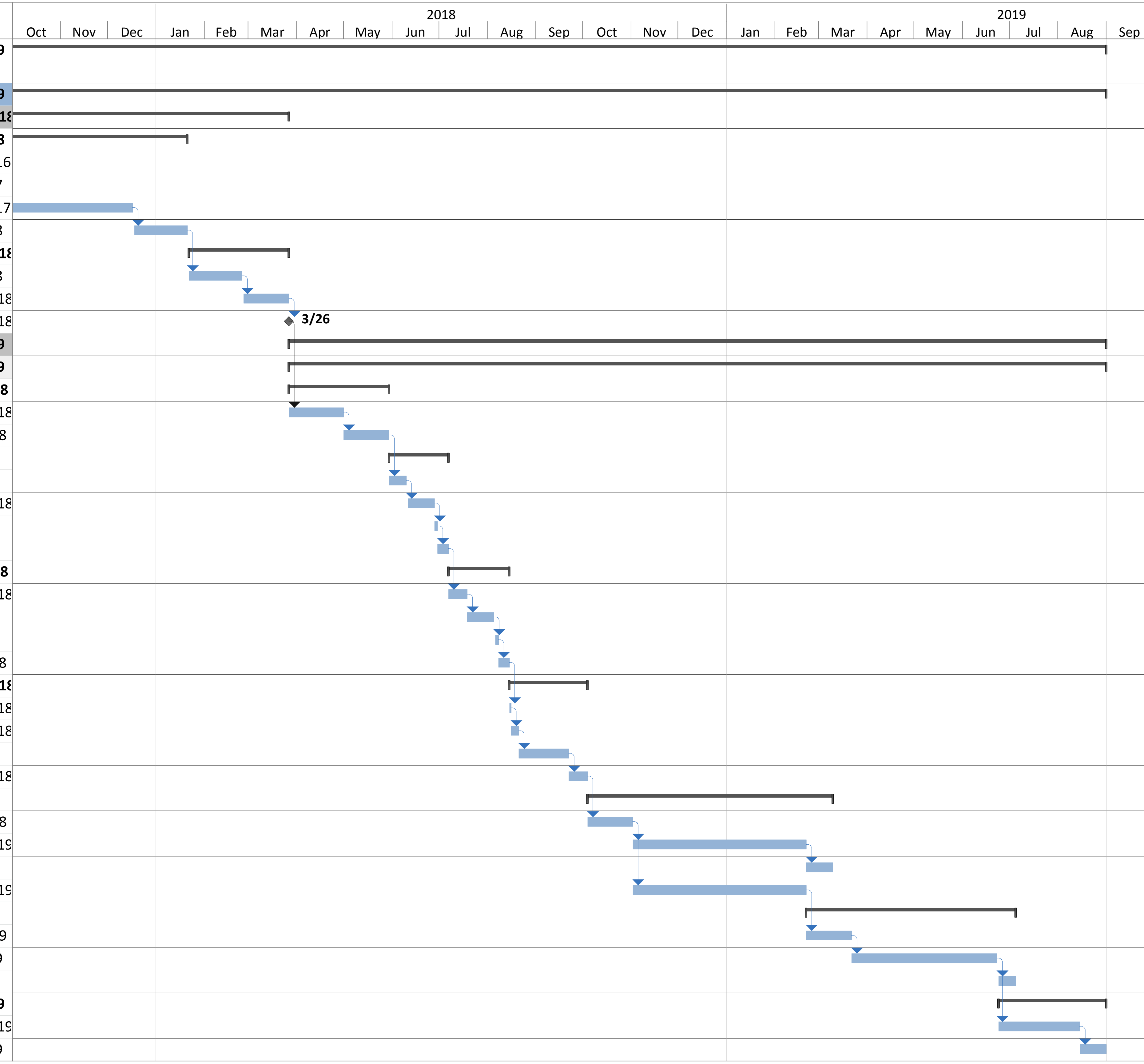
ID	Task Name	Duration	Start	Finish	Predecessors
1	**LOWER YELLOWSTONE IRRIGATION PROJECT - BYPASS CHANNEL ALTERNATIVE**	**740 days**	**Mon 5/23/16**	**Tue 10/2/18**	
2	**CONSTRUCTION**	**740 days**	**Mon 5/23/16**	**Tue 10/2/18**	
3	Notice to Proceed	0 days	Mon 5/23/16	Mon 5/23/16	
4	**Weir Construction**	**112 days**	**Mon 5/23/16**	**Thu 9/29/16**	
5	Mobilization	10 days	Mon 5/23/16	Thu 6/2/16	3
6	Haul Roads and Access Ramps	13 days	Fri 6/3/16	Fri 6/17/16	5
7	Sheet Pile	59 days	Sat 6/18/16	Thu 8/25/16	6
8	Excavation	59 days	Wed 7/6/16	Mon 9/12/16	7SS+15 days
9	Place Fill	74 days	Wed 7/6/16	Thu 9/29/16	7SS+15 days
10	Concrete Placement	52 days	Wed 7/20/16	Sat 9/17/16	8SS+12 days
11	Remove/Cut Sheetpile	64 days	Wed 7/13/16	Sat 9/24/16	9SS+6 days
12	**Bypass Channel - Phase 1**	**214 days**	**Wed 3/8/17**	**Sat 11/11/17**	
13	Moblization	15 days	Wed 3/8/17	Fri 3/24/17	11FS+140 days
14	Erosion Control and Site Access	7 days	Sat 3/25/17	Sat 4/1/17	13
15	Clearing and Grubbing	177 days	Mon 4/3/17	Wed 10/25/1	14
16	Outlet Structure	68 days	Mon 4/3/17	Tue 6/20/17	14
17	Inlet Structure	57 days	Mon 4/3/17	Wed 6/7/17	14
18	Excavate Channel from Outlet to DS Outer Bend Protection	68 days	Thu 6/8/17	Fri 8/25/17	17
19	Excavate Channel Between Inlet and Plug	45 days	Fri 6/23/17	Mon 8/14/17	18SS+13 days
20	Screening and Placement of Channel Bottom Armor	72 days	Thu 6/15/17	Wed 9/6/17	18SS+6 days
21	Install Channel Plug	15 days	Tue 8/15/17	Thu 8/31/17	19
22	Place DS Channel Bend Protection	67 days	Sat 8/26/17	Sat 11/11/17	18
23	**Bypass Channel - Phase 2**	**168 days**	**Wed 3/21/18**	**Tue 10/2/18**	
24	Moblization	15 days	Wed 3/21/18	Fri 4/6/18	22FS+110 days
25	Excavate Channel From DS Outer Bend Portection US Outer I	93 days	Sat 4/7/18	Tue 7/24/18	24
26	Excavate Channel Between Plug and US Outer Bend Riprap	95 days	Sat 4/7/18	Thu 7/26/18	24
27	Screening and Placement of Channel Bottom Armor	72 days	Fri 5/18/18	Thu 8/9/18	26FF+12 days
28	Place US Channel Bend Protection	33 days	Fri 7/27/18	Mon 9/3/18	26
29	Final Grade Spoil Area	5 days	Tue 9/4/18	Sat 9/8/18	28
30	Seed Site	10 days	Mon 9/10/18	Thu 9/20/18	29
31	Remove Access Crossings and Culverts	5 days	Fri 9/21/18	Wed 9/26/18	30
32	Demobilization	5 days	Thu 9/27/18	Tue 10/2/18	31



Project: LA River_Project Schedule Date: Wed 4/20/16	Task		Summary		External Milestone		Inactive Summary		Manual Summary		Deadline
	Split		Project Summary		Inactive Task		Duration-only		Start-only		Progress
	Milestone		External Tasks		Inactive Milestone		Manual Summary Rollup		Finish-only		Manual Progress

Modified Side Channel Project Schedule

ID	Task Name	Duration	Start	Finish
1	**LOWER YELLOWSTONE IRRIGATION PROJECT - MODIFIED SIDE CHANNEL ALTERNATIVE**	**1044 days**	**Mon 5/2/16**	**Sat 8/31/19**
2	**CONTRACT 1**	**1044 days**	**Mon 5/2/16**	**Sat 8/31/19**
3	**PRE-CONSTRUCTION AWARD**	**595 days**	**Mon 5/2/16**	**Mon 3/26/18**
4	**Plans & Specifications**	**540 days**	**Mon 5/2/16**	**Sat 1/20/18**
5	30% Design	210 days	Mon 5/2/16	Sat 12/31/16
6	60% Design	180 days	Mon 1/2/17	Sat 7/29/17
7	90% Design	120 days	Mon 7/31/17	Sat 12/16/17
8	BCOE	30 days	Mon 12/18/1	Sat 1/20/18
9	**Procurement & Award**	**55 days**	**Mon 1/22/18**	**Mon 3/26/18**
10	Advertise	30 days	Mon 1/22/18	Sat 2/24/18
11	Award	25 days	Mon 2/26/18	Mon 3/26/18
12	NTP	0 days	Mon 3/26/18	Mon 3/26/18
13	**CONSTRUCTION**	**449 days**	**Tue 3/27/18**	**Sat 8/31/19**
14	**High Flow Channel Construction**	**449 days**	**Tue 3/27/18**	**Sat 8/31/19**
15	**Mobilization and Preparatory Work**	**55 days**	**Tue 3/27/18**	**Tue 5/29/18**
16	Mobilization	30 days	Tue 3/27/18	Mon 4/30/18
17	Site Access and Staging	25 days	Tue 5/1/18	Tue 5/29/18
18	**Upstream Cofferdam**	**33 days**	**Wed 5/30/18**	**Fri 7/6/18**
19	Sheet Pile Cutoff	10 days	Wed 5/30/18	Sat 6/9/18
20	Borrow Fill Place and Compact	15 days	Mon 6/11/18	Wed 6/27/18
21	Bedding Placement	2 days	Thu 6/28/18	Fri 6/29/18
22	Riprap Placement	6 days	Sat 6/30/18	Fri 7/6/18
23	**Downstream Cofferdam**	**33 days**	**Sat 7/7/18**	**Tue 8/14/18**
24	Sheet Pile Cutoff	10 days	Sat 7/7/18	Wed 7/18/18
25	Borrow Fill Place and Compact	15 days	Thu 7/19/18	Sat 8/4/18
26	Bedding Placement	2 days	Mon 8/6/18	Tue 8/7/18
27	Riprap Placement	6 days	Wed 8/8/18	Tue 8/14/18
28	**Bridge Installation**	**43 days**	**Wed 8/15/18**	**Wed 10/3/18**
29	Earthwork	1 day	Wed 8/15/18	Wed 8/15/18
30	Abutments and Wingwalls	4 days	Thu 8/16/18	Mon 8/20/18
31	Concrete Cure Time	28 days	Tue 8/21/18	Fri 9/21/18
32	Prefab Bridge Installation	10 days	Sat 9/22/18	Wed 10/3/18
33	**Channel Construction**	**135 days**	**Thu 10/4/18**	**Sat 3/9/19**
34	Clearing and Grubbing	25 days	Thu 10/4/18	Thu 11/1/18
35	Channel Excavation	95 days	Fri 11/2/18	Wed 2/20/19
36	Finish Grading	15 days	Thu 2/21/19	Sat 3/9/19
37	Infill Existing Channel and Spread Material at Waste Site	95 days	Fri 11/2/18	Wed 2/20/19
38	**Bank Stabilization**	**115 days**	**Thu 2/21/19**	**Thu 7/4/19**
39	Bedding Placement	25 days	Thu 2/21/19	Thu 3/21/19
40	Riprap Placement	80 days	Fri 3/22/19	Sat 6/22/19
41	Boulder Placement	10 days	Mon 6/24/19	Thu 7/4/19
42	**Demobilization and Site Restoration**	**60 days**	**Mon 6/24/19**	**Sat 8/31/19**
43	Seeding and Restoration	45 days	Mon 6/24/19	Wed 8/14/19
44	Demobilization	15 days	Thu 8/15/19	Sat 8/31/19



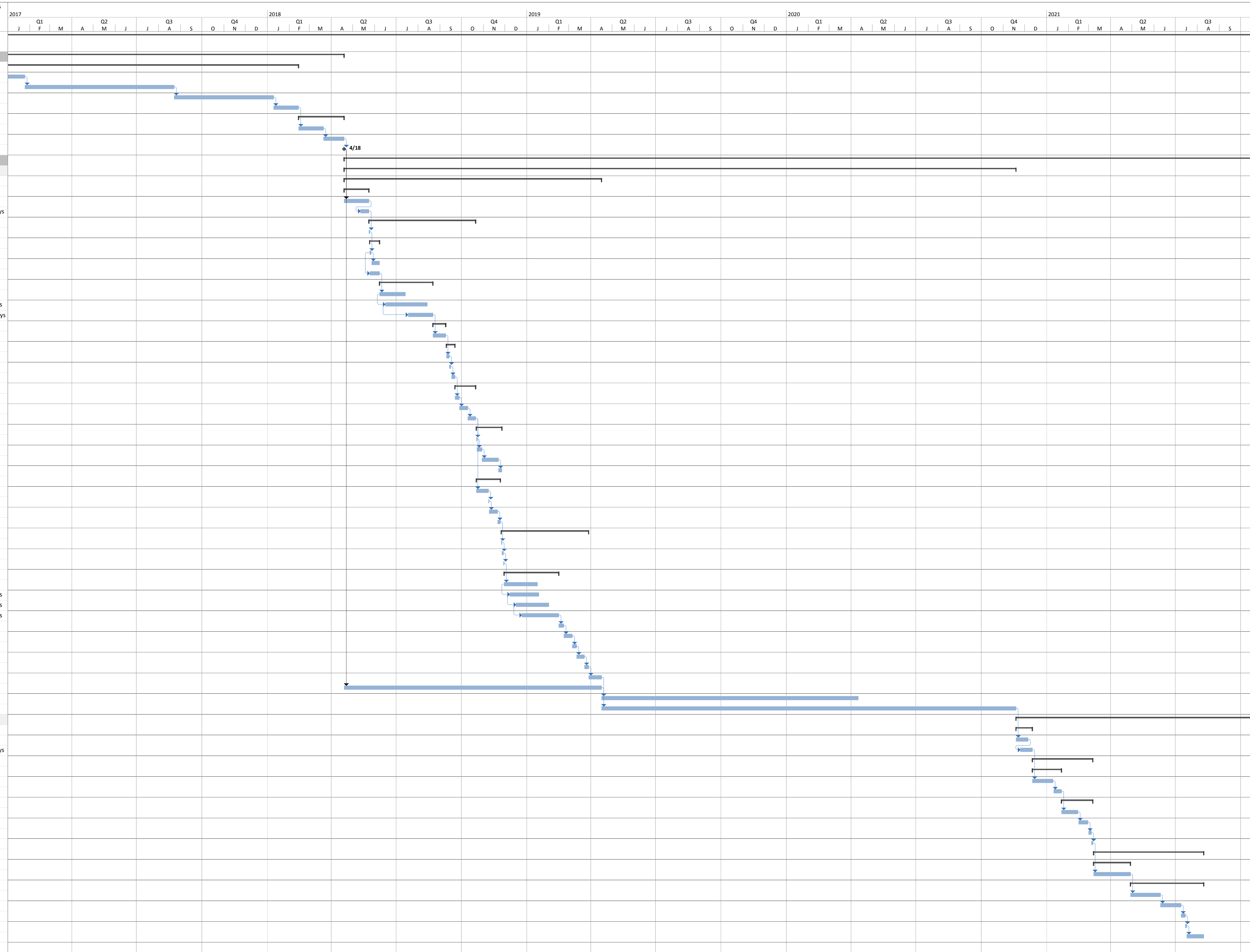
Project: LA River_Project Schedule
Date: Thu 5/19/16

Task	Summary	External Milestone	Inactive Summary	Manual Summary
Split	Project Summary	Inactive Task	Duration-only	Start-only
Milestone	External Tasks	Inactive Milestone	Manual Summary Rollup	Finish-only

Deadline
Progress
Manual Progress

Multiple Pump Project Schedule

ID	Task Name	Duration	Start	Finish	Predecessors
1	**LOWER YELLOWSTONE IRRIGATION PROJECT - MULTIPLE PUMP ALTERNATIVE**	**1691 days**	**Wed 5/25/16**	**Mon 10/18/21**	
2	**PRE-CONSTRUCTION AWARD**	**595 days**	**Wed 5/25/1**	**Wed 4/18/1**	
3	**Plans & Specifications**	**540 days**	**Wed 5/25/1**	**Tue 2/13/18**	
4	30% Design	210 days	Wed 5/25/16	Tue 1/24/17	
5	60% Design	180 days	Wed 1/25/17	Tue 8/22/17	4
6	90% Design	120 days	Wed 8/23/17	Tue 1/9/18	5
7	BCOE	30 days	Wed 1/10/18	Tue 2/13/18	6
8	**Procurement & Award**	**55 days**	**Wed 2/14/1**	**Wed 4/18/1**	
9	Advertise	30 days	Wed 2/14/18	Tue 3/20/18	7
10	Award	25 days	Wed 3/21/18	Wed 4/18/18	9
11	NTP	0 days	Wed 4/18/18	Wed 4/18/18	10
12	**CONSTRUCTION**	**1096 days**	**Thu 4/19/18**	**Mon 10/18/**	
13	**Multiple Pump Station Construction**	**810 days**	**Thu 4/19/18**	**Wed 11/18/**	
14	**Pump Station - Site 1**	**310 days**	**Thu 4/19/18**	**Mon 4/15/1**	
15	**Mobilization and Preparatory Work**	**30 days**	**Thu 4/19/18**	**Wed 5/23/1**	
16	Mobilization	30 days	Thu 4/19/18	Wed 5/23/18	11
17	Site Access and Staging	10 days	Sat 5/12/18	Wed 5/23/18	16FS-10 days
18	**Pump Station Work**	**129 days**	**Thu 5/24/18**	**Sat 10/20/18**	
19	Clearing and Grubbing	1 day	Thu 5/24/18	Thu 5/24/18	17
20	**Earthwork**	**12 days**	**Fri 5/25/18**	**Thu 6/7/18**	
21	Excavation - Dry Material	2 days	Fri 5/25/18	Sat 5/26/18	19
22	Excavation - Wet Material	10 days	Mon 5/28/18	Thu 6/7/18	21
23	Haul and Dispose of Excess Material	12 days	Fri 5/25/18	Thu 6/7/18	21SS
24	**Reinforced Concrete**	**64 days**	**Fri 6/8/18**	**Tue 8/21/18**	
25	Concrete Floor (Include 28-days of Curing)	31 days	Fri 6/8/18	Fri 7/13/18	23
26	Concrete Walls (Include 28-days of Curing)	50 days	Sat 6/16/18	Mon 8/13/18	25SS+7 days
27	Concrete Top Slab (Include 28-days of Curing)	30 days	Wed 7/18/18	Tue 8/21/18	26SS+27 days
28	**Irrigation Pumps and Motors**	**16 days**	**Wed 8/22/1**	**Sat 9/8/18**	
29	Install Pumps and Motors	16 days	Wed 8/22/18	Sat 9/8/18	27
30	**Piping**	**11 days**	**Mon 9/10/1**	**Fri 9/21/18**	
31	48" Pipe	4 days	Mon 9/10/18	Thu 9/13/18	29
32	84" Pipe	2 days	Fri 9/14/18	Sat 9/15/18	31
33	Hydraulic Gates	5 days	Mon 9/17/18	Fri 9/21/18	32
34	**Remaining Pump Station Work**	**25 days**	**Sat 9/22/18**	**Sat 10/20/18**	
35	Concrete Utility Vaults	5 days	Sat 9/22/18	Thu 9/27/18	33
36	Prefabricated Steel Building	10 days	Fri 9/28/18	Tue 10/9/18	35
37	Standby Generators with Buildings	10 days	Wed 10/10/1	Sat 10/20/18	36
38	**Discharge Pipelines**	**31 days**	**Mon 10/22/1**	**Mon 11/26/1**	
39	Clearing and Grubbing	1 day	Mon 10/22/1	Mon 10/22/1	37
40	Trench Excavation	6 days	Tue 10/23/1	Mon 10/29/1	39
41	84" Pipe	20 days	Tue 10/30/1	Wed 11/21/1	40
42	Trash Rack	4 days	Thu 11/22/1	Mon 11/26/1	41
43	**Feeder Canal**	**30 days**	**Mon 10/22/1**	**Sat 11/24/18**	
44	Sheet Pile Cofferdam	15 days	Mon 10/22/1	Wed 11/7/18	37
45	Clearing and Grubbing	1 day	Thu 11/8/18	Thu 11/8/18	44
46	Excavation	10 days	Fri 11/9/18	Tue 11/20/1	45
47	Trash Rack	4 days	Wed 11/21/1	Sat 11/24/18	46
48	**Fish Screen**	**106 days**	**Mon 11/26/1**	**Thu 3/28/19**	
49	Clearing and Grubbing	1 day	Mon 11/26/1	Mon 11/26/1	47
50	Channel Excavation	2 days	Tue 11/27/1	Wed 11/28/1	49
51	Structural Excavation	1 day	Thu 11/29/1	Thu 11/29/1	50
52	**Reinforced Concrete**	**66 days**	**Fri 11/30/18**	**Thu 2/14/19**	
53	Concrete Foundations (Include 28-days of Curing)	40 days	Fri 11/30/18	Tue 1/15/19	51
54	Concrete Floor (Include 28-days of Curing)	35 days	Sat 12/8/18	Thu 1/17/19	53SS+7 days
55	Concrete Footings (Include 28-days of Curing)	40 days	Mon 12/17/1	Thu 1/31/19	54SS+7 days
56	Concrete Walls (Include 28-days of Curing)	45 days	Tue 12/25/1	Thu 2/14/19	55SS+7 days
57	Structural Steel Supports	6 days	Fri 2/15/19	Thu 2/21/19	56
58	Fish Screen and Deadplates	10 days	Fri 2/22/19	Tue 3/5/19	57
59	Screen Cleaners	5 days	Wed 3/6/19	Mon 3/11/1	58
60	Fish Return Pump	10 days	Tue 3/12/19	Fri 3/22/19	59
61	Fish Return Pipes	5 days	Sat 3/23/19	Thu 3/28/19	60
62	Demobilization	15 days	Fri 3/29/19	Mon 4/15/1	61
63	Pump Station - Site 2	310 days	Thu 4/19/18	Mon 4/15/1	11
64	Pump Station - Site 3	310 days	Tue 4/16/19	Fri 4/10/20	62
65	Pump Station - Sites 4 and 5	500 days	Tue 4/16/19	Wed 11/18/2	63
66	**Demolition of Existing Intake Diversion Dam**	**286 days**	**Thu 11/19/2**	**Mon 10/18/**	
67	**Mobilization and Preparatory Work**	**20 days**	**Thu 11/19/2**	**Fri 12/11/20**	
68	Mobilization	15 days	Thu 11/19/2	Sat 12/5/20	65
69	Site Access and Staging	15 days	Wed 11/25/2	Fri 12/11/20	68FS-10 days
70	**Phase 1 Construction**	**73 days**	**Sat 12/12/20**	**Sat 3/6/21**	
71	**Phase 1 Cofferdam**	**35 days**	**Sat 12/12/20**	**Thu 1/21/21**	
72	Sheet Pile Cofferdam	25 days	Sat 12/12/20	Sat 1/9/21	69
73	Earthen Cofferdam	10 days	Mon 1/11/21	Thu 1/21/21	72
74	**Phase 1 Dam Removal**	**38 days**	**Fri 1/22/21**	**Sat 3/6/21**	
75	Rock Excavation	20 days	Fri 1/22/21	Sat 2/13/21	73
76	Timber Decking Removal	12 days	Mon 2/15/21	Sat 2/27/21	75
77	Timber Cribbing Removal	4 days	Mon 3/1/21	Thu 3/4/21	76
78	Timber Pile Demolition	2 days	Fri 3/5/21	Sat 3/6/21	77
79	**Phase 2 Construction**	**133 days**	**Mon 3/8/21**	**Mon 8/9/21**	
80	**Phase 2 Cofferdam**	**45 days**	**Mon 3/8/21**	**Wed 4/28/21**	
81	Sheet Pile Cofferdam	45 days	Mon 3/8/21	Wed 4/28/21	78
82	**Phase 2 Dam Removal**	**88 days**	**Thu 4/29/21**	**Mon 8/9/21**	
83	Rock Excavation	36 days	Thu 4/29/21	Wed 6/9/21	81
84	Timber Decking Removal	25 days	Thu 6/10/21	Thu 7/8/21	83
85	Timber Cribbing Removal	5 days	Fri 7/9/21	Wed 7/14/21	84
86	Timber Pile Demolition	2 days	Thu 7/15/21	Fri 7/16/21	85
87	Sheet Pile Demolition	20 days	Sat 7/17/21	Mon 8/9/21	86
88	Site Restoration	10 days	Sat 9/25/21	Wed 10/6/21	87
89	Demobilization	10 days	Thu 10/7/21	Mon 10/18/2	88



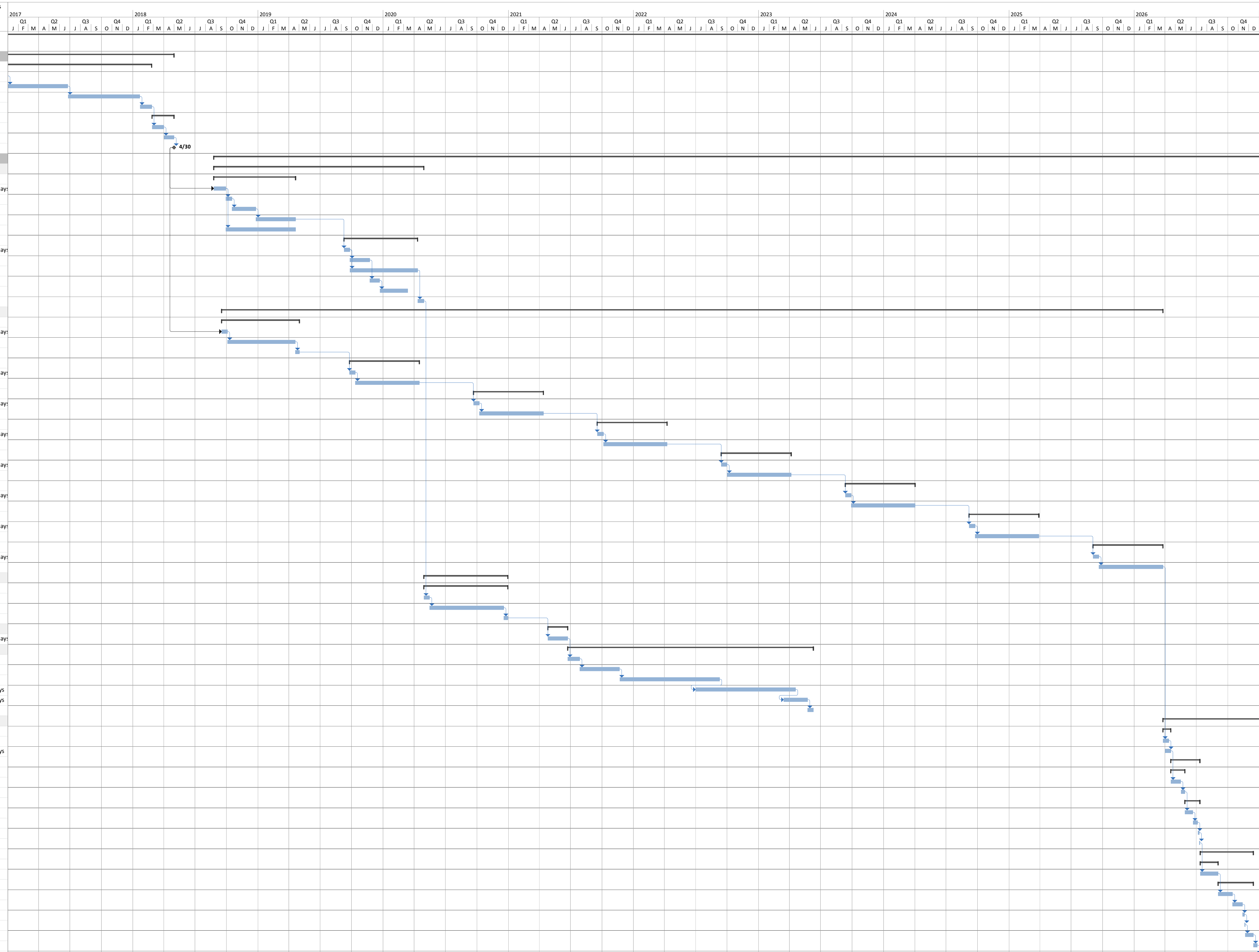
Project: LA River_Project Schedule
Date: Thu 5/19/16

Task	Milestone	Project Summary	External Milestone	Inactive Milestone	Duration-only	Manual Summary	Finish-only
Split	Summary	External Tasks	Inactive Task	Inactive Summary	Manual Summary Rollup	Start-only	Deadline

Progress
Manual Progress

Multiple Pumps with Conservation Measures Project Schedule

ID	Task Name	Duration	Start	Finish	Predecessors
1	**LOWER YELLOWSTONE IRRIGATION PROJECT - MULTIPLE PUMPS WITH CONSERVATION MEASURES ALTERNATIVE**	**3345 days**	**Mon 5/2/16**	**Wed 1/6/27**	
2	**PRE-CONSTRUCTION AWARD**	**625 days**	**Mon 5/2/16**	**Mon 4/30/18**	
3	**Plans & Specifications**	**570 days**	**Mon 5/2/16**	**Sat 2/24/18**	
4	30% Design	210 days	Mon 5/2/16	Sat 12/31/16	
5	60% Design	150 days	Mon 1/2/17	Sat 6/24/17	4
6	90% Design	180 days	Mon 6/26/17	Sat 1/20/18	5
7	BCOE	30 days	Mon 1/22/18	Sat 2/24/18	6
8	**Procurement & Award**	**55 days**	**Mon 2/26/18**	**Mon 4/30/18**	
9	Advertise	30 days	Mon 2/26/18	Sat 3/31/18	7
10	Award	25 days	Mon 4/2/18	Mon 4/30/18	9
11	NTP	0 days	Mon 4/30/18	Mon 4/30/18	10
12	**CONSTRUCTION**	**2620 days**	**Sat 8/25/18**	**Wed 1/6/27**	
13	**Convert Laterals to Pipe**	**525 days**	**Sat 8/25/18**	**Tue 4/28/20**	
14	**Construction - Year 1**	**205 days**	**Sat 8/25/18**	**Sat 4/20/19**	
15	Mobilization and Site preparation	30 days	Sat 8/25/18	Fri 9/28/18	11SS+100 days
16	18" Pipe Laterals	15 days	Sat 9/29/18	Tue 10/16/18	15
17	24" Pipe Laterals	60 days	Wed 10/17/18	Tue 12/25/18	16
18	60" Pipe Laterals	100 days	Wed 12/26/18	Sat 4/20/19	17
19	36" Pipe Laterals	175 days	Sat 9/29/18	Sat 4/20/19	15
20	**Construction - Year 2**	**185 days**	**Mon 9/9/19**	**Fri 4/10/20**	
21	Mobilization and Site Preparation	15 days	Mon 9/9/19	Wed 9/25/19	18FS+120 days
22	36" Pipe Laterals	50 days	Thu 9/26/19	Fri 11/22/19	21
23	48" Pipe Laterals	170 days	Thu 9/26/19	Fri 4/10/20	21
24	72" Pipe Laterals	25 days	Sat 11/23/19	Sat 12/21/19	22
25	Line Remaining Canals with Shotcrete	70 days	Mon 12/23/19	Thu 3/12/20	24
26	Site Restoration and Demobilization	15 days	Sat 4/11/20	Tue 4/28/20	23
27	**Line Main Canal**	**2355 days**	**Mon 9/17/18**	**Wed 3/25/26**	
28	**Construction - Year 1**	**195 days**	**Mon 9/17/18**	**Wed 5/1/19**	
29	Mobilization and Site Preparation	15 days	Mon 9/17/18	Wed 10/3/18	11SS+100 days
30	Place and Compact Fill in Main Canal	170 days	Thu 10/4/18	Fri 4/19/19	29
31	Site Restoration and Demobilization	10 days	Sat 4/20/19	Wed 5/1/19	30
32	**Construction - Year 2**	**175 days**	**Wed 9/25/19**	**Wed 4/15/20**	
33	Mobilization and Site Preparation	15 days	Wed 9/25/19	Fri 10/11/19	31FS+125 days
34	Place Canal Lining	160 days	Sat 10/12/19	Wed 4/15/20	33
35	**Construction - Year 3**	**175 days**	**Mon 9/21/20**	**Mon 4/12/21**	
36	Mobilization and Site Preparation	15 days	Mon 9/21/20	Wed 10/7/20	34FS+135 days
37	Place Canal Lining	160 days	Thu 10/8/20	Mon 4/12/21	36
38	**Construction - Year 4**	**175 days**	**Fri 9/17/21**	**Fri 4/8/22**	
39	Mobilization and Site Preparation	15 days	Fri 9/17/21	Mon 10/4/21	37FS+135 days
40	Place Canal Lining	160 days	Tue 10/5/21	Fri 4/8/22	39
41	**Construction - Year 5**	**175 days**	**Wed 9/14/22**	**Wed 4/5/23**	
42	Mobilization and Site Preparation	15 days	Wed 9/14/22	Fri 9/30/22	40FS+135 days
43	Place Canal Lining	160 days	Sat 10/1/22	Wed 4/5/23	42
44	**Construction - Year 6**	**175 days**	**Mon 9/11/23**	**Mon 4/1/24**	
45	Mobilization and Site Preparation	15 days	Mon 9/11/23	Wed 9/27/23	43FS+135 days
46	Place Canal Lining	160 days	Thu 9/28/23	Mon 4/1/24	45
47	**Construction - Year 7**	**175 days**	**Fri 9/6/24**	**Fri 3/28/25**	
48	Mobilization and Site Preparation	15 days	Fri 9/6/24	Mon 9/23/24	46FS+135 days
49	Place Canal Lining	160 days	Tue 9/24/24	Fri 3/28/25	48
50	**Construction - Year 8**	**175 days**	**Wed 9/3/25**	**Wed 3/25/26**	
51	Mobilization and Site Preparation	15 days	Wed 9/3/25	Fri 9/19/25	49FS+135 days
52	Place Canal Lining	160 days	Sat 9/20/25	Wed 3/25/26	51
53	**Check Structures and Flow Measuring Devices**	**210 days**	**Wed 4/29/20**	**Tue 12/29/20**	
54	**Construction**	**210 days**	**Wed 4/29/20**	**Tue 12/29/20**	
55	Mobilization	15 days	Wed 4/29/20	Fri 5/15/20	26
56	Place and Compact Fill in Main Canal	185 days	Sat 5/16/20	Thu 12/17/20	55
57	Demobilization	10 days	Fri 12/18/20	Tue 12/29/20	56
58	**Construct Wind Turbine**	**50 days**	**Mon 4/26/21**	**Tue 6/22/21**	
59	Build and Test Wind Turbine	50 days	Mon 4/26/21	Tue 6/22/21	57FS+100 days
60	**Construct Ranney Wells**	**615 days**	**Wed 6/23/21**	**Fri 6/9/23**	
61	Mobilization	30 days	Wed 6/23/21	Tue 7/27/21	59
62	Drill and Pump Tests	100 days	Wed 7/28/21	Sat 11/20/21	61
63	Well Installation	250 days	Mon 11/22/21	Thu 9/8/22	62
64	Pump Station Installation	250 days	Fri 7/1/22	Tue 4/18/23	63FS-60 days
65	Discharge Piping	60 days	Wed 3/15/23	Tue 5/23/23	64FS-30 days
66	Demoblization	15 days	Wed 5/24/23	Fri 6/9/23	65
67	**Demolition of Existing Intake Diversion Dam**	**246 days**	**Thu 3/26/26**	**Wed 1/6/27**	
68	**Mobilization and Preparatory Work**	**20 days**	**Thu 3/26/26**	**Fri 4/17/26**	
69	Mobilization	15 days	Thu 3/26/26	Sat 4/11/26	52
70	Site Access and Staging	15 days	Wed 4/1/26	Fri 4/17/26	69FS-10 days
71	**Phase 1 Construction**	**73 days**	**Sat 4/18/26**	**Sat 7/11/26**	
72	**Phase 1 Cofferdam**	**35 days**	**Sat 4/18/26**	**Thu 5/28/26**	
73	Sheet Pile Cofferdam	25 days	Sat 4/18/26	Sat 5/16/26	70
74	Earthen Cofferdam	10 days	Mon 5/18/26	Thu 5/28/26	73
75	**Phase 1 Dam Removal**	**38 days**	**Fri 5/29/26**	**Sat 7/11/26**	
76	Rock Excavation	20 days	Fri 5/29/26	Sat 6/20/26	74
77	Timber Decking Removal	12 days	Mon 6/22/26	Sat 7/4/26	76
78	Timber Cribbing Removal	4 days	Mon 7/6/26	Thu 7/9/26	77
79	Timber Pile Demolition	2 days	Fri 7/10/26	Sat 7/11/26	78
80	**Phase 2 Construction**	**133 days**	**Mon 7/13/26**	**Mon 12/14/26**	
81	**Phase 2 Cofferdam**	**45 days**	**Mon 7/13/26**	**Wed 9/2/26**	
82	Sheet Pile Cofferdam	45 days	Mon 7/13/26	Wed 9/2/26	79
83	**Phase 2 Dam Removal**	**88 days**	**Thu 9/3/26**	**Mon 12/14/26**	
84	Rock Excavation	36 days	Thu 9/3/26	Wed 10/14/26	82
85	Timber Decking Removal	25 days	Thu 10/15/26	Thu 11/12/26	84
86	Timber Cribbing Removal	5 days	Fri 11/13/26	Wed 11/18/26	85
87	Timber Pile Demolition	2 days	Thu 11/19/26	Fri 11/20/26	86
88	Sheet Pile Demolition	20 days	Sat 11/21/26	Mon 12/14/26	87
89	Site Restoration	10 days	Tue 12/15/26	Fri 12/25/26	88
90	Demobilization	10 days	Sat 12/26/26	Wed 1/6/27	89



Project: LA River_Project Schedule
Date: Thu 5/19/16

Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress | Manual Progress

Attachment B.3
Abbreviated Risk Analysis (ARA) Spreadsheets

Rock Ramp ARA

Abbreviated Risk Analysis

Project (less than $40M): **Lower Yellowstone River**

Project Development Stage/Alternative: **Feasibility (Alternatives)**

Risk Category: **Low Risk: Typical Construction, Simple**

Alternative: **Rock Ramp**

Meeting Date:

Total Estimated Construction Contract Cost = **$ 59,979,308**

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0.00%	$ -	$ -
1	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Concrete Crest Structure	$ 8,950,189		26.65%	$ 2,385,078	$ 11,335,267
2	06 FISH AND WILDLIFE FACILITIES	Coffer Dam	$ 4,167,924		40.81%	$ 1,701,095	$ 5,869,019
3	06 FISH AND WILDLIFE FACILITIES	Rock Ramp	$ 45,844,675		33.24%	$ 15,239,490	$ 61,084,165
4	06 FISH AND WILDLIFE FACILITIES	Mob/Demob, Haul Roads, Staging, etc.	$ 1,016,520		28.24%	$ 287,106	$ 1,303,626
5			$ -		0.00%	$ -	$ -
6			$ -		0.00%	$ -	$ -
7					0.00%	$ -	$ -
8			$ -		0.00%	$ -	$ -
9			$ -		0.00%	$ -	$ -
10			$ -		0.00%	$ -	$ -
11			$ -		0.00%	$ -	$ -
12	All Other	**Remaining Construction Items**	$ -	*0.0%*	0.00%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 5,453,000		18.84%	$ 1,027,121	$ 6,480,121
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 3,635,000		20.55%	$ 747,162	$ 4,382,162
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals				
Real Estate	$ -	0.00%	$ -	$ -
Total Construction Estimate	$ 59,979,308	32.6992%	$ 19,612,770	$ 79,592,078
Total Planning, Engineering & Design	$ 5,453,000	18.8359%	$ 1,027,121	$ 6,480,121
Total Construction Management	$ 3,635,000	20.5547%	$ 747,162	$ 4,382,162
Total	**$ 69,067,308**	**30.97%**	**$ 21,387,053**	**$ 90,454,361**

	Base	50%	80%
Range Estimate ($000's)	$69,067k	$81,899k	$90,454k

* 50% based on base is at 5% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analysis. Must include justification. Does not allocate to Real Estate.	

Lower Yellowstone River Rock Ramp

Feasibility (Alternatives)

Abbreviated Risk Analysis

Meeting Date: 0-Jan-00

Risk Level

Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3
	Negligible	Marginal	Moderate	Significant	Critical

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
Project Scope Growth					**Maximum Project Growth**	**40%**
PS-1	Concrete Crest Structure	Estimate is based on conceptual level design plans with many investigations remaining to complete that could change the design; Further analysis may show that the current design assumptions do not accomplish the project's intent, thus leading to more changes in the design.	Because of low design level, the scope/scale of this could change but is not likely to be significantly different than current assumptions.	Marginal	Likely	2
PS-2	Coffer Dam	See discussion above.	The current assumptions are likely to change. Further investigations could show need for more dewatering efforts than currently assumed.	Moderate	Likely	3
PS-3	Rock Ramp	See discussion above.	Current assumptions show that the design accomplishes the project's intent. However, some investigations still remain, thus there is still a risk that this could change. Any scope growth could lead to cost impacts though.	Moderate	Likely	3
PS-4	Mob/Demob, Haul Roads, Staging, etc.	See discussion above.	Because of low design level, the scope/scale of this could change but is not likely to be significantly different than current assumptions.	Marginal	Likely	2
PS-5	0			Negligible	Unlikely	0
PS-6	0			Negligible	Unlikely	0
PS-7	0			Negligible	Unlikely	0
PS-8	0			Negligible	Unlikely	0
PS-9	0			Negligible	Unlikely	0
PS-10	0			Negligible	Unlikely	0
PS-11	0			Negligible	Unlikely	0

PS-12	Remaining Construction Items			Negligible	Unlikely	0
PS-13	Planning, Engineering, & Design	See discussion above.	Potential need for more investigations to be completed, above and beyond what is already assumed. These investigations could present moderate cost increases.	Negligible	Unlikely	0
PS-14	Construction Management	See discussion above.	Construction management could increase moderately given any scope increases as more management would be required to oversee the additional construction.	Negligible	Unlikely	0
Acquisition Strategy				**Maximum Project Growth**		**30%**
AS-1	Concrete Crest Structure	Due to conceptual level of this project, there is limited contracting plan information; Estimate assumes relatively conservative assumptions regarding number of contracts and sub-contractors; Harsh weather could be a risk, but contractors would likely be experienced in this region; No 8a or small business likely due to scale of the project;	Current estimate assumes one contract to be bid out. Contractor assumes several subs, and schedule includes non-construction period during harsh winter months. So assumptions are relatively conservative, but still have some risk of changing. Impacts would likely be marginal at most if they occured.	Marginal	Likely	2
AS-2	Coffer Dam	See concerns listed above.	See discussion listed above.	Marginal	Likely	2
AS-3	Rock Ramp	See concerns listed above.	See discussion listed above.	Marginal	Likely	2
AS-4	Mob/Demob, Haul Roads, Staging, etc.	See concerns listed above.	See discussion listed above.	Marginal	Likely	2
AS-5	0			Negligible	Unlikely	0
AS-6	0			Negligible	Unlikely	0
AS-7	0			Negligible	Unlikely	0
AS-8	0			Negligible	Unlikely	0
AS-9	0			Negligible	Unlikely	0
AS-10	0			Negligible	Unlikely	0
AS-11	0			Negligible	Unlikely	0
AS-12	Remaining Construction Items			Negligible	Unlikely	0
AS-13	Planning, Engineering, & Design	See concerns listed above.	See discussion listed above.	Marginal	Likely	2
AS-14	Construction Management	See concerns listed above.	See discussion listed above.	Marginal	Likely	2
Construction Elements				**Maximum Project Growth**		**15%**

CE-1	Concrete Crest Structure	Placing concrete within cofferdam and near flowing water.	Not likely to be significant impact but there could be issues in placing the concrete that change the current productivities.	Marginal	Possible	1
CE-2	Coffer Dam	Diversion and control of water	Current dewatering assumptions and sheet pile cofferdams are likely sufficient. There is still a risk that once in place, they are not sufficient. Changes to dewatering efforts could see a large increase in costs.	Significant	Possible	3
CE-3	Rock Ramp	Placing rock within cofferdams and near flowing water	Not likely to be significant impact but there could be issues in placing the rock ramp that change the current productivities.	Marginal	Possible	1
CE-4	Mob/Demob, Haul Roads, Staging, etc.	No significant risks anticipated	These construction elements are common and are unlikely to have any risks that cause cost increases.	Negligible	Unlikely	0
CE-5	0			Negligible	Unlikely	0
CE-6	0			Negligible	Unlikely	0
CE-7	0			Negligible	Unlikely	0
CE-8	0			Negligible	Unlikely	0
CE-9	0			Negligible	Unlikely	0
CE-10	0			Negligible	Unlikely	0
CE-11	0			Negligible	Unlikely	0
CE-12	Remaining Construction Items			Negligible	Unlikely	0
CE-13	Planning, Engineering, & Design	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
CE-14	Construction Management	Diversion and control of water	If increased effort of diverting flows is required then oversight could increase as well.	Marginal	Possible	1
Quantities for Current Scope				**Maximum Project Growth**		**20%**
Q-1	Concrete Crest Structure	None anticipated	No significant risks are anticipated for the quantity of the crest structure.	Negligible	Unlikely	0
Q-2	Coffer Dam	Cofferdam quantities and dewatering assumptions	The cofferdams have detailed quantity take-offs that have been verified, thus these are likely reasonable. There is risk of the contractor requiring more sheet piling and/or longer periods to dewater. This risk is low but could be significant increase.	Significant	Possible	3

Q-3	Rock Ramp	Confidence in rock quantities	Quantities have been calculated with the best info available and have been reviewed. But there is a chance they could change, which could cause a cost increase.	Marginal	Possible	1
Q-4	Mob/Demob, Haul Roads, Staging, etc.	Number of mob/demob periods and assumed mob/demob durations	There is a low risk that the number of mob/demob periods increase. Also a risk that the time to mob equipment and crews to site could be greater than those assumed. These risks are low, but could cause moderate increase if they occur.	Moderate	Possible	2
Q-5	0			Negligible	Unlikely	0
Q-6	0			Negligible	Unlikely	0
Q-7	0			Negligible	Unlikely	0
Q-8	0			Negligible	Unlikely	0
Q-9	0			Negligible	Unlikely	0
Q-10	0			Negligible	Unlikely	0
Q-11	0			Negligible	Unlikely	0
Q-12	Remaining Construction Items			Negligible	Unlikely	0
Q-13	Planning, Engineering, & Design	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
Q-14	Construction Management	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
Specialty Fabrication or Equipment				**Maximum Project Growth**		**50%**
FE-1	Concrete Crest Structure	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
FE-2	Coffer Dam	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
FE-3	Rock Ramp	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
FE-4	Mob/Demob, Haul Roads, Staging, etc.	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
FE-5	0			Negligible	Unlikely	0
FE-6	0			Negligible	Unlikely	0

FE-7	0			Negligible	Unlikely	0
FE-8	0			Negligible	Unlikely	0
FE-9	0			Negligible	Unlikely	0
FE-10	0			Negligible	Unlikely	0
FE-11	0			Negligible	Unlikely	0
FE-12	Remaining Construction Items			Negligible	Unlikely	0
FE-13	Planning, Engineering, & Design	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
FE-14	Construction Management	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
Cost Estimate Assumptions				**Maximum Project Growth**		**25%**
CT-1	Concrete Crest Structure	Productivity assumptions	The assumptions regarding the productivity of placing the concrete crest structure could differ once in the field. Conservative assumptions were used, but there is still a risk of these being different than the contractor.	Marginal	Likely	2
CT-2	Coffer Dam	Productivity of placing cofferdams	The cofferdam installation will be completed along the flowing river channel. Therefore there is some risk that current assumptions are wrong. Estimate attempted to make conservative placement assumptions and therefore not likely to see a significant cost increase.	Marginal	Likely	2
CT-3	Rock Ramp	Productivity assumptions; Site accessibility at disposal locations	This alternative involves placing large quantities of rock. Estimated production rates may not be correct, but conservative assumptions have been assumed. Therefore not likley to be a large increase but could occur.	Marginal	Likely	2
CT-4	Mob/Demob, Haul Roads, Staging, etc.	Site accessibility and transport delays	Due to needing to access the site from Joe's Island, there are no existing roadways capable of handling the construction traffic to and from the site. Therefore, access roads are assumed to be installed. But the access speeds and traffic assumptions may be different during construction than currently assumed. This could lead to cost increases if it happens.	Moderate	Possible	2
CT-5	0			Negligible	Unlikely	0
CT-6	0			Negligible	Unlikely	0
CT-7	0			Negligible	Unlikely	0

CT-8	0			Negligible	Unlikely	0
CT-9	0			Negligible	Unlikely	0
CT-10	0			Negligible	Unlikely	0
CT-11	0			Negligible	Unlikely	0
CT-12	Remaining Construction Items			Negligible	Unlikely	0
CT-13	Planning, Engineering, & Design	Percentages assumed for PED	A typical percentage for this item has been assumed. Percentage may change, but not likely to increase significantly from current.	Marginal	Possible	1
CT-14	Construction Management	Percentages assumed for CM	A typical percentage for this item has been assumed. Percentage may change, but not likely to increase significantly from current.	Marginal	Possible	1
External Project Risks				**Maximum Project Growth**		**20%**
EX-1	Concrete Crest Structure	Severe winter weathere; unanticipated inflations in fuel, and materials; market conditions and bidding climate;	Winter weather is an issue and construction will be likely completed around those times. But impacts to cost/schedule could still occur. The risk of inflation to fuel and other material items is real and could be a significant impact. The bidding climate at time of award, and for possible numerous contracts, could be unfavorable to the cost. Given all these risks, a significant impact would be assumed if they all occured.	Significant	Possible	3
EX-2	Coffer Dam	See discussion above.	See discussion above.	Significant	Possible	3
EX-3	Rock Ramp	See discussion above.	See discussion above.	Significant	Possible	3
EX-4	Mob/Demob, Haul Roads, Staging, etc.	See discussion above.	See discussion above.	Significant	Possible	3
EX-5	0			Negligible	Unlikely	0
EX-6	0			Negligible	Unlikely	0
EX-7	0			Negligible	Unlikely	0
EX-8	0			Negligible	Unlikely	0
EX-9	0			Negligible	Unlikely	0
EX-10	0			Negligible	Unlikely	0
EX-11	0			Negligible	Unlikely	0

EX-12	Remaining Construction Items			Negligible	Unlikely	**0**
EX-13	Planning, Engineering, & Design	See discussion above.	See discussion above.	Significant	Possible	**3**
EX-14	Construction Management	See discussion above.	See discussion above.	Significant	Possible	**3**

Lower Yellowstone River Rock Ramp
Feasibility (Alternatives)
Abbreviated Risk Analysis

Risk Evaluation

WBS	Potential Risk Areas	Project Scope Growth	Acquisition Strategy	Construction Elements	Quantities for Current Scope	Specialty Fabrication or Equipment	Cost Estimate Assumptions	External Project Risks	Cost in Thousands
01 LANDS AND DAMAGES	**Real Estate**								$0
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	**Concrete Crest Structure**	2	2	1	0	0	2	3	$8,950
06 FISH AND WILDLIFE FACILITIES	Coffer Dam	3	2	3	3	0	2	3	$4,168
06 FISH AND WILDLIFE FACILITIES	Rock Ramp	3	2	1	1	0	2	3	$45,845
06 FISH AND WILDLIFE FACILITIES	Mob/Demob, Haul Roads, Staging, etc.	2	2	0	2	0	2	3	$1,017
0	0	0	0	0	0	0	0	0	$0
0	0	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
All Other	Remaining Construction Items	0	0	0	0	0	0	0	$0
30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	0	2	0	0	0	1	3	$5,453
31 CONSTRUCTION MANAGEMENT	Construction Management	0	2	1	0	0	1	3	$3,635
									$69,067
Risk		$ 5,010	$ 2,692	$ 6,051	$ 1,120	$ -	$ 2,347	$ 4,168	**$21,387**
Fixed Dollar Risk Allocation		$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$0**
	Risk	$ 5,010	$ 2,692	$ 6,051	$ 1,120	$ -	$ 2,347	$ 4,168	**$21,387**
								Total	**$90,454**

Bypass Channel ARA

Abbreviated Risk Analysis

Project (less than $40M): **Lower Yellowstone River** | **Alternative:** **Bypass Channel**

Project Development Stage/Alternative: **Feasibility (Alternatives)**

Risk Category: **Low Risk: Typical Construction, Simple** | **Meeting Date:**

Total Estimated Construction Contract Cost = **$ 49,424,497**

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		0.00%	$ -	$ -
1	09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	Bypass Channel	$ 18,046,778		8.82%	$ 1,591,828	$ 19,638,606
2	15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Intake Weir	$ 12,266,807		8.82%	$ 1,082,002	$ 13,348,809
3	16 BANK STABILIZATION	Bank Stabilization Rock	$ 19,110,912		8.82%	$ 1,685,690	$ 20,796,602
4			$ -		0.00%	$ -	$ -
5			$ -		0.00%	$ -	$ -
6			$ -		0.00%	$ -	$ -
7					0.00%	$ -	$ -
8			$ -		0.00%	$ -	$ -
9			$ -		0.00%	$ -	$ -
10			$ -		0.00%	$ -	$ -
11			$ -		0.00%	$ -	$ -
12	All Other	Remaining Construction Items	$ -	*0.0%*	0.00%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	$ -		0.00%	$ -	$ -
14	31 CONSTRUCTION MANAGEMENT	Construction Management	$ 2,996,000		8.82%	$ 264,264	$ 3,260,264
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals	Contract Cost	% Contingency	$ Contingency	Total
Real Estate	$ -	0.00%	$ -	$ -
Total Construction Estimate	$ 49,424,497	8.8206%	$ 4,359,519	$ 53,784,016
Total Planning, Engineering & Design	$ -	0.0000%	$ -	$ -
Total Construction Management	$ 2,996,000	8.8206%	$ 264,264	$ 3,260,264
Total	**$ 52,420,497**	**8.82%**	**$ 4,623,784**	**$ 57,044,281**

	Base	50%	80%
Range Estimate ($000's)	$52,420k	$55,194k	$57,044k

* 50% based on base is at 5% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analsyis. Must include justification. Does not allocate to Real Estate.	

Lower Yellowstone River Bypass Channel

Feasibility (Alternatives)
Abbreviated Risk Analysis
Meeting Date: 0-Jan-00

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
Project Scope Growth				**Maximum Project Growth**		**40%**
PS-1	Bypass Channel	None	No risks anticipated as the designs have been fully developed to the 100% level.	Negligible	Unlikely	0
PS-2	Intake Weir	None	See discussion above.	Negligible	Unlikely	0
PS-3	Bank Stabilization Rock	None	See discussion above.	Negligible	Unlikely	0
PS-4	0	None	See discussion above.	Negligible	Unlikely	0
PS-5	0			Negligible	Unlikely	0
PS-6	0			Negligible	Unlikely	0
PS-7	0			Negligible	Unlikely	0
PS-8	0			Negligible	Unlikely	0
PS-9	0			Negligible	Unlikely	0
PS-10	0			Negligible	Unlikely	0
PS-11	0			Negligible	Unlikely	0

PS-12	Remaining Construction Items			Negligible	Unlikely	0
PS-13	Planning, Engineering, & Design	None	See discussion above.	Negligible	Unlikely	0
PS-14	Construction Management	None	See discussion above.	Negligible	Unlikely	0
Acquisition Strategy				**Maximum Project Growth**		**30%**
AS-1	Bypass Channel	None	Contract had already been awarded, and assumptions in estimate were likely over estimated. Therefore no likely cost increase due to acquisition strategy issues.	Negligible	Unlikely	0
AS-2	Intake Weir	None	See discussion above.	Negligible	Unlikely	0
AS-3	Bank Stabilization Rock	None	See discussion above.	Negligible	Unlikely	0
AS-4	0	None	See discussion above.	Negligible	Unlikely	0
AS-5	0			Negligible	Unlikely	0
AS-6	0			Negligible	Unlikely	0
AS-7	0			Negligible	Unlikely	0
AS-8	0			Negligible	Unlikely	0
AS-9	0			Negligible	Unlikely	0
AS-10	0			Negligible	Unlikely	0
AS-11	0			Negligible	Unlikely	0
AS-12	Remaining Construction Items			Negligible	Unlikely	0
AS-13	Planning, Engineering, & Design	None	See discussion above.	Negligible	Unlikely	0
AS-14	Construction Management	None	See discussion above.	Negligible	Unlikely	0
Construction Elements				**Maximum Project Growth**		**15%**
CE-1	Bypass Channel	None	Construction elements are of no risk as the project was previously bid on, and current estimate is likely conservative.	Negligible	Unlikely	0

CE-2	Intake Weir	None	See discussion above.	Negligible	Unlikely	0
CE-3	Bank Stabilization Rock	None	See discussion above.	Negligible	Unlikely	0
CE-4	0	None	See discussion above.	Negligible	Unlikely	0
CE-5	0			Negligible	Unlikely	0
CE-6	0			Negligible	Unlikely	0
CE-7	0			Negligible	Unlikely	0
CE-8	0			Negligible	Unlikely	0
CE-9	0			Negligible	Unlikely	0
CE-10	0			Negligible	Unlikely	0
CE-11	0			Negligible	Unlikely	0
CE-12	Remaining Construction Items			Negligible	Unlikely	0
CE-13	Planning, Engineering, & Design	None	See discussion above.	Negligible	Unlikely	0
CE-14	Construction Management	None	See discussion above.	Negligible	Unlikely	0
Quantities for Current Scope				**Maximum Project Growth**		**20%**
Q-1	Bypass Channel	None	Designs have been built out to the 100% level. Therefore quantities used in the estimate are highly reliable and and are very unlikely to change at this point.	Negligible	Unlikely	0
Q-2	Intake Weir	None	See discussion above.	Negligible	Unlikely	0
Q-3	Bank Stabilization Rock	None	See discussion above.	Negligible	Unlikely	0
Q-4	0	None	See discussion above.	Negligible	Unlikely	0
Q-5	0			Negligible	Unlikely	0

Q-6	0			Negligible	Unlikely	0
Q-7	0			Negligible	Unlikely	0
Q-8	0			Negligible	Unlikely	0
Q-9	0			Negligible	Unlikely	0
Q-10	0			Negligible	Unlikely	0
Q-11	0			Negligible	Unlikely	0
Q-12	Remaining Construction Items			Negligible	Unlikely	0
Q-13	Planning, Engineering, & Design	None	See discussion above.	Negligible	Unlikely	0
Q-14	Construction Management	None	See discussion above.	Negligible	Unlikely	0
Specialty Fabrication or Equipment				**Maximum Project Growth**		**50%**
FE-1	Bypass Channel	None	No specialty fabrication or equipment required for this alternative.	Negligible	Unlikely	0
FE-2	Intake Weir	None	See discussion above.	Negligible	Unlikely	0
FE-3	Bank Stabilization Rock	None	See discussion above.	Negligible	Unlikely	0
FE-4	0	None	See discussion above.	Negligible	Unlikely	0
FE-5	0			Negligible	Unlikely	0
FE-6	0			Negligible	Unlikely	0
FE-7	0			Negligible	Unlikely	0
FE-8	0			Negligible	Unlikely	0
FE-9	0			Negligible	Unlikely	0
FE-10	0			Negligible	Unlikely	0
FE-11	0			Negligible	Unlikely	0

FE-12	Remaining Construction Items			Negligible	Unlikely	0
FE-13	Planning, Engineering, & Design	None	See discussion above.	Negligible	Unlikely	0
FE-14	Construction Management	None	See discussion above.	Negligible	Unlikely	0
Cost Estimate Assumptions				**Maximum Project Growth**		**25%**
CT-1	Bypass Channel	None	Conservative assumptions were made across the board in the cost estimate. This was proven when contractor bids were received. Thus no risk of cost increases from the assumptions made within the MCACES.	Negligible	Unlikely	0
CT-2	Intake Weir	None	See discussion above.	Negligible	Unlikely	0
CT-3	Bank Stabilization Rock	None	See discussion above.	Negligible	Unlikely	0
CT-4	0	None	See discussion above.	Negligible	Unlikely	0
CT-5	0			Negligible	Unlikely	0
CT-6	0			Negligible	Unlikely	0
CT-7	0			Negligible	Unlikely	0
CT-8	0			Negligible	Unlikely	0
CT-9	0			Negligible	Unlikely	0
CT-10	0			Negligible	Unlikely	0
CT-11	0			Negligible	Unlikely	0
CT-12	Remaining Construction Items			Negligible	Unlikely	0
CT-13	Planning, Engineering, & Design	None	See discussion above.	Negligible	Unlikely	0
CT-14	Construction Management	None	See discussion above.	Negligible	Unlikely	0
External Project Risks				**Maximum Project Growth**		**20%**

EX-1	Bypass Channel	Weather, market volatility, unexpected increases in materials/gas	There are some small possibility of these risks occuring. But if this alternative moves forward, it would likely begin construciton quickly and therefore there shouldn't be any major changes to material prices. Contractor is likely very capable of working in the weather conditions at the site. Also, if project needs to be re-bid, likely would not expect price increase.	Marginal	Possible	1
EX-2	Intake Weir	None	See discussion above.	Marginal	Possible	1
EX-3	Bank Stabilization Rock	None	See discussion above.	Marginal	Possible	1
EX-4	0	None	See discussion above.	Marginal	Possible	1
EX-5	0			Negligible	Unlikely	0
EX-6	0			Negligible	Unlikely	0
EX-7	0			Negligible	Unlikely	0
EX-8	0			Negligible	Unlikely	0
EX-9	0			Negligible	Unlikely	0
EX-10	0			Negligible	Unlikely	0
EX-11	0			Negligible	Unlikely	0
EX-12	Remaining Construction Items			Negligible	Unlikely	0
EX-13	Planning, Engineering, & Design	None	See discussion above.	Marginal	Possible	1
EX-14	Construction Management	None	See discussion above.	Marginal	Possible	1

Lower Yellowstone River Bypass Channel
Feasibility (Alternatives)
Abbreviated Risk Analysis

Risk Evaluation

WBS	Potential Risk Areas	Project Scope Growth	Acquisition Strategy	Construction Elements	Quantities for Current Scope	Specialty Fabrication or Equipment	Cost Estimate Assumptions	External Project Risks	Cost in Thousands
01 LANDS AND DAMAGES	**Real Estate**								$0
09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	**Bypass Channel**	0	0	0	0	0	0	1	$18,047
15 FLOODWAY CONTROL AND DIVERSION STRUCTURES	Intake Weir	0	0	0	0	0	0	1	$12,267
16 BANK STABILIZATION	Bank Stabilization Rock	0	0	0	0	0	0	1	$19,111
0	0	0	0	0	0	0	0	1	$0
0	0	0	0	0	0	0	0	0	$0
0	0	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
All Other	Remaining Construction Items	0	0	0	0	0	0	0	$0
30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	0	0	0	0	0	0	1	$0
31 CONSTRUCTION MANAGEMENT	Construction Management	0	0	0	0	0	0	1	$2,996
									$52,420
Risk		$ -	$ -	$ 3,669	$ -	$ -	$ -	$ 954	**$4,624**
Fixed Dollar Risk Allocation		$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$0**
	Risk	$ -	$ -	$ 3,669	$ -	$ -	$ -	$ 954	**$4,624**
								Total	**$57,044**

Modified Side Channel ARA

Abbreviated Risk Analysis

Project (less than $40M): **Lower Yellowstone River**

Alternative: **Modified Side Channel**

Project Development Stage/Alternative: **Feasibility (Alternatives)**

Risk Category: **Low Risk: Typical Construction, Simple**

Meeting Date:

Total Estimated Construction Contract Cost = **$ 35,180,547**

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ 220,000		25.00%	$ 55,000	$ 275,000
1		Mob, Demob & Site Preparation	$ 2,254,556		29.96%	$ 675,528	$ 2,930,085
2		Diversion and Control of Water	$ 2,178,186		36.97%	$ 805,283	$ 2,983,470
3	08 ROADS, RAILROADS, AND BRIDGES	Bridge Installation	$ 975,827		35.74%	$ 348,726	$ 1,324,553
4	09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	Channel Construction	$ 12,490,132		36.29%	$ 4,532,849	$ 17,022,981
5	16 BANK STABILIZATION	Channel Armoring	$ 17,281,844		34.80%	$ 6,013,658	$ 23,295,503
6			$ -		0.00%	$ -	$ -
7			$ -		0.00%	$ -	$ -
8			$ -		0.00%	$ -	$ -
9			$ -		0.00%	$ -	$ -
10			$ -		0.00%	$ -	$ -
11			$ -		0.00%	$ -	$ -
12	All Other	**Remaining Construction Items**	$ -	*0.0%*	0.00%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 3,201,000		23.21%	$ 742,931	$ 3,943,931
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 2,133,000		24.93%	$ 531,717	$ 2,664,717
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals				
Real Estate	$ 220,000	25.00%	$ 55,000	$ 275,000.00
Total Construction Estimate	$ 35,180,547	35.2%	$ 12,376,044	$ 47,556,591
Total Planning, Engineering & Design	$ 3,201,000	23.2%	$ 742,931	$ 3,943,931
Total Construction Management	$ 2,133,000	24.9%	$ 531,717	$ 2,664,717
Total	**$ 40,734,547**	**33.6%**	**$ 13,705,692**	**$ 54,440,239**

	Base	50%	80%
Range Estimate ($000's)	$40,735k	$48,958k	$54,440k

* 50% based on base is at 5% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analysis. Must include justification. Does not allocate to Real Estate.)

Lower Yellowstone River Modified Side Channel

Feasibility (Alternatives)

Abbreviated Risk Analysis

Meeting Date: 0-Jan-00

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
Project Scope Growth				**Maximum Project Growth**		**40%**
PS-1	Mob, Demob & Site Preparation	Estimate is based on conceptual level design plans with many investigations remaining to complete that could change the design; Further analysis may show that the current design assumptions do not accomplish the project's intent, thus leading to more changes in the design.	Because of low design level, the scope/scale of this could change but is not likely to be significantly different than current assumptions.	Marginal	Likely	2
PS-2	Diversion and Control of Water	See discussion above.	The current assumptions are likely to change. Further investigations could show need for more dewatering efforts than currently assumed.	Moderate	Likely	3
PS-3	Bridge Installation	See discussion above; ice considerations	Only one bridge is required for crews to travel over the channel. May be slight risk that larger bridge/abutments may be required. Further investigations need to be completed in order to account for ice flows. Current bridge may require changes in future designs	Moderate	Likely	3
PS-4	Channel Construction	See discussion above.	Current assumptions show that the design accomplishes the project's intent. However, some investigations still remain, thus there is still a risk that this could change. Any scope growth could lead to significant cost impacts though.	Significant	Possible	3
PS-5	Channel Armoring	See discussion above.	Current assumptions show that the design accomplishes the project's intent. However, some investigations still remain, thus there is still a risk that this could change. Any scope growth could lead to significant impacts though.	Significant	Possible	3
PS-6	0			Negligible	Unlikely	0
PS-7	0			Negligible	Unlikely	0
PS-8	0			Negligible	Unlikely	0
PS-9	0			Negligible	Unlikely	0
PS-10	0			Negligible	Unlikely	0
PS-11	0			Negligible	Unlikely	0

PS-12	Remaining Construction Items			Negligible	Unlikely	0
PS-13	Planning, Engineering, & Design	See discussion above.	Potential need for more investigations to be completed, above and beyond what is already assumed. These investigations could present moderate cost increases.	Moderate	Possible	2
PS-14	Construction Management	See discussion above.	Construction management could increase moderately given any scope increases as more management would be required to oversee the additional construction.	Moderate	Possible	2
Acquisition Strategy				**Maximum Project Growth**		**30%**
AS-1	Mob, Demob & Site Preparation	Due to conceptual level of this project, there is limited contracting plan information; Estimate assumes relatively conservative assumptions regarding number of contracts and sub-contractors; Harsh weather could be a risk, but contractors would likely be experienced in this region; No 8a or small business likely due to scale of the project;	Current estimate assumes one contract to be bid out. Contractor assumes several subs, and schedule includes non-construction period during harsh winter months. So assumptions are relatively conservative, but still have some risk of changing. Impacts would likely be marginal at most if they occured.	Marginal	Likely	2
AS-2	Diversion and Control of Water	See concerns listed above.	See discussion listed above.	Marginal	Likely	2
AS-3	Bridge Installation	See concerns listed above.	See discussion listed above.	Marginal	Likely	2
AS-4	Channel Construction	See concerns listed above.	See discussion listed above.	Marginal	Likely	2
AS-5	Channel Armoring	See concerns listed above.	See discussion listed above.	Marginal	Likely	2
AS-6	0			Negligible	Unlikely	0
AS-7	0			Negligible	Unlikely	0
AS-8	0			Negligible	Unlikely	0
AS-9	0			Negligible	Unlikely	0
AS-10	0			Negligible	Unlikely	0
AS-11	0			Negligible	Unlikely	0
AS-12	Remaining Construction Items			Negligible	Unlikely	0
AS-13	Planning, Engineering, & Design	See concerns listed above.	See discussion listed above.	Marginal	Likely	2
AS-14	Construction Management	See concerns listed above.	See discussion listed above.	Marginal	Likely	2
Construction Elements				**Maximum Project Growth**		**15%**
CE-1	Mob, Demob & Site Preparation	Number of mob/demob periods	Current estimate assumes several mob/demob periods that occur before/after the winter closure period. Risk of requiring more mob/demob efforts than currently assumed is there, but not likely to occur.	Moderate	Unlikely	1

CE-2	Diversion and Control of Water	Diversion and control of water	Current assumption for earthen cofferdam with sheetpile cut-offs are likely to be enough. But estimate also made assumptions for well points to be installed. Changes to these dewatering efforts are likely by the contractor, but due to conservative assumptions used, costs is not likely to increase significantly.	Marginal	Likely	2
CE-3	Bridge Installation	No significant risks anticipated	The bridge work should be standard work for the contractor, and therefore very unlikely to see significant cost increases.	Negligible	Unlikely	0
CE-4	Channel Construction	No significant risks anticipated	The construction elements involved for the channel construction are common. Therefore no risks likely to occur or increase costs.	Negligible	Unlikely	0
CE-5	Channel Armoring	No significant risks anticipated	The construction elements involved for the channel construction are common. Therefore no risks likely to occur or increase costs.	Negligible	Unlikely	0
CE-6	0			Negligible	Unlikely	0
CE-7	0			Negligible	Unlikely	0
CE-8	0			Negligible	Unlikely	0
CE-9	0			Negligible	Unlikely	0
CE-10	0			Negligible	Unlikely	0
CE-11	0			Negligible	Unlikely	0
CE-12	Remaining Construction Items			Negligible	Unlikely	0
CE-13	Planning, Engineering, & Design	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
CE-14	Construction Management	Diversion and control of water	If increased effort of diverting flows is required then oversight could increase as well.	Marginal	Possible	1
Quantities for Current Scope				**Maximum Project Growth**		**20%**
Q-1	Mob, Demob & Site Preparation	Number of mob/demob periods and assumed mob/demob durations	There is a low risk that the number of mob/demob periods increase. Also a risk that the time to mob equipment and crews to site could be greater than those assumed. These risks are low, but could cause moderate increase if they occur.	Moderate	Possible	2
Q-2	Diversion and Control of Water	Cofferdam quantities; Well point and other pumping assumptions	The cofferdams have detailed quantity take-offs that have been verified, thus these are not-likely to change. The dewater wells and pumps are based on general assumptions currently, and there is a risk of the contractor requiring more wells and/or longer periods to dewater. This risk is low but could be significant increase.	Significant	Possible	3

Q-3	Bridge Installation	Accounting for ice flow	Bridge quantities for abutments and earthwork are likely to change once further analysis determines the exact height needed to avoid or limit damage from ice. These are not significant cost drivers for the bridge but could have a moderate impact.	Moderate	Likely	3
Q-4	Channel Construction	Confidence level in earthwork quantities	Based on the current design, the quantities were calculated using CAD and therefore are expected to be accurate. The quantities have been backchecked and therefore are not likely to change unless further analysis shows the design must change. Thus the risk of occuring is low, but increases in quantities could have moderate cost impacts.	Moderate	Possible	2
Q-5	Channel Armoring	Confidence level in armoring quantities	The quantities were calculated using the typical bank sections. Further design would likely develop more sections for use in the calculation. However, further sections are likely not going to increase the quantities therefore likelihood and impact of increases would be low.	Marginal	Possible	1
Q-6	0			Negligible	Unlikely	0
Q-7	0			Negligible	Unlikely	0
Q-8	0			Negligible	Unlikely	0
Q-9	0			Negligible	Unlikely	0
Q-10	0			Negligible	Unlikely	0
Q-11	0			Negligible	Unlikely	0
Q-12	Remaining Construction Items			Negligible	Unlikely	0
Q-13	Planning, Engineering, & Design	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
Q-14	Construction Management	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
Specialty Fabrication or Equipment				**Maximum Project Growth**		**50%**
FE-1	Mob, Demob & Site Preparation	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
FE-2	Diversion and Control of Water	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
FE-3	Bridge Installation	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
FE-4	Channel Construction	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
FE-5	Channel Armoring	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0

FE-6	0			Negligible	Unlikely	0
FE-7	0			Negligible	Unlikely	0
FE-8	0			Negligible	Unlikely	0
FE-9	0			Negligible	Unlikely	0
FE-10	0			Negligible	Unlikely	0
FE-11	0			Negligible	Unlikely	0
FE-12	Remaining Construction Items			Negligible	Unlikely	0
FE-13	Planning, Engineering, & Design	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
FE-14	Construction Management	None anticipated	No specialty fabrication or equipment required.	Negligible	Unlikely	0
Cost Estimate Assumptions				**Maximum Project Growth**		**25%**
CT-1	Mob, Demob & Site Preparation	Site accessibility and transport delays	Due to needing to access the site from Joe's Island, there are no existing roadways capable of handling the construction traffic to and from the site. Therefore, access roads are assumed to be installed. But the access speeds and traffic assumptions may be different during construction than currently assumed. This could lead to cost increases if it happens.	Moderate	Possible	2
CT-2	Diversion and Control of Water	Productivity of placing cofferdams	The cofferdam installation will be completed along the flowing river channel. Therefore there is some risk that current assumptions are wrong. Estimate attempted to make conservative placement assumptions and therefore not likely to see a significant cost increase.	Marginal	Possible	1
CT-3	Bridge Installation	Unit price for bridge	Due to conceptual level of the design, a bridge quote has not been obtained as no details are available. However, the MII unit price used is relatively conservative based on past bridge estimates. Thus it is possible that the costs would change, but not anticipated to increase significantly as cost is adequate for a basic road bridge.	Moderate	Possible	2
CT-4	Channel Construction	Productivity assumptions; Site accessibility at disposal locations	This alternative is excavating large quantity and disposing of nearby using large haulers. However, the current production rates may not be correct. Also accessing some of the disposal locations may show to be more difficult than assumed. These are not likely to be the case, but could increase earthwork costs significantly.	Significant	Possible	3

CT-5	Channel Armoring	Unit prices for bedding, riprap, and boulders	In order for this estimate to be comparable to previously developed alternatives, the same unit price for the stone material and delivery were assumed. However, given the distances the stone would need to be transported over, there is a likelihood that costs could increase greatly given supply and transport assumptions. This may not be likely to occur but could be significant impact to the rock prices.	Significant	Possible	3
CT-6	0			Negligible	Unlikely	0
CT-7	0			Negligible	Unlikely	0
CT-8	0			Negligible	Unlikely	0
CT-9	0			Negligible	Unlikely	0
CT-10	0			Negligible	Unlikely	0
CT-11	0			Negligible	Unlikely	0
CT-12	Remaining Construction Items			Negligible	Unlikely	0
CT-13	Planning, Engineering, & Design	Percentages assumed for PED	A typical percentage for this item has been assumed. Percentage may change, but not likely to increase significantly from current.	Marginal	Possible	1
CT-14	Construction Management	Percentages assumed for CM	A typical percentage for this item has been assumed. Percentage may change, but not likely to increase significantly from current.	Marginal	Possible	1
External Project Risks				**Maximum Project Growth**		**20%**
EX-1	Mob, Demob & Site Preparation	Severe winter weathere; unanticipated inflations in fuel, and materials; market conditions and bidding climate;	Winter weather is an issue and construction will be likely completed around those times. But impacts to cost/schedule could still occur. The risk of inflation to fuel and other material items is real and could be a significant impact. The bidding climate at time of award, and for possible numerous contracts, could be unfavorable to the cost. Given all these risks, a significant impact would be assumed if they all occured.	Significant	Possible	3
EX-2	Diversion and Control of Water	See discussion above.	See discussion above.	Significant	Possible	3
EX-3	Bridge Installation	See discussion above.	See discussion above.	Significant	Possible	3
EX-4	Channel Construction	See discussion above.	See discussion above.	Significant	Possible	3
EX-5	Channel Armoring	See discussion above.	See discussion above.	Significant	Possible	3

EX-6	0			Negligible	Unlikely	**0**
EX-7	0			Negligible	Unlikely	**0**
EX-8	0			Negligible	Unlikely	**0**
EX-9	0			Negligible	Unlikely	**0**
EX-10	0			Negligible	Unlikely	**0**
EX-11	0			Negligible	Unlikely	**0**
EX-12	Remaining Construction Items			Negligible	Unlikely	**0**
EX-13	Planning, Engineering, & Design	See discussion above.	See discussion above.	Significant	Possible	**3**
EX-14	Construction Management	See discussion above.	See discussion above.	Significant	Possible	**3**

Lower Yellowstone River Modified Side Channel
Feasibility (Alternatives)
Abbreviated Risk Analysis

Risk Evaluation

WBS	Potential Risk Areas	Project Scope Growth	Acquisition Strategy	Construction Elements	Quantities for Current Scope	Specialty Fabrication or Equipment	Cost Estimate Assumptions	External Project Risks	Cost in Thousands
01 LANDS AND DAMAGES	**Real Estate**								$220,000
0	**Mob, Demob & Site Preparation**	2	2	1	2	0	2	3	$2,255
0	Diversion and Control of Water	3	2	2	3	0	1	3	$2,178
08 ROADS, RAILROADS, AND BRIDGES	Bridge Installation	3	2	0	3	0	2	3	$976
09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	Channel Construction	3	2	0	2	0	3	3	$12,490
16 BANK STABILIZATION	Channel Armoring	3	2	0	1	0	3	3	$17,282
0	0	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
All Other	Remaining Construction Items	0	0	0	0	0	0	0	$0
30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	2	2	0	0	0	1	3	$3,201
31 CONSTRUCTION MANAGEMENT	Construction Management	2	2	1	0	0	1	3	$2,133
									$40,515
Risk		$ 3,343	$ 1,579	$ 2,976	$ 994	$ -	$ 2,314	$ 2,445	**$13,651**
Fixed Dollar Risk Allocation		$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$0**
	Risk	$ 3,343	$ 1,579	$ 2,976	$ 994	$ -	$ 2,314	$ 2,445	**$13,651**
								Total	**$54,165**

Multiple Pump ARA

Abbreviated Risk Analysis

Project (less than $40M): **Lower Yellowstone River**

Alternative: **Multiple Pump Alternative**

Project Development Stage/Alternative: **Feasibility (Alternatives)**

Risk Category: **Low Risk: Typical Construction, Simple**

Meeting Date:

Total Estimated Construction Contract Cost = **$ 84,277,276**

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ 443,000		25.00%	$ 110,750	$ 553,750
1	04 DAMS	Dam Removal	$ 6,599,764		45.02%	$ 2,971,122	$ 9,570,886
2	19 BUILDINGS, GROUNDS, AND UTILITIES	Mob, Demob & Site Prep	$ 1,821,234		29.48%	$ 536,863	$ 2,358,097
3	19 BUILDINGS, GROUNDS, AND UTILITIES	Diversion and Control of Water	$ 2,489,513		39.25%	$ 977,025	$ 3,466,538
4	19 BUILDINGS, GROUNDS, AND UTILITIES	Pump Stations	$ 23,599,255		38.10%	$ 8,992,108	$ 32,591,363
5	19 BUILDINGS, GROUNDS, AND UTILITIES	Discharge Pipelines	$ 25,527,106		32.46%	$ 8,286,712	$ 33,813,818
6	19 BUILDINGS, GROUNDS, AND UTILITIES	Feeder Canal	$ 2,449,067		27.68%	$ 677,917	$ 3,126,984
7	19 BUILDINGS, GROUNDS, AND UTILITIES	Fish Screen	$ 18,301,220		38.02%	$ 6,957,999	$ 25,259,219.15
8	19 BUILDINGS, GROUNDS, AND UTILITIES	Power System Uprating	$ 3,490,118		46.90%	$ 1,636,975	$ 5,127,092.65
9			$ -		0.00%	$ -	$ -
10			$ -		0.00%	$ -	$ -
11			$ -		0.00%	$ -	$ -
12	All Other	**Remaining Construction Items**	$ -	*0.0%*	0.00%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 7,664,000		26.52%	$ 2,032,783	$ 9,696,783
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 5,108,000		26.52%	$ 1,354,835	$ 6,462,835
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals				
Real Estate	$ 443,000	25.0%	$ 110,750	$ 553,750.00
Total Construction Estimate	$ 84,277,276	36.8%	$ 31,036,720	$ 115,313,996
Total Planning, Engineering & Design	$ 7,664,000	26.5%	$ 2,032,783	$ 9,696,783
Total Construction Management	$ 5,108,000	26.5%	$ 1,354,835	$ 6,462,835
Total	**$ 97,492,276**	**35.4%**	**$ 34,535,089**	**$ 132,027,365**

	Base	**50%**	**80%**
Range Estimate ($000's)	$97,492k	$118,213k	$132,027k

* 50% based on base is at 5% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analsyis. Must include justification. Does not allocate to Real Estate.	

Lower Yellowstone River Multiple Pump Alternative

Feasibility (Alternatives)

Abbreviated Risk Analysis

Meeting Date: 0-Jan-00

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
Project Scope Growth					Maximum Project Growth	**40%**
PS-1	Dam Removal	Estimate is based on conceptual level design plans with many investigations remaining to complete that could change the design; Further analysis may show that the current design assumptions do not accomplish the project's intent, thus leading to more changes in the design.	The dam removal requires signficantly more analysis to determine the extent of the rock/boulder debris field downstream of the existing dam. There is a chance that current assumptions are off, which although not likely, it would be significant to the costs.	Significant	Possible	3
PS-2	Mob, Demob & Site Prep	See concerns above.	Because of low design level, the scope/scale of this could change but is not likely to be significantly different than current assumptions.	Marginal	Likely	2
PS-3	Diversion and Control of Water	See concerns above.	The current assumptions are likely to change. Further investigations could show need for more dewatering efforts than currently assumed.	Moderate	Likely	3
PS-4	Pump Stations	See concerns above; Ice protection	If further investigations show that more pumps are required, then a major cost increase could occur. However, further analysis could also show that less pumps are required. Thus, the likelihood of a change is very low and the impact could swing either way, and thus is only moderate. Further analysis into ice flows could require changes to the scope of the pump stations. Could be significant impact.	Significant	Unlikely	2
PS-5	Discharge Pipelines	See concerns above.	Discharge pipelines, based on current pump station design, are not likely to increase in scope. The current design calls for large pipe, with already expensive costs, thus any change should not be significant impact.	Marginal	Possible	1
PS-6	Feeder Canal	See concerns above.	No significant risks to scope growing as all items that could be required are included. Some minor issues may arise upon further analysis but these are unlikely and should not increase costs significantly.	Marginal	Possible	1
PS-7	Fish Screen	See concerns above; Ice protection	No significant risk to scope growth as design assumptions are robust for the fish screen. Furhter analysis could change the design but not likely to occur and cost imapcts likely would only be moderate. Further analysis into possible ice flows could significantly impact the design of the fish screens.	Significant	Unlikely	2

PS-8	Power System Uprating	See concerns above.	Current scale of the power system changes are based on preliminary analysis and discussions with the local power company. Much analysis is likely still needed to ensure there is sufficient utility structures capable of providing power to the pumps. The current assumptions are likely to change and could have significant cost impacts.	Significant	Likely	4
PS-9	0			Negligible	Unlikely	0
PS-10	0			Negligible	Unlikely	0
PS-11	0			Negligible	Unlikely	0
PS-12	Remaining Construction Items			Negligible	Unlikely	0
PS-13	Planning, Engineering, & Design	See concerns above.	Potential need for more investigations to be completed, above and beyond what is already assumed. These investigations could present moderate cost increases.	Moderate	Possible	2
PS-14	Construction Management	See concerns above.	Construction management could increase moderately given any scope increases as more management would be required to oversee the additional construction.	Moderate	Possible	2
Acquisition Strategy				**Maximum Project Growth**		**30%**
AS-1	Dam Removal	Due to conceptual level of this project, there is limited contracting plan information; Estimate assumes relatively conservative assumptions regarding number of contracts and sub-contractors; Harsh weather could be a risk, but contractors would likely be experienced in this region; No 8a or small business likely due to scale of the project;	Contracting plan changes could significantly impact each of these costs. If the work needs to be broken into multiple contracts then costs would increase. Individual components may be constructed at different times, based on water demands and winter weather conditions, which also could impact costs. Without lack of a detailed contracting plan, there could be changes both increasing and decreasing costs, thus it is likely to change but only marginal impact to costs.	Marginal	Likely	2
AS-2	Mob, Demob & Site Prep	See concerns above.	See discussion above.	Marginal	Likely	2
AS-3	Diversion and Control of Water	See concerns above.	See discussion above.	Marginal	Likely	2
AS-4	Pump Stations	See concerns above.	See discussion above.	Marginal	Likely	2
AS-5	Discharge Pipelines	See concerns above.	See discussion above.	Marginal	Likely	2
AS-6	Feeder Canal	See concerns above.	See discussion above.	Marginal	Likely	2
AS-7	Fish Screen	See concerns above.	See discussion above.	Marginal	Likely	2
AS-8	Power System Uprating	See concerns above.	See discussion above.	Marginal	Likely	2
AS-9	0			Negligible	Unlikely	0

AS-10	0			Negligible	Unlikely	0
AS-11	0			Negligible	Unlikely	0
AS-12	Remaining Construction Items			Negligible	Unlikely	0
AS-13	Planning, Engineering, & Design	See concerns above.	See discussion above.	Marginal	Likely	2
AS-14	Construction Management	See concerns above.	See discussion above.	Marginal	Likely	2
Construction Elements				**Maximum Project Growth**		**15%**
CE-1	Dam Removal	Working in wet conditions within the channel, even when dewatered; potential for construction mods/claims; high risk due to river water being diverted nearby and likely working in wet conditions;	The dewatering effort is a significant cost driver. The existing rock downstream of the dam could be a significant hinderance to effectively dewatering the area. Current assumptions are conservative, but there could be significant risks to these assumptions changing.	Significant	Likely	4
CE-2	Mob, Demob & Site Prep	Number of mob/demob periods	There are numerous mob/demob periods across mutliple areas in the study region. These assumptions are assumed to be conservative but are still likely to change.	Marginal	Likely	2
CE-3	Diversion and Control of Water	The assumptions required for dewatering are based on limited information; Future analysis could greatly change the dewatering efforts.	Conservative assumptions have currently been made for dewatering during pump station construction. However, some items may require more dewatering efforts that are currently not assumed. This could impact costs signficantly but is not likely to occur.	Significant	Unlikely	2
CE-4	Pump Stations	Special subcontractors likely needed to install and test pumps and other equipment; Deep excavation for pump stations could increase risks;	The contractors tasked with the installation of the pumps should not be hard to find and would likely be able to complete with little risk; The excavation should not be that difficult but contractor may make different assumptions on how to exactly excavate the area. If shoring or some other methodology is required, costs could increase signficantly.	Significant	Possible	3
CE-5	Discharge Pipelines	See discussions in CE-4	Not likely to be a significant impact.	Marginal	Possible	1
CE-6	Feeder Canal	See discussions in CE-4	Not likely to be a significant impact.	Marginal	Possible	1
CE-7	Fish Screen	See discussions in CE-4	Not likely to be a significant impact.	Marginal	Possible	1
CE-8	Power System Uprating	See discussions in CE-4	Not likely to be a significant impact.	Marginal	Possible	1
CE-9	0			Negligible	Unlikely	0
CE-10	0			Negligible	Unlikely	0
CE-11	0			Negligible	Unlikely	0

CE-12	Remaining Construction Items			Negligible	Unlikely	0
CE-13	Planning, Engineering, & Design	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
CE-14	Construction Management	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
Quantities for Current Scope				**Maximum Project Growth**		**20%**
Q-1	Dam Removal	Quantities are based on conceptual level designs and therefore are anticipated to change as project progresses; Many investigations remain to assist in developing accurate quantities.	Due to the low level of design for this alternative quantities are likely to change as the project progresses. The quantity development did take very conservative assumptions and therefore increases to the quantities is not likely to be significant. Thus it is possible that they will change, but due to conservative assumptions, should only be a marginal impact at most to certain elements.	Marginal	Likely	2
Q-2	Mob, Demob & Site Prep	See concerns above.	See discussion above.	Marginal	Likely	2
Q-3	Diversion and Control of Water	See concerns above.	See discussion above.	Marginal	Likely	2
Q-4	Pump Stations	See concerns above.	See discussion above.	Marginal	Likely	2
Q-5	Discharge Pipelines	See concerns above.	See discussion above.	Marginal	Likely	2
Q-6	Feeder Canal	See concerns above.	See discussion above.	Marginal	Likely	2
Q-7	Fish Screen	See concerns above.	See discussion above.	Marginal	Likely	2
Q-8	Power System Uprating	See concerns above.	See discussion above.	Marginal	Likely	2
Q-9	0			Negligible	Unlikely	0
Q-10	0			Negligible	Unlikely	0
Q-11	0			Negligible	Unlikely	0
Q-12	Remaining Construction Items			Negligible	Unlikely	0
Q-13	Planning, Engineering, & Design	See concerns above.	See discussion above.	Marginal	Likely	2
Q-14	Construction Management	See concerns above.	See discussion above.	Marginal	Likely	2
Specialty Fabrication or Equipment				**Maximum Project Growth**		**50%**
FE-1	Dam Removal	None anticipated	No significant risks anticipated	Negligible	Unlikely	0

FE-2	Mob, Demob & Site Prep	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-3	Diversion and Control of Water	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-4	Pump Stations	Main irrigation pumps and associated equipment	Discussions have already been held with contractors capable of providing these items. So it can be assumed that there is a reasonable ability to obtain. However, there is still a risk at time of construction the materials needed are not available or have increased in costs. Thus the impact could be moderate.	Moderate	Possible	2
FE-5	Discharge Pipelines	Delivery of large pipes.	The pipes are not huge by any means but delivering 8-ft diameter pipes to this location may be troublesome. It is not likely but could be significant cost increase.	Moderate	Possible	2
FE-6	Feeder Canal	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-7	Fish Screen	Fish return pumps and associated equipment	Discussions have already been held with contractors capable of providing these items. So it can be assumed that there is a reasonable ability to obtain. However, there is still a risk at time of construction the materials needed are not available or have increased in costs. Thus the impact could be moderate.	Moderate	Possible	2
FE-8	Power System Uprating	Electrical towers and equipment to upgrade power system	Cost were provide by the local power company, and are not anticipated to be significantly off. However, at time of construction, and upon further analysis, there may be more specialty items needed. This is not likely but could be a marginal impact.	Marginal	Possible	1
FE-9	0			Negligible	Unlikely	0
FE-10	0			Negligible	Unlikely	0
FE-11	0			Negligible	Unlikely	0
FE-12	Remaining Construction Items			Negligible	Unlikely	0
FE-13	Planning, Engineering, & Design	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-14	Construction Management	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
Cost Estimate Assumptions				**Maximum Project Growth**		**25%**
CT-1	Dam Removal	Rock disposal assumptions; cofferdam assumptions	Current estimate assumes disposing of rock removed from the dam nearby, likely on Joe's island. There is risk rock may need to be be trucked to another location, which would increase the haul costs significantly; Placement of cofferdam may be more difficult than assumed and may not be as efficient at diverting flows. Contractor may assume different methods to control flows and seepage.	Significant	Possible	3

CT-2	Mob, Demob & Site Prep	Mob/demob and site prep have been developed based on general assumptions.	The assumptions have been conservatively estimated and therefore are not likely to increase much.	Marginal	Possible	1
CT-3	Diversion and Control of Water	Sheet pile cofferdams and well points sufficient for construction	The estimate assumes sheetpiles with well points also. There is also an assumption of pumping during the pump station work. These assumptions are conservative, but until further analysis is completed there is still a significant impact risk.	Significant	Possible	3
CT-4	Pump Stations	Use of cost quotes on major equipment items; Productivity assumptions;	Significant percentage of cost for this item are in the pump and motor quotes. These were provided by a vendor and then received sub markups in MII. Thus they are likely conservative, but still could increase at time of construction; All productivity assumptions have been estimated with best engineering judgment at this time. These could change though which would obviously impact costs.	Moderate	Possible	2
CT-5	Discharge Pipelines			Moderate	Possible	2
CT-6	Feeder Canal			Moderate	Possible	2
CT-7	Fish Screen	Use of previous project costs for fish screens and deadplates	A previous project estimate was used to estimate the unit costs for the fish screen and dead plates. The value was escalated to current prices, but still may not be accurate at time of construction. This could be significant impact with low likelihood.	Significant	Possible	3
CT-8	Power System Uprating			Moderate	Possible	2
CT-9	0			Negligible	Unlikely	0
CT-10	0			Negligible	Unlikely	0
CT-11	0			Negligible	Unlikely	0
CT-12	Remaining Construction Items			Negligible	Unlikely	0
CT-13	Planning, Engineering, & Design	Percentages assumed for PED	A typical percentage for this item has been assumed. Percentage may change, but not likely to increase significantly from current.	Marginal	Possible	1
CT-14	Construction Management	Percentages assumed for CM	A typical percentage for this item has been assumed. Percentage may change, but not likely to increase significantly from current.	Marginal	Possible	1
External Project Risks					Maximum Project Growth	20%

EX-1	Dam Removal	Severe winter weathere; unanticipated inflations in fuel, and materials; market conditions and bidding climate;	Winter weather is an issue and construction will be likely completed around those times. But impacts to cost/schedule could still occur. The risk of inflation to fuel and other material items is real and could be a significant impact. The bidding climate at time of award, and for possible numerous contracts, could be unfavorable to the cost. Given all these risks, a significant impact would be assumed if they all occured.	Significant	Possible	**3**
EX-2	Mob, Demob & Site Prep	See concerns above.	See discussion above.	Significant	Possible	**3**
EX-3	Diversion and Control of Water	See concerns above.	See discussion above.	Significant	Possible	**3**
EX-4	Pump Stations	See concerns above.	See discussion above.	Significant	Possible	**3**
EX-5	Discharge Pipelines	See concerns above.	See discussion above.	Significant	Possible	**3**
EX-6	Feeder Canal	See concerns above.	See discussion above.	Significant	Possible	**3**
EX-7	Fish Screen	See concerns above.	See discussion above.	Significant	Possible	**3**
EX-8	Power System Uprating	See concerns above.	See discussion above.	Significant	Possible	**3**
EX-9	0			Negligible	Unlikely	**0**
EX-10	0			Negligible	Unlikely	**0**
EX-11	0			Negligible	Unlikely	**0**
EX-12	Remaining Construction Items			Negligible	Unlikely	**0**
EX-13	Planning, Engineering, & Design	See concerns above.	See discussion above.	Significant	Possible	**3**
EX-14	Construction Management	See concerns above.	See discussion above.	Significant	Possible	**3**

Lower Yellowstone River Multiple Pump Alternative
Feasibility (Alternatives)
Abbreviated Risk Analysis

Risk Evaluation

WBS	Potential Risk Areas	Project Scope Growth	Acquisition Strategy	Construction Elements	Quantities for Current Scope	Specialty Fabrication or Equipment	Cost Estimate Assumptions	External Project Risks	Cost in Thousands
01 LANDS AND DAMAGES	**Real Estate**								$443,000
04 DAMS	**Dam Removal**	3	2	4	2	0	3	3	$6,600
19 BUILDINGS, GROUNDS, AND UTILITIES	Mob, Demob & Site Prep	2	2	2	2	0	1	3	$1,821
19 BUILDINGS, GROUNDS, AND UTILITIES	Diversion and Control of Water	3	2	2	2	0	3	3	$2,490
19 BUILDINGS, GROUNDS, AND UTILITIES	Pump Stations	2	2	3	2	2	2	3	$23,599
19 BUILDINGS, GROUNDS, AND UTILITIES	Discharge Pipelines	1	2	1	2	2	2	3	$25,527
19 BUILDINGS, GROUNDS, AND UTILITIES	Feeder Canal	1	2	1	2	0	2	3	$2,449
19 BUILDINGS, GROUNDS, AND UTILITIES	**Fish Screen**	2	2	1	2	2	3	3	$18,301
19 BUILDINGS, GROUNDS, AND UTILITIES	**Power System Uprating**	4	2	1	2	1	2	3	$3,490
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
0	**0**	0	0	0	0	0	0	0	$0
All Other	Remaining Construction Items	0	0	0	0	0	0	0	$0
30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	2	2	0	2	0	1	3	$7,664
31 CONSTRUCTION MANAGEMENT	Construction Management	2	2	0	2	0	1	3	$5,108
									$97,049
Risk		$ 4,555	$ 3,783	$ 9,550	$ 3,217	$ 3,301	$ 4,163	$ 5,856	**$34,424**
Fixed Dollar Risk Allocation		$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$0**
	Risk	$ 4,555	$ 3,783	$ 9,550	$ 3,217	$ 3,301	$ 4,163	$ 5,856	**$34,424**
								Total	**$131,474**

Multiple Pumps with Conservation Measures ARA

Abbreviated Risk Analysis

Project (less than $40M): **Lower Yellowstone River**

Project Development Stage/Alternative: **Feasibility (Alternatives)**

Risk Category: **Low Risk: Typical Construction, Simple**

Alternative: **Multiple Pumps w/ Conservation Mea**

Meeting Date:

Total Estimated Construction Contract Cost = **$ 313,059,999**

	CWWBS	Feature of Work	Contract Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ 2,800,000		25.00%	$ 700,000	$ 3,500,000
1		Mob, Demob & Site Prep	$ 2,658,292		27.57%	$ 733,006	$ 3,391,298
2		Diversion and Control of Water	$ 4,158,633		39.25%	$ 1,632,081	$ 5,790,715
3	04 DAMS	Existing Dam Removal	$ 2,533,964		45.02%	$ 1,140,755	$ 3,674,719
4	09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	Convert Laterals to Pipe	$ 61,636,775		34.25%	$ 21,110,979	$ 82,747,754
5	09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	Line Open Canals	$ 128,664,185		31.04%	$ 39,936,622	$ 168,600,807
6	09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	Check Structures	$ 2,547,694		34.74%	$ 884,953	$ 3,432,647
7	09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	Flow Measuring Devices	$ 887,117		27.68%	$ 245,560	$ 1,132,676.44
8	19 BUILDINGS, GROUNDS, AND UTILITIES	Convert Fields to Sprinklers	$ 14,920,816		29.24%	$ 4,362,342	$ 19,283,157.44
9	19 BUILDINGS, GROUNDS, AND UTILITIES	Wind Turbines	$ 3,584,337		30.74%	$ 1,101,955	$ 4,686,292.79
10	20 PERMANENT OPERATING EQUIPMENT	Ranney Wells	$ 91,468,186		33.02%	$ 30,206,753	$ 121,674,938.77
11			$ -		0.00%	$ -	$ -
12	All Other	**Remaining Construction Items**	$ -	*0.0%*	0.00%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 28,458,000		26.52%	$ 7,548,141	$ 36,006,141
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 18,972,000		26.52%	$ 5,032,094	$ 24,004,094
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals

	Contract Cost	% Contingency	$ Contingency	Total
Real Estate	$ 2,800,000	25.0%	$ 700,000	$ 3,500,000.00
Total Construction Estimate	$ 313,059,999	32.4%	$ 101,355,006	$ 414,415,005
Total Planning, Engineering & Design	$ 28,458,000	26.5%	$ 7,548,141	$ 36,006,141
Total Construction Management	$ 18,972,000	26.5%	$ 5,032,094	$ 24,004,094
Total	**$ 363,289,999**	**31.6%**	**$ 114,635,241**	**$ 477,925,240**

	Base	50%	80%
Range Estimate ($000's)	$363,290k	$432,071k	$477,925k

* 50% based on base is at 5% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analysis. Must include justification. Does not allocate to Real Estate.	

Lower Yellowstone River Multiple Pumps w/ Conservation M

Feasibility (Alternatives)

Abbreviated Risk Analysis

Meeting Date: 0-Jan-00

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
Project Scope Growth				**Maximum Project Growth**		**40%**
PS-1	Mob, Demob & Site Prep	Estimate is based on conceptual level design plans with many investigations remaining to complete that could change the design; Further analysis may show that the current design assumptions do not accomplish the project's intent, thus leading to more changes in the design.	Because of low design level, the scope/scale of this could change but is not likely to be significantly different than current assumptions.	Marginal	Likely	2
PS-2	Diversion and Control of Water	See discussion above.	The current assumptions are likely to change. Further investigations could show need for more dewatering efforts than currently assumed.	Moderate	Likely	3
PS-3	Existing Dam Removal	See discussion above.	The dam removal requires signficantly more analysis to determine the extent of the rock/boulder debris field downstream of the existing dam. There is a chance that current assumptions are off, which although not likely, it would be significant to the costs.	Significant	Possible	3
PS-4	Convert Laterals to Pipe	See discussion above.	Large quantity of laterals are anticipated to be converted to pipes. But current conditions, primarily the slopes, may show that this is not feasible. This would then change the design by possibly requiring pumps, lining of canals, etc.	Significant	Possible	3
PS-5	Line Open Canals	See discussion above.	Current assumptions are based on a benefit-cost analysis of various canal lining methods. The method chosen is a more robust lining method, but may be shown to be over designed. Thus the impact for this risk is low, as costs/quantities could actually decrease. Also, the estimate currently assumes lining the entire canal, which may not be needed upon further research.	Negligible	Likely	1
PS-6	Check Structures	See discussion above.	Check structures are based off typical drawings from previous reports, and are basic check structures. Future phases may require more significant structures, and/or higher quantities to accomplish this feature's intent.	Moderate	Likely	3
PS-7	Flow Measuring Devices	See discussion above.	Flow measuring devices are based off typical drawings from previous reports, and are basic check structures. Future phases may require more significant structures, and/or higher quantities to accomplish this feature's intent. Expected only to have a marginal impact though.	Marginal	Possible	1

PS-8	Convert Fields to Sprinklers	See discussion above.	Much more analysis needs to be completed to determine exactly which farms will be converted. Current assumption is a rough 50% of farms that are fed by the laterals to be converted to pipes. This is likley to change, but possibly could decrease too. Therefore the impact is to be considered low.	Marginal	Possible	1
PS-9	Wind Turbines	See discussion above.	Current assumptions are based on estimated energy required for the Ranney wells. Further analysis needs to be completed to finalize this value. Thus there is a risk of this changing, but estimate has already taken conservative steps. Therefore, costs not likely to increase significantly.	Marginal	Possible	1
PS-10	Ranney Wells	See discussion above; Ice protection	Ranney well installation design is based on current assumption of water requirements needed to be pumped into the canal. Further design refinements could change the water needs, and therefore change this design. This is not likely, but could be a moderate impact to costs. Further analysis into ice flows may require changes to the Ranney Well design. Unlikely to occur but could be significant impact to costs.	Significant	Unlikely	2
PS-11	0			Negligible	Unlikely	0
PS-12	Remaining Construction Items			Negligible	Unlikely	0
PS-13	Planning, Engineering, & Design	See discussion above.	Potential need for more investigations to be completed, above and beyond what is already assumed. These investigations could present moderate cost increases.	Moderate	Possible	2
PS-14	Construction Management	See discussion above.	Construction management could increase moderately given any scope increases as more management would be required to oversee the additional construction.	Moderate	Possible	2
Acquisition Strategy				**Maximum Project Growth**		**30%**
AS-1	Mob, Demob & Site Prep	Due to conceptual level of this project, there is limited contracting plan information; Estimate assumes relatively conservative assumptions regarding number of contracts and sub-contractors; Harsh weather could be a risk, but contractors would likely be experienced in this region; No 8a or small business likely due to scale of the project;	Contracting plan changes could significantly impact each of these costs. If the work needs to be broken into multiple contracts then costs would increase. Individual components may be constructed at different times, based on water demands and winter weather conditions, which also could impact costs. Without lack of a detailed contracting plan, there could be changes both increasing and decreasing costs, thus it is likely to change but only marginal impact to costs.	Marginal	Likely	2
AS-2	Diversion and Control of Water	See discussion above.	See discussion above.	Marginal	Likely	2
AS-3	Existing Dam Removal	See discussion above.	See discussion above.	Marginal	Likely	2
AS-4	Convert Laterals to Pipe	See discussion above.	See discussion above.	Marginal	Likely	2
AS-5	Line Open Canals	See discussion above.	See discussion above.	Marginal	Likely	2
AS-6	Check Structures	See discussion above.	See discussion above.	Marginal	Likely	2

AS-7	Flow Measuring Devices	See discussion above.	See discussion above.	Marginal	Likely	2
AS-8	Convert Fields to Sprinklers	See discussion above.	See discussion above.	Marginal	Likely	2
AS-9	Wind Turbines	See discussion above.	See discussion above.	Marginal	Likely	2
AS-10	Ranney Wells	See discussion above.	See discussion above.	Marginal	Likely	2
AS-11	0			Negligible	Unlikely	0
AS-12	Remaining Construction Items			Negligible	Unlikely	0
AS-13	Planning, Engineering, & Design	See discussion above.	See discussion above.	Marginal	Likely	2
AS-14	Construction Management	See discussion above.	See discussion above.	Marginal	Likely	2
Construction Elements					**Maximum Project Growth**	**15%**
CE-1	Mob, Demob & Site Prep	Number of mob/demob periods	There are numerous mob/demob periods across mutliple areas in the study region. These assumptions are assumed to be conservative but are still likely to change.	Marginal	Likely	2
CE-2	Diversion and Control of Water	The assumptions required for dewatering are based on limited information; Future analysis could greatly change dewatering efforts;	Conservative assumptions have currently been made for dewatering of certain measures. However, some items may require dewatering that are currently not assumed to need it. This could impact costs signficantly but is not likely to occur.	Significant	Unlikely	2
CE-3	Existing Dam Removal	Working in wet conditions within the channel, even when dewatered; potential for construction mods/claims; high risk due to river water being diverted nearby;	The dewatering effort is a significant cost driver. The existing rock downstream of the dam could be a significant hinderance to effectively dewatering the area. Current assumptions are conservative, but there could be significant risks to these assumptions changing.	Significant	Likely	4
CE-4	Convert Laterals to Pipe	Scheduling conversion of laterals around irrigation needs.	No significant risks for this item, but the work would need to be coordinated efficiently with the irrigation district to ensure that water is available for farm use. May cause increases to costs and schedule but is not likely to be significant.	Marginal	Likely	2
CE-5	Line Open Canals	Diversion and control of water could be significant risk; Coordinating the construction with irrigation season.	Current assumption is that the intake to the canal would be closed when the canal is lined. Therefore, no significant dewatering costs are assumed. Further analysis may show the need for more dewatering efforts. Coordinating the work with irrigation season may also add some risk.	Significant	Possible	3
CE-6	Check Structures	Scheduling conversion of laterals around irrigation needs.	No significant risks for this item, but the work would need to be coordinated efficiently with the irrigation district to ensure that water is available for farm use. May cause increases to costs and schedule but is not likely to be significant.	Marginal	Possible	1

CE-7	Flow Measuring Devices	Scheduling conversion of laterals around irrigation needs.	No significant risks for this item, but the work would need to be coordinated efficiently with the irrigation district to ensure that water is available for farm use. May cause increases to costs and schedule but is not likely to be significant.	Marginal	Possible	1
CE-8	Convert Fields to Sprinklers	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
CE-9	Wind Turbines	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
CE-10	Ranney Wells	Diversion and control of water; specialty contractor	Contractor would likely be able to adequately control water for well installations, and contractor should be more than capable to install. Still a slight risk that construction required is more complex than currently assumed.	Marginal	Possible	1
CE-11	0			Negligible	Unlikely	0
CE-12	Remaining Construction Items			Negligible	Unlikely	0
CE-13	Planning, Engineering, & Design	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
CE-14	Construction Management	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
Quantities for Current Scope				**Maximum Project Growth**		**20%**
Q-1	Mob, Demob & Site Prep	Quantities are based on conceptual level designs and therefore are anticipated to change as project progresses; Many investigations remain to assist in developing accurate quantities.	Due to the low level of design for this alternative quantities are likely to change as the project progresses. The quantity development did take very conservative assumptions and therefore increases to the quantities is not likely to be significant. Thus it is possible that they will change, but due to conservative assumptions, should only be a marginal impact at most to certain elements.	Marginal	Likely	2
Q-2	Diversion and Control of Water	See discussion above.	See discussion above.	Marginal	Likely	2
Q-3	Existing Dam Removal	See discussion above.	See discussion above.	Marginal	Likely	2
Q-4	Convert Laterals to Pipe	See discussion above.	See discussion above.	Marginal	Likely	2
Q-5	Line Open Canals	See discussion above.	See discussion above.	Marginal	Likely	2
Q-6	Check Structures	See discussion above.	See discussion above.	Marginal	Likely	2
Q-7	Flow Measuring Devices	See discussion above.	See discussion above.	Marginal	Likely	2
Q-8	Convert Fields to Sprinklers	See discussion above.	See discussion above.	Marginal	Likely	2
Q-9	Wind Turbines	See discussion above.	See discussion above.	Marginal	Likely	2

Q-10	Ranney Wells	See discussion above.	See discussion above.	Marginal	Likely	2
Q-11	0			Negligible	Unlikely	0
Q-12	Remaining Construction Items			Negligible	Unlikely	0
Q-13	Planning, Engineering, & Design	See discussion above.	See discussion above.	Marginal	Likely	2
Q-14	Construction Management	See discussion above.	See discussion above.	Marginal	Likely	2
Specialty Fabrication or Equipment				**Maximum Project Growth**		**50%**
FE-1	Mob, Demob & Site Prep	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-2	Diversion and Control of Water	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-3	Existing Dam Removal	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-4	Convert Laterals to Pipe	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-5	Line Open Canals	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-6	Check Structures	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-7	Flow Measuring Devices	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-8	Convert Fields to Sprinklers	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
FE-9	Wind Turbines	None anticipated	Wind turbines are a specialty item, but the assumption is that the turbines needed would be constructed at a pre-existing wind farm. The contractor would also be an experienced turbine builder, thus very low risk for the equipment not functioning as designed.	Moderate	Possible	2
FE-10	Ranney Wells	None anticipated	Estimate assumes a contractor with experience installing these wells would be used. The design is at a point for these that the proposed wells would be sufficient in providing the needed amount of water upon construction. However, more analysis remains to ensure that these assumptions are correct.	Moderate	Possible	2
FE-11	0			Negligible	Unlikely	0
FE-12	Remaining Construction Items			Negligible	Unlikely	0
FE-13	Planning, Engineering, & Design	None anticipated	No significant risks anticipated	Negligible	Unlikely	0

FE-14	Construction Management	None anticipated	No significant risks anticipated	Negligible	Unlikely	0
Cost Estimate Assumptions				**Maximum Project Growth**		**25%**
CT-1	Mob, Demob & Site Prep	Mob/demob and site prep have been developed based on general assumptions.		Negligible	Unlikely	0
CT-2	Diversion and Control of Water	Cofferdam productivity at existing dam;	Placement of both a sheetpile cofferdam and earthen portion may be more difficult than assumed. Also, different crews and placement methods may be used. These risk could increase costs for dewatering significantly.	Significant	Possible	3
CT-3	Existing Dam Removal	Rock disposal assumptions	Current estimate assumes disposing of rock removed from the dam nearby, likely on Joe's island. There is risk rock may need to be be trucked to another location, which would increase the haul costs significantly.	Significant	Possible	3
CT-4	Convert Laterals to Pipe	Crew and productivity assumptions	This work is pretty straight forward, and the current assumptions in the estimate are not likely to see significant changes. Therefore there is a possible risk of the assumptions on crews and productivity changing, but would only be a marginal impact.	Marginal	Possible	1
CT-5	Line Open Canals	Crew and productivity assumptions	The assumptions in the estimate have been based on previous canal lining analysis completed by the BOR. The unit cost for the lining has been compared with previous costs from BOR and are in-line, if not slightly conservative. Therefore risk of increase is small and would likely be moderate at most.	Moderate	Possible	2
CT-6	Check Structures	Crew and productivity assumptions	Typical construction efforts required, and not likely to change significantly.	Marginal	Likely	2
CT-7	Flow Measuring Devices	Crew and productivity assumptions	Typical construction efforts required, and not likely to change significantly.	Marginal	Likely	2
CT-8	Convert Fields to Sprinklers	Cost estimate assumptions; power costs	Use of industry standard installation costs has been compared with recent costs to install sprinkler systems within this region. After the MII markups are applied, unit costs are pretty conservative, therefore there is a small risk of the costs increasing for this item. Costs for updating power grid to power the pumps required for spinkler pressurizaiont is not included. This is a likley cost and could be significant given the amount of spinklers to be placed.	Significant	Possible	3
CT-9	Wind Turbines			Moderate	Possible	2
CT-10	Ranney Wells			Marginal	Possible	1
CT-11	0			Negligible	Unlikely	0
CT-12	Remaining Construction Items			Negligible	Unlikely	0
CT-13	Planning, Engineering, & Design	Percentages assumed for PED	A typical percentage for this item has been assumed. Percentage may change, but not likely to increase significantly from current.	Marginal	Possible	1

CT-14	Construction Management	Percentages assumed for CM	A typical percentage for this item has been assumed. Percentage may change, but not likely to increase significantly from current.	Marginal	Possible	1
External Project Risks				Maximum Project Growth		20%
EX-1	Mob, Demob & Site Prep	Severe winter weathere; unanticipated inflations in fuel, and materials; market conditions and bidding climate;	Winter weather is an issue and construction will be likely completed around those times. But impacts to cost/schedule could still occur. The risk of inflation to fuel and other material items is real and could be a significant impact. The bidding climate at time of award, and for possible numerous contracts, could be unfavorable to the cost. Given all these risks, a significant impact would be assumed if they all occured.	Significant	Possible	3
EX-2	Diversion and Control of Water	See discussion above.	See discussion above.	Significant	Possible	3
EX-3	Existing Dam Removal	See discussion above.	See discussion above.	Significant	Possible	3
EX-4	Convert Laterals to Pipe	See discussion above.	See discussion above.	Significant	Possible	3
EX-5	Line Open Canals	See discussion above.	See discussion above.	Significant	Possible	3
EX-6	Check Structures	See discussion above.	See discussion above.	Significant	Possible	3
EX-7	Flow Measuring Devices	See discussion above.	See discussion above.	Significant	Possible	3
EX-8	Convert Fields to Sprinklers	See discussion above.	See discussion above.	Significant	Possible	3
EX-9	Wind Turbines	See discussion above.	See discussion above.	Significant	Possible	3
EX-10	Ranney Wells	See discussion above.	See discussion above.	Significant	Possible	3
EX-11	0			Negligible	Unlikely	0
EX-12	Remaining Construction Items			Negligible	Unlikely	0
EX-13	Planning, Engineering, & Design	See discussion above.	See discussion above.	Significant	Possible	3
EX-14	Construction Management	See discussion above.	See discussion above.	Significant	Possible	3

Lower Yellowstone River Multiple Pumps w/ Conservation Measures

Feasibility (Alternatives)

Abbreviated Risk Analysis

Risk Evaluation

WBS	Potential Risk Areas	Project Scope Growth	Acquisition Strategy	Construction Elements	Quantities for Current Scope	Specialty Fabrication or Equipment	Cost Estimate Assumptions	External Project Risks	Cost in Thousands
01 LANDS AND DAMAGES	**Real Estate**								$2,800,000
0	**Mob, Demob & Site Prep**	2	2	2	2	0	0	3	$2,658
0	Diversion and Control of Water	3	2	2	2	0	3	3	$4,159
04 DAMS	Existing Dam Removal	3	2	4	2	0	3	3	$2,534
09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	Convert Laterals to Pipe	3	2	2	2	0	1	3	$61,637
09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	Line Open Canals	1	2	3	2	0	2	3	$128,664
09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	Check Structures	3	2	1	2	0	2	3	$2,548
09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	**Flow Measuring Devices**	1	2	1	2	0	2	3	$887
19 BUILDINGS, GROUNDS, AND UTILITIES	**Convert Fields to Sprinklers**	1	2	0	2	0	3	3	$14,921
19 BUILDINGS, GROUNDS, AND UTILITIES	**Wind Turbines**	1	2	0	2	2	2	3	$3,584
20 PERMANENT OPERATING EQUIPMENT	**Ranney Wells**	2	2	1	2	2	1	3	$91,468
0	**0**	0	0	0	0	0	0	0	$0
All Other	Remaining Construction Items	0	0	0	0	0	0	0	$0
30 PLANNING, ENGINEERING, AND DESIGN	Planning, Engineering, & Design	2	2	0	2	0	1	3	$28,458
31 CONSTRUCTION MANAGEMENT	Construction Management	2	2	0	2	0	1	3	$18,972
									$360,490
Risk		$ 15,770	$ 14,052	$ 35,642	$ 11,948	$ 4,545	$ 10,226	$ 21,753	**$113,935**
Fixed Dollar Risk Allocation		$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$0**
	Risk	$ 15,770	$ 14,052	$ 35,642	$ 11,948	$ 4,545	$ 10,226	$ 21,753	**$113,935**
								Total	**$474,425**

Attachment B.4
Detailed Quantity Takeoffs

Modified Side Channel Quantities

Item Description	quantity	unit	Comment
Mob/Demob	1	ls	
Coffer dam-upstream			
Earth embankment	21,400	cy	See separate tab
sheet pile	4,800	sf	See separate tab
riprap, d100=27 inch	2,800	cy	See separate tab
bedding 4"minus	600	cy	See separate tab
Coffer dam-downstream			
Earth embankment	21,400	cy	See separate tab, assume same as upstream c
sheet pile	4,800	sf	See separate tab, assume same as upstream c
riprap, d100=27 inch	2,800	cy	See separate tab, assume same as upstream c
bedding 4"minus	600	cy	See separate tab, assume same as upstream c
Dewatering (subgrade for riprap placement and bridge footings)	1	ls	
Clearing and grubbing, including some tree removal	226	ac	See separate tab
Excavation	1,143,900	cy	From CAD
Embankment (compact) overbanks, side channels and floodplain	362,265	cy	From CAD, assume all fill is included in this lin
Haul and dispose (grade); less than 5 miles RT	781,635	cy	From CAD
Finish grading (shaping) channel	100	ac	See separate tab
Channel armoring (1 to 6 inch d50)	50,100	cy	See separate tab
Bank protection at confluence			
Riprap d100 = 27 inch	30,300	cy	See separate tab
Riprap bedding	6,500	cy	See separate tab
Bank protection on bend cutoff (sta 147+00 - 157+00)			
Riprap d100 = 16 inch	8,200	cy	See separate tab
Riprap bedding	4,100	cy	See separate tab
Bank protection on bend cutoff (sta 92+50 - 101+00)			
Riprap d100 = 16 inch	5,500	cy	See separate tab
Riprap bedding	2,800	cy	See separate tab
Grade-control structures (5 structures)			
Cobble/Boulder material	2,000	cy	See separate tab
Riprap d100 = 16 inch	11,000	cy	See separate tab
Riprap bedding	5,500	cy	See separate tab
Construction access road (30' wide with shoulders)	17,000	lf	Measured length, assumed width with should
Staging Areas	34	ac	See separate tab
Bridge Crossing			
Bridge 150 ft clear span truss style bridge	1	ls	
Concrete for Abutments/Wingwalls	74	cy	See separate tab
Micropiles to 10 foot depth	40	ls	Assumed number and depth
Haul road construction and rehabilitation (24' wide, gravel road base)	4000	ft	Measured length
Seed, mulch and netting	128	ac	See separate tab
Erosion control-silt fence	10000	lf	
Dewatering ponds	3	ac-ft	3-1 ac-ft ponds

Quantities for: Upstream Riprap Protection

Comments/Assumptions: Based on RS 20762

Item Description	Length (ft)	Bank Ht (ft)	Side Slope (XH:1V)	Slope Length (ft)	Thickness (ft)	Quantity	Rounded Quantity	Unit
27" D100 Riprap								
U/S Confluence, YS River	**1000**	**20**	**2.5**	**53.85**	**3.5**	**6981**	**7000**	**CY**
U/S Confluence, HFC LB								
Slope 1		4	8	32.25				
Slope 2		4	6	24.33				
Slope 3		10.5	4	43.09				
Top and Toes				13.50				
Total	**860**			**113.17**	**3.5**	**12616**	**12600**	**CY**
U/S Confluence, HFC RB								
Slope 1		4	8	32.25				
Slope 2		4	6	24.33				
Slope 3		4.25	4	17.52				
Top and Toes				13.50				
Total	**940**			**87.60**	**3.5**	**10675**	**10700**	**CY**
				Grand Total		**30271**	**30300**	**CY**
9" Bedding								
Bedding Volume					**0.75**	**6487**	**6500**	**CY**

Quantities for: Side Channel Cutoff Riprap (Sta 147+00 - 157+00)

Comments/Assumptions: Based on RS 16254

Item Description	Length (ft)	Bank Ht (ft)	Side Slope (XH:1V)	Slope Length (ft)	Thickness (ft)	Quantity	Rounded Quantity	Unit
16" D100 Riprap on Left Bank, Sta 152+50 - 157+00								
Left Bank 16" D100 Riprap								
Slope 1		4	8	32.25				
Slope 2		4	6	24.33				
Slope 3		0.4	4	1.65				
Top and Toes				11.50				
Total	**650**			**69.73**	**1.5**	**2518**	**2600**	**CY**
16" D100 Riprap on Right Bank, Sta 147+00 - 154+00								
Right Bank 16" D100 Riprap								
Slope 1		4	8	32.25				
Slope 2		4	6	24.33				
Slope 3		10.4	4	42.78				
Top and Toes				11.50				
Total	**900**			**110.86**	**1.5**	**5543**	**5600**	**CY**
9" Bedding								
Bedding Volume	**1550**			**Varies**	**0.75**	**4030**	**4100**	**CY**

Quantities for: Right Bank Side Channel Cutoff Riprap (Sta 93+50 - 101+00)

Comments/Assumptions: Based on RS 10264

Item Description	Length (ft)	Bank Ht (ft)	Side Slope (XH:1V)	Slope Length (ft)	Thickness (ft)	Quantity	Rounded Quantity	Unit
16" D100 Riprap on Right Bank								
Right Bank 16" D100 Riprap								
Slope 1		4	8	32.25				
Slope 2		4	6	24.33				
Slope 3		8.5	4	35.05				
Top and Toes				11.50				
Total	**950**			**103.13**	**1.5**	**5443**	**5500**	**CY**
9" Bedding								
Bedding Volume	**950**			**103.13**	**0.75**	**2721**	**2800**	**CY**

Quantities for: Grade Control Structure

Comments/Assumptions: Based on RS 20273. Crest length is 50', bank protection extends for 240' (from USACE Desi

Item Description	Length (ft)	Bank Ht (ft)	Side Slope (XH:1V)	Slope Length (ft)	Thickness (ft)	Quantity	Rounded Quantity	Unit
16" D100 Riprap								
Channel Bed	**43**			**40.00**	**0**	**0**	**0**	**CY**
Left Bank								
Slope 1		4	8	32.25				
Slope 2		4	6	24.33				
Slope 3		4.0	4	16.49				
Top				5.00				
Total	**240**			**78.07**	**1.5**	**1041**	**1000**	**CY**
Right Bank								
Slope 1		4	8	32.25				
Slope 2		4	6	24.33				
Slope 3		4	4	16.49				
Top				11.50				
Total	**240**			**84.57**	**1.5**	**1128**	**1100**	**CY**
					Grand Total	**2169**	**2200**	**CY**
Cobble/Boulder Material (Bed, 64mm - 512mm)								
Bed	**50.0**			**38.50**	**6**	**428**	**400**	**CY**
9" Bedding								
Bedding Volume, Banks	480			162.65	0.75	1084	1100	CY
Bedding Volume, Bed	50.0			38.50	0	0	0	CY
					Grand Total	**1084**	**1100**	**CY**

Grand Totals for 5 Structures

16" D100 Riprap							
					Grand Total	**11000**	**CY**
Cobble/Boulder Material (Bed, 64mm - 512mm)							
					Grand Total	**2000**	**CY**
9" Bedding							
					Grand Total	**5500**	**CY**

Quantities for: Upstream Coffer Dam

Comments/Assumptions: Assume 15' tall, 640 ft long (best estimate is 600 ft long), 4" minus bedding, 400' of sheet pile

Item Description	Length (ft)	Bank Ht/ Height (ft)	Side Slope (XH:1V)	Slope Length (ft)	Thickness/ Topwidth (ft)	Quantity	Rounded Quantity	Unit
27" D100 Riprap								
Face Riprap	**640**	**15**	**2**	**33.54**	**3.5**	**2783**	**2800**	**CY**
4" minus Bedding								
Bedding for Face Riprap	**640**			**33.54**	**0.75**	**596**	**600**	**CY**
Earth Fill for Embankment								
Compacted Earth Fill	**640.0**	**15**	**2**	**33.54**	**20**	**21333**	**21400**	**CY**
PZ 22 Sheet Pile								
PZ 22 Sheet Pile	**400.0**	**12**				**4800**	**4800**	**SF**

Quantities for: Channel Armor

Comments/Assumptions:

Item Description	Length (ft)	Armored Bank Height (ft)	Side Slope (XH:1V)	Slope Length (ft)	Thickness/ Topwidth (ft)	Quantity	Rounded Quantity	Unit
9" Armor Layer								
Left Bank	20400	3	8	24.19	0.75	13706	13,700	CY
Right Bank	20400	3	8	24.19	0.75	13706	13,700	CY
Bed	20400			40.00	0.75	22667	22,700	CY
						Grand Total	**50,100**	**CY**

Quantities for: Finished Grading (HFC Area)

Comments/Assumptions: Assume upper bank height is 6 feet (estimated average from RAS model)

Item Description	Length (ft)	Bank Ht (ft)	Side Slope (XH:1V)	Slope Length (ft)	Quantity	Rounded Quantity	Unit
16" D100 Riprap							
Channel Bed	**20440**			**40.00**	**18.8**	**19**	**ac**
Left Bank							
Slope 1		4	8	32.25			
Slope 2		4	6	24.33			
Slope 3		6.0	4	24.74			
Top				5.00			
Total	**20440**			**86.32**	**40.5**	**41**	**ac**
Right Bank							
Slope 1		4	8	32.25			
Slope 2		4	6	24.33			
Slope 3		6	4	24.74			
Top				5.00			
Total	**20440**			**86.32**	**40.5**	**41**	**ac**
				Grand Total	**100**	**100**	**ac**

Quantities for: Misc. Areas and Volumes

Comments/Assumptions:

Item Description	Length (ft)	Width (ft)	Area (ac)	Rounded Quantity	Unit	Comment
Staging Areas						
Single Staging Area	540	540	6.7			Assume 540' x 540'
		Number:	5.0			
		Total	**33.5**	**34**	**ac**	
Construction Access Road						
Construction Access Road	17000	30	11.7	12	ac	Assume 30' Wide
Disturbed channel and overbanks (Channel Margins)						
Channel Margins	20400	100	46.8	47		Assume 50' disturbance on both banks
Abandoned Channel Area 1	2200	350	17.7			
Abandoned Channel Area 2	3450	275	21.8			
Abandoned Channel Area 3	1470	220	7.4	47		
New channel reach Area 1	1500	150	5.2			
New channel reach Area 2	2000	150	6.9			
New channel reach Area 3	1400	150	4.8	17		
		Total	**110.6**	**111**	**ac**	
Clearing and Grubbing						
Disturbed channel and overbanks				64	ac	channel margins and new channel
Staging areas				34	ac	See staging area calculations
Disposal site	3550	1420	115.7	116	ac	on bluff
Construction Access Road				12	ac	see construction access rd calculations
		Total		**226**	**ac**	
Seed, mulch and net						
Channel Margins				47	ac	
Staging areas				34	ac	
Abandoned Channel Areas				47	ac	
		Total		**128**	**ac**	
					ac	

Item Description	Length (ft)	Height (ft)	Side Slope (XH:1V)	Width (ft)	Number	Quantity	Rounded Quantity	Unit
Abutment and Wingwall Concrete								
Abutments	24	12		1.00	2	21	21	CY
U/S Wingwalls	12	12		0.75	2	8	8	CY
D/S Wingwalls	12	12		0.75	2	8	8	CY
						Grand Total	**37**	**CY**

Ice Factor	100%
Abutment Quantity:	42
Wingwalls Quantity:	32
Total:	74

Multiple Pump Quantities

Multiple Pump Station Alternative QTO Line Items - 2016-03-23

Item Description	UOM	Site 1	Site 2	Site 3	Site 4	Site 5	Quantity
Mob/Demob	LS	1	1	1	1	1	5
Intake/Feeder Canals:							
Dewatering for channel excavation near river (at 5 sites)	LS	1	1	1	1	1	5
Clearing and grubbing (where on land)	SY	3,400	11,200	12,300	5,700	10,000	42,600
Dredging / In-water excavation (assumed 5% of total excavation)	CY	600	2,100	2,300	1,100	1,900	8,000
Excavation (on land)	CY	12,000	40,000	44,000	20,000	35,000	151,000
Trashrack (60' wide x 6' tall)	EA	1	1	1	1	1	5
Fish Screens:							
Dewatering for excavation (at 5 sites)	LS	1	1	1	1	1	5
Clearing and grubbing	SY	1,720	1,720	1,720	1,720	1,720	8,600
Excavation for fish screen facility	CY	5,831	5,831	5,831	5,831	5,831	29,155
Reinforced concrete	CY	1,498	1,498	1,498	1,498	1,498	7,491
Reinforcement	Tons	140	140	140	140	140	699
Fish screens and deadplates	SF	4,176	4,176	4,176	4,176	4,176	20,880
Steel support structures for fish screens (estimated per 2004 study, for 5 site	Tons	50	50	50	50	50	250
Screen cleaners **(NOTE: price is in 2004 dollars, for 5 sites)**	LS	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 88,000	$ 440,000
6" Crushed surfacing (access road surfacing around buildings)	CY	107	107	107	107	107	533
Fish return pumps (total cost for 10 pumps with HPUs, per vendor)	LS	$ 306,000	$ 306,000	$ 306,000	$ 306,000	$ 306,000	$ 1,530,000
18" HDPE Fish return pipe	LF	50	50	50	50	50	250
14" HDPE Fish return pipe	LF	1,000	2,400	2,600	1,400	2,200	9,600
Pump Stations:							
Dewatering for excavation (at 5 sites)	LS	1	1	1	1	1	5
Clearing and grubbing	SY	2,600	2,600	2,600	2,600	2,600	13,000
Excavation for wetwell (5 sites, assumes 1:1 temp. cut slopes)	CY	26,300	26,300	26,300	26,300	26,300	131,500
Reinforced concrete	CY	616	616	616	616	616	3,080
Reinforcement	Tons	100	100	100	100	100	500
Pumps, motors, and controls (per estimates from pump vendors, 5 sites)	LS	$ 1,673,938	$ 1,726,799	$ 1,726,799	$ 1,762,040	$ 1,762,040	$ 8,651,616
48" steel pipe (individual pump discharge lines)	LF	190	190	190	190	190	950
84" steel pipeline (assume 9' depth to IE)	LF	20	20	20	20	20	100
48" check valves	EACH	4	4	4	4	4	20
48" gate valves	EACH	4	4	4	4	4	20
Concrete utility vaults (11' wide x 14' long x 12' deep)	EACH	4	4	4	4	4	20
48" x 84" wyes	EACH	3	3	3	3	3	15
48" bends (45 degrees)	EACH	3	3	3	3	3	15
48" x 84" reducers	EACH	2	2	2	2	2	10
Prefabricated steel building for pump station, heated and insulated, 40' x 25'	EACH	1	1	1	1	1	5
Standby generators:	-						
Site 1: 500 kW, 3 phase, 480V standby generator - (price per vendor)	LS	$ 120,000					$ 120,000
Site 2: 1250 kW (price per vendor)	LS		$ 450,000				$ 450,000
Site 3: 1750 kW (price per vendor)	LS			$ 625,000			$ 625,000
Site 4: 1750 kW (price per vendor)	LS				$ 625,000		$ 625,000
Site 5: 2000 kW (price per vendor)	LS					$ 675,000	$ 675,000
6" Crushed surfacing (access road surfacing around buildings)	CY	40	40	40	40	40	200
Discharge Pipelines:							
Clearing and grubbing	SY	800	3,000	16,800	12,300	5,400	38,300
Excavate trenches (assumes temporary side slopes at 1:1)	CY	1,422	6,000	33,600	24,600	10,800	76,422
72" steel pipeline (assume 8' depth to IE)	LF	300					300
84" steel pipeline (assume 9' depth to IE)	LF		1,000	5,600	4,100	1,800	12,500
Concrete Outlet Structures:							
Excavation	CY	446	365	281		473	1,564
Reinforced concrete (BOR type 1 concrete transitions)	CY	130	109	87		120	447
Reinforcement	Tons	11.6	9.7	7.8		10.7	39.8
Riprap (9" nominal, 18" thick)	CY	800	361	361		361	1,883
Bedding Stone (6" thick)	CY	267	120	120		120	628
Access Roads:							
Clearing and grubbing	SY	3,733	11,200	4,356	9,022	1,556	29,867
Excavation (assumed 2' average cut, 50% of road length)	CY	1,067	3,200	1,244	2,578	444	8,533
Fill (assumed 2' average cut, 50% of road length)	CY	1,067	3,200	1,244	2,578	444	8,533
6" Crushed surfacing (access road surfacing)	CY	444	1,333	519	1,074	185	3,556
Power System Uprating:							
(all cost estimates per MDU)							
Site 1	LS	1					1
Site 2	LS		1				1
Site 3	LS			1			1
Sites 4 and 5 total:	LS					1	1

Feeder Canal QTO

Calc By:	Matt Moore	Date:	2/22/2016
Revised:	JPP	Date:	3/4/2016
Checked By:	FMB	Date:	3/4/2016

Feeder Canal to Pump Site Number	Average existing elevation (Feet NAVD88)	Average depth to Canal Invert (Feet)	Feeder Canal Length (Feet)	Bottom Width (Feet)	Top Width (Feet)	Section Area (SF)	Estimated Cut Volume (CY)	Estimated Wet Excavation (CY)	Estimated Dry Excavation (CY)
1	2000	17	300	32	101	1143	12,701	600	12,000
2	1972	17	1000	32	100	1124	41,630	2100	40,000
3	1964	17	1100	32	100	1130	46,056	2300	44,000
4	1950	17	500	32	101	1147	21,232	1100	20,000
5	1947	17	900	32	100	1113	37,084	1900	35,000
Total Intake Channel Excavation:							**158,703**	**8,000**	**151,000**
								[5% of total Vol.]	[95% of total Vol.]

Feeder Canal Wet Excavation **8,000**
Feeder Canal Dry Excavation **151,000**

Feeder Canal Clearing Area **43,000**

(See original QTO workbook for calculations of the existing elevation and average depth. Only the summary sheet is shown, here)

Fish Screen Quantity Takeoff

By:	JPP	Date:	2/23/2016
Checked By:	FMB	Date:	3/4/2016

Clearing

L	180	Feet
W	86	Feet
Area	1720	SY
Num. of Sites	5	
Total Area	**8600**	**SY**

Access Roads

(Onsite, around the fish screens only)

L	180	Feet
W	16	Feet
Number	2	
Thickness	0.5	Feet
Area	5760	SF
Volume	107	CY
Num. of Sites	5	
Total Volume	**533**	**CY**

Excavation

Assume that the existing ground at the PS location is at the 100 year flood elevation.

Excavate to the bottoms of the walls:

Width	42	Feet
Depth	23	Feet
Length	126	Feet
Section Area	966	SF
Volume	4508	CY

Trapezoidal Section:

Base W	74	Feet
Depth	3.5	Feet
Top W	88	Feet
Length	126	Feet
Section Area	284	SF
Volume	1323	CY

Total Vol. per site	5831	CY
Num. of Sites	5	
Total Excav.	**29155**	**CY**

Fish Return Pipe

Fish return pipe from the bypass sump to the fish pump

Length each	25	Feet
Number	10	
Total	250	Feet

Assume fish return pipe length = intake canal length + 200'

14" dia. HDPE pipe, length varies at each site

	Length, each		Length, total	
Site 1	500	Feet	1000	Feet
Site 2	1200	Feet	2400	Feet
Site 3	1300	Feet	2600	Feet
Site 4	700	Feet	1400	Feet
Site 5	1100	Feet	2200	Feet
Total			9600	LF

Fish Screens and Deadplates

Cost information per Shawn Foster email dated 2016-02-16.

Length	116	Feet
Height	18	Feet
Number	2	
Total Area	4176	SF
Unit Cost	$ 300.00	per SF
Cost per Site	$ 1,252,800.00	
Num. of Sites	5	
Total Cost	$ 6,264,000.00	

Fish Screens Support Structure

Base on weight estimate listed in 2004 study by BOR. Scale linearly based on length and height.

	Reference proj.	Design value	Factor
Length	244	126	52%
Height	20	25	125%
Weight	150000	96824	65%

Estimated weight per site:	48.41	Tons
Number of sites:	5	
Estimated weight total:	**242**	**Tons**

Fish Screen Cleaner

Fish screen cleaners will be approximately the same price and type as cleaners in the 2004 cost estimate by BOR.
Smaller screen size won't significantly affect price of screen cleaners. Note that price is still in 2004 dollars.

Cost in 2004 (per pair):	$ 88,000
Number of sites:	5
Total screen cleaner cost in 2004 dollars:	**$ 440,000**

Walls and Concrete QTO

	Length	Height/Width	Thickness	Area	Volume	Reinf. Ratic	Reinforcing
R Wall-footing	214.0	8.0	2.5	1712	4280	6.59	28192
R Wall-stem	214.0	22.0	1.5	4708	7062	6.59	46517
L Wall-footing	214.0	8.0	2.5	1712	4280	6.59	28192
L Wall-stem	214.0	22.0	1.5	4708	7062	6.59	46517
Floor	136.0	38.0	1.0	5168	5168	9.11	47080
R Screen Fdn	126.0	20.0	2.5	2520	6300	6.59	41498
L Screen Fdn	126.0	20.0	2.5	2520	6300	6.59	41498

Reinforced Concrete Volume, per site	1498	CY, per site
Reinforcement Weight, per site	140	Tons, per site
Total Reinforced Concrete Volume	**7491**	**CY**
Total Reinforcement Weight	**699**	**Tons**

Fish Return Pumps

Cost estimates as provided by Magic Valley Heli-Arc & Mfg, Inc. on March 17, 2016.

BP-420 Pump	$ 93,000
HPU	$ 35,000
Ancillary Equipment	$ 25,000
Total Cost per Pump	$ 153,000
Num. of Pumps per Site	2
Number of Sites	5
Total Cost	$ 1,530,000

Pump Station Quantity Takeoff

By:	JPP	Date:	2/23/2016
Checked By:	FMB	Date:	3/4/2016
		Revision Date:	5/12/2016

All calculations are for a single, typical pump station, except where noted.

Access Roads

(Onsite, around the fish screens only)

L	110	Feet
W	16	Feet
Number	1	
Thickness	0.5	Feet
Area	1760	SF
Volume	33	CY
Num. of Sites	5	
Total Volume	**163**	**CY**

Excavation

Assume that the existing ground at the PS location is at the 100 year flood elevation.

Assume temporary side slopes are cut at 1:1 from the foundation to the EG.

Bottom L	34	Feet
Bottom W	44	Feet
Depth	57	Feet
Side Slopes	1	:1
Bottom Area	1496	SF
Top Area	23384	SF
Volume	26262	CY
Num. of Sites	5	
Total Volume	**131311**	**CY**

Clearing

Use calculation for excavation, above.

Area	2598	SY
Num. of Sites	5	
Total Clearing	**12991**	**SY**

Pumps Revised on

Base cost estimate on quote for Site 5 from Russell Pumps, dated 2016-02-19, including adder for 480V power.

Per Russell Pumps, cost for pumps and motors at sites 1-4 would be 2-5% less than at site 5.

Cost for pumps at Site 5: $ 440,510

	Site 1	**Site 2**	**Site 3**	**Site 4**	**Site 5**
Num. of Pumps	4	4	4	4	4
Cost Adj.	95%	98%	98%	100%	100%
Cost Each	$ 418,485	$ 431,700	$ 431,700	$ 440,510	$ 440,510
Total Cost	$ 1,673,938	$ 1,726,799	$ 1,726,799	$ 1,762,040	$ 1,762,040

Total Pump and Motor Cost: $ 8,651,616

Pump Station Walls Added on 2

	Length	Height/Width	Thickness	Area	Volume	Reinf. Ratio (l	Reinforcing
D/S Wall-lower	26.0	25.0	2.3	650	1517	11.77	17851
D/S Wall-upper	26.0	32.0	1.5	832	1248	12.57	15687
U/S Wall-lower	26.0	25.0	2.3	650	1517	11.77	17851
U/S Wall-upper	26.0	7.0	1.5	182	273	12.57	3432
R Wall-lower	30.0	25.0	3.0	750	2250	12.12	27270
R Wall-upper	30.0	32.0	1.5	960	1440	17.39	25042
L Wall-lower	30.0	25.0	3.0	750	2250	12.12	27270
L Wall-upper	30.0	32.0	1.5	960	1440	17.39	25042
R Wing	21.0	25.0	1.5	525	788	6.59	5187

L Wing	21.0	25.0	1.5	525	788	6.59	5187
Sump Floor	26.0	30.0	3.0	780	2340	9.11	21317
Top Slab	26.0	30.0	1.0	780	780	7.00	5460

Reinforced Concrete Volume, per site	616	CY, per site
Reinforcement Weight, per site	98	Tons, per site
Total Reinforced Concrete Volume	**3080**	**CY**
Total Reinforcement Weight	**491**	**Tons**

Discharge Pipelines

Assumes all pipelines are buried with 2' of cover and the temporary sideslopes are at 1:1.

	Length	Dia	Depth	Base Width	Top Width	Sectional Are	Excavated Volume
Site 1	300	6	8	8	24	128	38400
Site 2	1000	7	9	9	27	162	162000
Site 3	5600	7	9	9	27	162	907200
Site 4	4100	7	9	9	27	162	664200
Site 5	1800	7	9	9	27	162	291600

	2063400	CF
Total Excavated Volume:	**76422**	**CY**
Total Cleared Area:	**38300**	**SY**

Ice Protection Berms (Added: 2016-05-12) (Added: 20

All dimensions are approximate, for a typical ice protection berm, top elevation 2' above the 100 year flood

Left Side:

Length	280	Feet
Width	62	Feet
Average Height	4	Feet
Top Area	17360	SF
Bottom Area	20300	SF
Left Side Vol.:	75320	CF
	2790	CY

Right Side:

Length	230	Feet
Width	30	Feet
Average Height	4	Feet
Top Area	6900	SF
Bottom Area	9600	SF
Right Side Vol.:	33000	CF
	1222	CY

Total berm volume per site:	4012	CY
Number of sites:	5	
Total ice berm volume:	**20059**	**CY**

Pipe Outlet Structure Quantity Takeoff

By: JPP Date: 2/24/2016
Checked By: FMB Date: 3/4/2016

Discharge Pipeline Outlets

Estimate for Type 1 concrete outlet transitions, per USBR's "Design of Small Canals"
Wall thickness of 1.5' estimated by scaling up textbook values.
Floor area measured in AutoCAD. Wall heights based on 10' design depth in irrigation canal + 4' at headwall.

	Length	Height/Width	Thickness	Area	Volume	Reinf. Ratic	Reinforcing
Site 1:							
L Wall	23.5	10.0	1.5	235	353	6.6	2322
Head Wall	7.0	14.0	1.5	98	147	6.6	968
R Wall	101.0	10.0	1.5	1010	1515	6.6	9979
Floor			1.0	1205	1205	6.6	7937
2 Wings (total)	20.0	10.0	1.5	200	300	6.6	1976
Site 2:							
L Wall	23.5	10.0	1.5	235	353	6.6	2322
Head Wall	7.0	14.0	1.5	98	147	6.6	968
R Wall	77.0	10.0	1.5	770	1155	6.6	7608
Floor			1.0	985	985	6.6	6488
2 Wings (total)	20.0	10.0	1.5	200	300	6.6	1976
Site 3:							
L Wall	23.5	10.0	1.5	235	353	6.6	2322
Head Wall	7.0	14.0	1.5	98	147	6.6	968
R Wall	53.5	10.0	1.5	535	803	6.6	5286
Floor			1.0	758	758	6.6	4993
2 Wings (total)	20.0	10.0	1.5	200	300	6.6	1976
Site 4/5:							
L Wall	23.5	10.0	1.5	235	353	6.6	2322
Head Wall	19.0	14.0	1.5	266	399	6.6	2628
R Wall	60.6	10.0	1.5	606	909	6.6	5988
Floor			1.0	1276	1276	6.6	8405
2 Wings (total)	20.0	10.0	1.5	200	300	6.6	1976

Total Reinforced Concrete Volume **447 CY**
Total Reinforcement Weight **40 Tons**

Excavation:

Rough estimate based on average cut depth at each site.

	Area	Depth	Volume
Site 1	1205	10	12050
Site 2	985	10	9850
Site 3	758	10	7580
Site 4/5	1276	10	12760

Total excavation volume all sites: **1564 CY**

Riprap

QTO is as shown on drawings C-001 to C-005.

	Site 1	Site 2	Site 3	Site 4	Site 5	
Length	180	100	100	100	100	feet
Width	80	65	65	65	65	feet
Thickness	1.5	1.5	1.5	1.5	1.5	feet
Area	14400	6500	6500	6500	6500	SF
Volume	800.00	361.11	361.11	361.11	361.11	CY, per site

Total riprap volume, all sites: **2244 CY**

Access Road Quantity Takeoff

By:	JPP	Date:	2/17/2016
Checked By:	FMB	Date:	3/4/2016

All calculations assume that 50% of each road is cut by an average of 2' and 50% is filled by an average of 2'.

Access Roads

(Onsite, around the fish screens only)

	Site 1	Site 2	Site 3	Site 4	Site 5	Total	
Road Width	20	20	20	20	20		
Length	1200	3600	1400	2900	500		
Side Slopes	2	2	2	2	2		
Cut/Fill Depth	2	2	2	2	2		
Clear Area	33600	100800	39200	81200	14000	268800	SF
Cut Volume	28800	86400	33600	69600	12000	230400	CF
Fill Volume	28800	86400	33600	69600	12000	230400	CF
Surfacing Area	24000	72000	28000	58000	10000	192000	SF
Surf. Thickness	0.5	0.5	0.5	0.5	0.5		FT
Surf. Volume	12000	36000	14000	29000	5000	96000	CF

Total Clearing Area	**29867**	**SY**
Total Cut Volume	**8533**	**CY**
Total Fill Volume	**8533**	**CY**
Total Surfacing Volume	**3556**	**CY**

Multiple Pumps with Conservation Measures Quantities

Canal Lining Area Calculation **Last updated:** **2/22/2016**

(Assumptions:

1. Based the U.S BOR's 2002 canal lining demonstration project report, geomembrane with concrete cover was selected for canal lining method.
2. Canal lining area represents finish surface of canal geometry between top of both canal slopes and does not include any overlaps of fabrics or anchors that are buried.
3. Eleven (11) typical canal cross sections used for the area calculations were based on the U.S BOR's 1992(?) document, and no additional sections were included.

	Cross Sections - U.S.BOR's 1992 document								Surface Area at Each Section [SF/ft]				
Location	RM [mi]	RM [ft]	Bottom [ft]	SS [H:V]	Ht [ft]	V [fps]	S [ft/ft]	Q [cfs]	Sideslope (x2) [SF/ft]	Bottom [SF/ft]	Full X-Section [SF/ft]	Distance [ft]	Surface Area [SF]
U/S End of Canal	0	0											
at Headgate (1)	0.05	264	28.5	1.5:1	40	2.2	0.0001	847	144.0	28.5	172.5	660	113850
at Headgate (2)	0.2	1056	23.5	1.5:1	26	2.15	0.0001	828	93.6	23.5	117.1	28908	3385127
below Lateral HH	11	58080	20.5	1.5:1	12	2.1	0.0001	745	43.2	20.5	63.7	50424	3212009
below Pumping Plant	19.3	101904	21.5	1.5:1	11	2	0.0001	630	39.6	21.5	61.1	36168	2209865
at Sears Bridge	24.7	130416	20.5	1.5:1	18	1.99	0.0001	609	64.8	20.5	85.3	44088	3760706
below Fox Creek Siphon	36	190080	23	1.5:1	10	1.89	0.0001	529	36.0	23.0	59.0	46992	2772528
below Lone Tree Creek Siphon	42.5	224400	23.5	1.5:1	9	1.76	0.0001	419	32.4	23.5	55.9	29040	1623336
below Lateral G	47	248160	15.5	1.5:1	8	2.08	0.0002	318	28.8	15.5	44.3	22440	994092
below Lateral J	51	269280	16.5	1.5:1	7	2.37	0.0003	284	25.2	16.5	41.7	26400	1100880
below Lateral M	57	300960	14.5	1.5:1	6	2	0.0001	164	21.6	14.5	36.1	25080	905388
below Lateral P	60.5	319440	9	1.5:1	5	1.87	0.0001	75.7	18.0	9.0	27.0	60984	1646568
D/S End of Canal	70.3	371184											

Total: **21,724,349** **[SF]**

Total: **371,184** **[LF]**

Total: **70.3** **[MI]**

	Shotcrete Volume			Fill Canal Volume		
Location	Surface Area [sf]	Shotcrete [in]	V [cy]	Length [lf]	XS Area [sf]	V x 50% [cy]
U/S End of Canal						
at Headgate (1)	113,850	3.0	1,054	660	2970	36,300
at Headgate (2)	3,385,127	3.0	31,344	28,908	1320	706,372
below Lateral HH	3,212,009	3.0	29,741	50,424	339	316,551
below Pumping Plant	2,209,865	3.0	20,462	36,168	300	200,766
at Sears Bridge	3,760,706	3.0	34,821	44,088	671	547,426
below Fox Creek Siphon	2,772,528	3.0	25,672	46,992	265	230,609
below Lone Tree Creek Siphon	1,623,336	3.0	15,031	29,040	227	122,210
below Lateral G	994,092	3.0	9,205	22,440	158	65,658
below Lateral J	1,100,880	3.0	10,193	26,400	131	64,167
below Lateral M	905,388	3.0	8,383	25,080	98	45,283
below Lateral P	1,646,568	3.0	15,246	60,984	60	67,760
D/S End of Canal						

Total: **2,403,102** **[CY]**

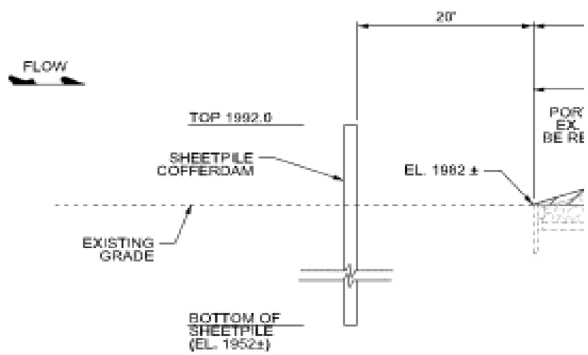
Note: Assumes 50% of existing canal to be filled

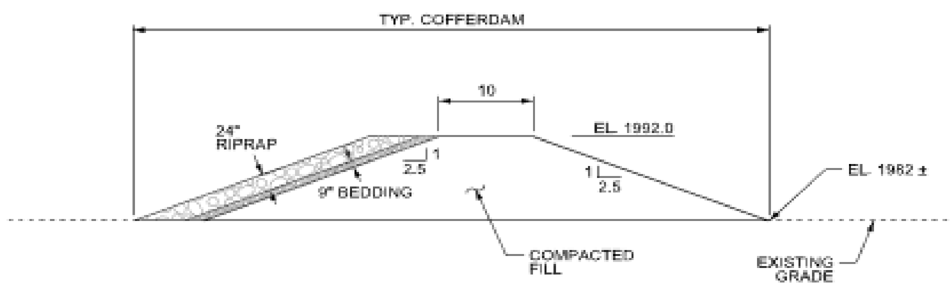
Cofferdam Calculation **Last updated:** **3/4/2016**

(Assumptions:

1. Dam removal will take place in 2 phases.
2. A typical cofferdam will be a sheetpile with the exception of the segment along the flow direction (west to east) in Phase 1.
3. A sheetpile will be total of 40 feet in height (10' exposed + 30' embedded).

Location	Length [ft]	Sheetpile Height [ft]	Earthen Dam (X-Section) Comp Fill [SF/ft]	Earthen Dam (X-Section) 9" Bedding [SF/ft]	Earthen Dam (X-Section) 24" Riprap [SF/ft]	Sheetpile Area [SF]	Earthen Dam (Volume) Comp Fill	Earthen Dam (Volume) 9" Bedding	Earthen Dam (Volume) 24" Riprap	
Phase 1 - Removal of North half										
Sheetpile (U/S Face & D/S Face)	895	40				***35,800***				
Earthen (along the flow direction)	410		380.0	21.20	56.54		155800	8694	23183	[CF]
							5,770	***322***	***859***	[CY]
Phase 2 - Removal of South half										
Sheetpile	1420	40				***56,800***				





TYPICAL EARTHEN COFFERDAM

N.T.S

Existing Intake Dam Removal Calculation **Last updated:** **3/4/2016**

(Assumptions:

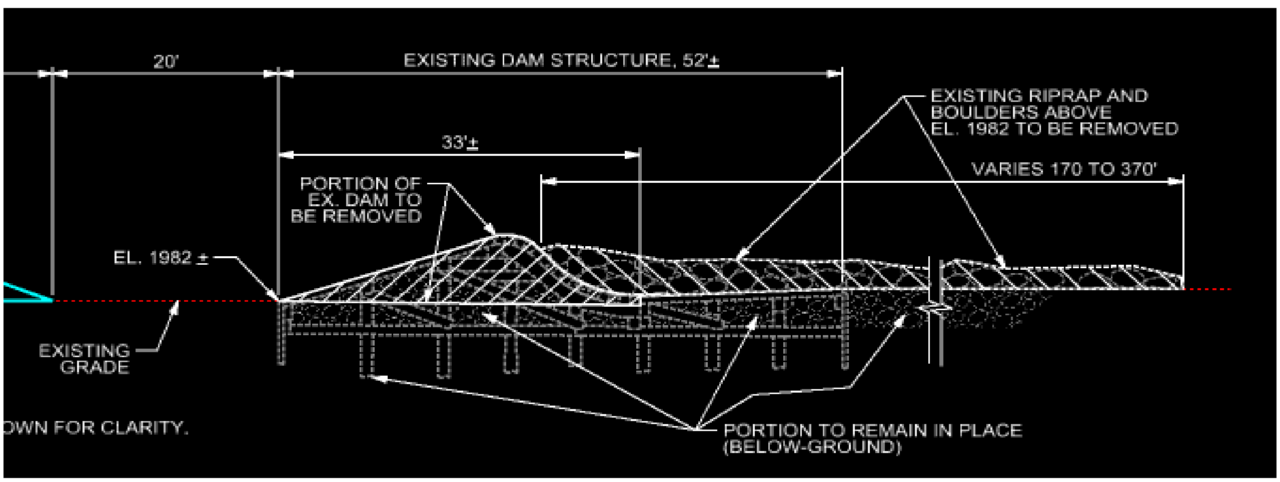
1. A typical intake dam geometry (shown here) is based on the USACE's 1910 as-built plans.
2. Only the portion of the dam that is above adjacent ground elevation (1981.5) was assumed to be removed.
3. The dam crest was assumed to be 1988'.
4. The portion of the dam that is below ground, including timber piles, will be left in place.
5. Quantity of riprap and boulders downstream of the existing dam was based on bathymetric survey.

		X-Section			Volume		
Location	Length [ft]	Removal [SF/ft]	[SF/ft]	[SF/ft]	Removal [CF]	[CY]	
Existing Dam	700	112.0			78400		

Total: **2904** [CY]

			Volume		
Location	Surface Area [SF]	Avg Thickness [ft]	Removal [CF]	[SF/ft]	[SF/ft]
Riprap and Boulders D/S of Ex. Dam	190190	6	1141140.0		

Total: **42264** [CY]



Convert Laterals to Pipe - Lengths

1.5	2	3	4	5	6	No Piping
	Pipe Length (feet)					
-	1,653	14,994	16,181	11,800	-	-
-	1,760	27742	26425	23911	-	14089
-	2973	14688	5766	-	4134	-
-	511	32620	-	300	-	5900
3026	8027	35775	5200	4096	-	9904
-	10548	2150	-	-	2700	-
-	17075	25522	23635	-	-	8400
-	-	14377	5600	11000	-	-
652	-	5275	5600	-	-	-
-	-	-	6684	-	-	-
-	-	3232	-	-	-	-
-	-		8622	-	-	-
3678	42547	176375	103713	51107	6834	38293

Attachment B.5
Labor Rates

General Decision Number: MT160077 01/08/2016 MT77

Superseded General Decision Number: MT20150077

State: Montana

Construction Type: Heavy

Counties: Big Horn, Carter, Daniels, Dawson, Fallon, Garfield, McCone, Phillips, Powder River, Prairie, Richland, Roosevelt, Rosebud, Sheridan, Treasure and Wibaux Counties in Montana.

HEAVY CONSTRUCTION PROJECTS

Note: Under Executive Order (EO) 13658, an hourly minimum wage of $10.15 for calendar year 2016 applies to all contracts subject to the Davis-Bacon Act for which the solicitation was issued on or after January 1, 2015. If this contract is covered by the EO, the contractor must pay all workers in any classification listed on this wage determination at least $10.15 (or the applicable wage rate listed on this wage determination, if it is higher) for all hours spent performing on the contract in calendar year 2016. The EO minimum wage rate will be adjusted annually. Additional information on contractor requirements and worker protections under the EO is available at www.dol.gov/whd/govcontracts.

Modification Number	Publication Date
0	01/08/2016

ELEC0233-021 06/01/2015

PHILLIPS COUNTY

	Rates	Fringes
ELECTRICIAN.....................	$ 29.98	11.60

ELEC0532-013 06/01/2015

BIG HORN, CARTER, DANIELS, DAWSON, FALLON, GARFIELD, MCCONE, POWDER RIVER, PRAIRIE, RICHLAND, ROOSEVELT, ROSEBUD, SHERIDAN, TREASURE, AND WILBAUX COUNTIES

	Rates	Fringes
ELECTRICIAN.....................	$ 31.39	12.84

ENGI0400-010 05/01/2013

	Rates	Fringes

POWER EQUIPMENT OPERATOR:
(Zone 1)
(1) A-frame truck Crane,

```
          oiler  (except crane)..$ 23.47            10.40
     (2)  Crane
     Oiler,Bulldozer, Roller
     (Dirt and Grade
     Compaction), Backhoe........$ 23.94            10.40
     (3) Mechanic................$ 24.34            10.40
     (4) Cranes, 25 tons - 44
     tons........................$ 27.00            11.40
     (5) Cranes, 45 tons to and
     incl. 74 tons...............$ 28.00            11.40
     (6) Cranes, 75 tons to and
     incl. 149 tons; Cranes,
     Whirley (All)...............$ 29.00            11.40
     (7) Cranes, 150 tons to
     including 250 tons (add
     $1.00

       for every 100 tons over
     250 tons); Crane, Stiff-
     Leg or

       Derrick; Helicopter
     Hoist; Crane, Tower (all)...$ 30.00            11.40

ZONE DEFINITIONS FOR POWER EQUPMENT OPERATORS:
  The zone hourly rates applicable to each project shall be
  determined by measuring the road miles over the shortest
  practical maintained route from the nearest County Court
  House of the following listed towns to the center of the
  job:

  BILLINGS, BOZEMAN, BUTTE, GREAT FALLS, HELENA, KALISPELL,
  MISSOULA

Zone 1:   0 to 30 miles - Base Pay
Zone 2:  30 to 60 miles - Base Pay + $3.50
Zone 3:  Over 60 miles - Base Pay + $5.50

----------------------------------------------------------------
* IRON0732-018 06/01/2015

                                  Rates          Fringes

IRONWORKER:  Reinforcing and
Structural.......................$ 27.00          19.78+a

  a: PAID HOLIDAYS: New Years Day, Memorial Day, July 4th,
  Labor Day, Veteran's DAy, Thanksgiving Day, Day following
  Thanksgiving, and Christmas Day.

----------------------------------------------------------------
  SUMT2011-052 02/08/2011

                                  Rates          Fringes

CARPENTER (Form Work Only).......$ 24.30             7.80

CARPENTER, Excludes Form Work....$ 21.13             7.00

LABORER:  Common or General......$ 17.99             5.90
```

LABORER: Pipelayer	$ 21.10	5.46
LABORER: Landscape and Irrigation	$ 15.14	1.30
OPERATOR: Bobcat/Skid Steer/Skid Loader	$ 23.53	8.05
OPERATOR: Excavator	$ 23.62	8.05
OPERATOR: Grader/Blade	$ 25.44	8.45
OPERATOR: Loader (Front End)	$ 24.58	8.05
OPERATOR: Scraper	$ 23.00	6.76
TRUCK DRIVER: Dump Truck	$ 19.99	5.09

WELDERS - Receive rate prescribed for craft performing operation to which welding is incidental.

==

Unlisted classifications needed for work not included within the scope of the classifications listed may be added after award only as provided in the labor standards contract clauses (29CFR 5.5 (a) (1) (ii)).

The body of each wage determination lists the classification and wage rates that have been found to be prevailing for the cited type(s) of construction in the area covered by the wage determination. The classifications are listed in alphabetical order of "identifiers" that indicate whether the particular rate is a union rate (current union negotiated rate for local), a survey rate (weighted average rate) or a union average rate (weighted union average rate).

Union Rate Identifiers

A four letter classification abbreviation identifier enclosed in dotted lines beginning with characters other than "SU" or "UAVG" denotes that the union classification and rate were prevailing for that classification in the survey. Example: PLUM0198-005 07/01/2014. PLUM is an abbreviation identifier of the union which prevailed in the survey for this classification, which in this example would be Plumbers. 0198 indicates the local union number or district council number where applicable, i.e., Plumbers Local 0198. The next number, 005 in the example, is an internal number used in processing the wage determination. 07/01/2014 is the effective date of the most current negotiated rate, which in this example is July 1, 2014.

Union prevailing wage rates are updated to reflect all rate changes in the collective bargaining agreement (CBA) governing this classification and rate.

Survey Rate Identifiers

Classifications listed under the "SU" identifier indicate that no one rate prevailed for this classification in the survey and the published rate is derived by computing a weighted average rate based on all the rates reported in the survey for that classification. As this weighted average rate includes all rates reported in the survey, it may include both union and non-union rates. Example: SULA2012-007 5/13/2014. SU indicates the rates are survey rates based on a weighted average calculation of rates and are not majority rates. LA indicates the State of Louisiana. 2012 is the year of survey on which these classifications and rates are based. The next number, 007 in the example, is an internal number used in producing the wage determination. 5/13/2014 indicates the survey completion date for the classifications and rates under that identifier.

Survey wage rates are not updated and remain in effect until a new survey is conducted.

Union Average Rate Identifiers

Classification(s) listed under the UAVG identifier indicate that no single majority rate prevailed for those classifications; however, 100% of the data reported for the classifications was union data. EXAMPLE: UAVG-OH-0010 08/29/2014. UAVG indicates that the rate is a weighted union average rate. OH indicates the state. The next number, 0010 in the example, is an internal number used in producing the wage determination. 08/29/2014 indicates the survey completion date for the classifications and rates under that identifier.

A UAVG rate will be updated once a year, usually in January of each year, to reflect a weighted average of the current negotiated/CBA rate of the union locals from which the rate is based.

WAGE DETERMINATION APPEALS PROCESS

1.) Has there been an initial decision in the matter? This can be:

* an existing published wage determination
* a survey underlying a wage determination
* a Wage and Hour Division letter setting forth a position on a wage determination matter
* a conformance (additional classification and rate) ruling

On survey related matters, initial contact, including requests for summaries of surveys, should be with the Wage and Hour Regional Office for the area in which the survey was conducted because those Regional Offices have responsibility for the Davis-Bacon survey program. If the response from this initial contact is not satisfactory, then the process described in 2.) and 3.) should be followed.

With regard to any other matter not yet ripe for the formal process described here, initial contact should be with the Branch of Construction Wage Determinations. Write to:

Branch of Construction Wage Determinations
Wage and Hour Division
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

2.) If the answer to the question in 1.) is yes, then an interested party (those affected by the action) can request review and reconsideration from the Wage and Hour Administrator (See 29 CFR Part 1.8 and 29 CFR Part 7). Write to:

Wage and Hour Administrator
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

The request should be accompanied by a full statement of the interested party's position and by any information (wage payment data, project description, area practice material, etc.) that the requestor considers relevant to the issue.

3.) If the decision of the Administrator is not favorable, an interested party may appeal directly to the Administrative Review Board (formerly the Wage Appeals Board). Write to:

Administrative Review Board
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

4.) All decisions by the Administrative Review Board are final.

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END OF GENERAL DECISION

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Attachment B.6
Estimated Construction Durations

Modified Side Channel Construction Durations

TITLE: Yellowstone River - Modified Side Channel
SUBJECT: Estimated Construction Durations
MADE BY: SKV
CHECKED BY:

JOB NO.: T35234
DATE: 5/10/2016

08 - Roads, Railroads and Bridges

Item	Prod. Rate	Prod. Index	Work Hrs/Day	UOM	Quantity	Crews (EA)	Duration (Hrs.)	Duration (Days)
Mobilization	0.10	100%	10	DAY	10	1	100.0	10.00
Prefabricated Bridge Installation								
Structural Excavation	25.00	100%	10	CY	50	1	2.0	0.20
Concrete Abutments and Wingwalls								
Concrete, Forms	*60.63*	*100%*	*10*	*SFC*	*300*	*1*	*4.9*	*0.49*
Reinforcing Steel	*0.07*	*100%*	*10*	*TON*	*2.8*	*2*	*21.3*	*2.13*
Concrete, Placement	*18.75*	*100%*	*10*	*CY*	*41*	*1*	*2.2*	*0.22*
Bridge Installation	18.13	100%	10	SF	3,600	2	99.3	9.93
Haul Road Construction and Rehab								
Clearing and Grubbing	0.13	100%	10	ACRE	2	1	17.6	1.76
Fine Grading	250.00	100%	10	SY	10,667	2	21.3	2.13
Aggregate Base Course	675.00	100%	10	SY	10,667	1	15.8	1.58
Demobilization	0.10	100%	10	DAY	5	1	50.0	5.00

16 - Bank Stabilization

Item	Prod. Rate	Prod. Index	Work Hrs/Day	UOM	Quantity	Crews (EA)	Duration (Hrs.)	Duration (Days)
Mobilization	0.10	100%	10	DAY	20	1	200.0	20.00
Channel Armoring								
Bedding Stone Placement	30.00	100%	10	CY	24,840	4	207.0	20.70
Riprap Placement	25.00	100%	10	CY	115,610	6	770.7	77.07
Boulder Placement	17.50	100%	10	CY	2,200	2	62.9	6.29
Demobilization	0.10	100%	10	DAY	5	1	50.0	10.00

09 - Channels

Item	Prod. Rate	Prod. Index	Work Hrs/Day	UOM	Quantity	Crews (EA)	Duration (Hrs.)	Duration (Days)
Mobilization	0.10	100%	10	DAY	20	1	200.0	20.00
Site Preparation								
Staging Areas								
Clearing and Grubbing	0.13	100%	10	ACRE	33.5	3	89.3	8.93
Fine Grading	250.00	100%	10	SY	162,140	4	162.1	16.21
Aggregate Base Course	675.00	100%	10	SY	81,070	2	60.1	6.01
Temporary Fencing	25.00	100%	10	LF	10,800	4	108.0	10.80
Access/Haul Roads								
Clearing and Grubbing	0.13	100%	10	ACRE	11.7	2	46.8	4.68
Fine Grading	250.00	100%	10	SY	56,667	2	113.3	11.33
Aggregate Base Course	675.00	100%	10	SY	56,667	2	42.0	4.20
Erosion Control								
Silt Fence	43.75	100%	10	LF	10,000	2	114.3	11.43
Jute Mesh	300.00	100%	10	SY	10,000	2	16.7	1.67
Upstream Cofferdam								
Sheetpile Cutoff	60.63	100%	10	SF	4,800	1	79.2	7.92
Earthen Cofferdam								
Borrow Fill Excavate and Load	130.00	100%	10	CY	24,610	2	94.7	9.47
Cycel Haul to/from Borrow Site	60.61	100%	10	CY	24,610	4	101.5	10.15
Place and Compact Embankment	240.00	100%	10	CY	24,610	2	51.3	5.13
Bedding Placement	30.00	100%	10	CY	690	2	11.5	1.15
Riprap Placement	25.00	100%	10	CY	3,080	2	61.6	6.16
Downstream Cofferdam								
Sheetpile Cutoff	60.63	100%	10	SF	4,800	1	79.2	7.92
Earthen Cofferdam								
Borrow Fill Excavate and Load	130.00	100%	10	CY	24,610	2	94.7	9.47
Cycel Haul to/from Borrow Site	60.61	100%	10	CY	24,610	4	101.5	10.15
Place and Compact Embankment	240.00	100%	10	CY	24,610	2	51.3	5.13
Bedding Placement	30.00	100%	10	CY	690	2	11.5	1.15
Riprap Placement	25.00	100%	10	CY	3,080	2	61.6	6.16
Clearing and Grubbing	0.13	100%	10	ACRE	226	8	226.0	22.60
Channel Excavation	210.00	100%	10	CY	1,143,900	6	907.9	90.79
Cycle Haul to/from Overbank Sites	72.70	100%	10	CY	416,605	6	955.1	95.51
Place and Compact Channel Fill	224.00	100%	10	CY	416,605	6	310.0	31.00
Cycle Haul to/from Borrow Site	60.61	100%	10	CY	898,880	10	1483.1	148.31
Spread Material at Disposal Site	140.00	100%	10	CY	898,880	8	802.6	80.26
Finish Grading, Channel	900.00	100%	10	SY	484,000	4	134.4	13.44
Seeding								
Mechanical Seeding	0.19	100%	10	ACRE	128	4	170.7	17.07
Mulching	75.00	100%	10	MSF	5,576	2	37.2	3.72
Netting	312.50	100%	10	SY	619,520	4	495.6	49.56
Demobilization	0.10	100%	10	DAY	5	1	50.0	10.00

Multiple Pump Construction Durations

TITLE: Yellowstone River - Multiple Pump Alternative
SUBJECT: Estimated Construction Durations
MADE BY: SKV
CHECKED BY:

JOB NO.: T35234
DATE: 5/10/2016

Typical Pump Station Durations

Item	Prod. Rate	Prod. Index	Work Hrs/Day	UOM	Quantity	Crews (EA)	Duration (Hrs.)	Duration (Days)
Mobilization	0.10	100%	30	DAY	30	1	300.0	10.00
Staging Areas								
Clearing and Grubbing	0.13	100%	10	ACRE	0.5	1	3.7	0.37
Fine Grading	250.00	100%	10	SY	2,500	1	10.0	1.00
Aggregate Base Course	675.00	100%	10	SY	2,500	1	3.7	0.37
Temporary Fencing	25.00	100%	10	LF	600	2	12.0	1.20
Access/Haul Roads								
Clearing and Grubbing	0.13	100%	10	ACRE	0.8	1	6.4	0.64
Fine Grading	250.00	100%	10	SY	3,733	1	14.9	1.49
Aggregate Base Course	675.00	100%	10	SY	2,667	1	4.0	0.40
Erosion Control								
Silt Fence	43.75	100%	10	LF	2,500	2	28.6	2.86
Jute Mesh	300.00	100%	10	SY	5,000	2	8.3	0.83
Feeder Canal Dewater								
Sheet Piling	60.63	100%	10	SF	8,000	1	132.0	13.20
Wellpoints	2.00	100%	10	LF	400	2	100.0	10.00
Pump Staitons								
Clearing and Grubbing	0.13	100%	10	ACRE	0.54	1	4.3	0.43
Earthwork								
Channel Excavation	180.00	100%	10	CY	13,150	4	18.3	1.83
Wet Excavation	35.00	100%	10	CY	13,150	4	93.9	9.39
Cycle Haul to/from Borrow Site	53.10	100%	10	CY	12,098	2	113.9	11.39
Spread Material at Disposal Site	140.00	100%	10	CY	12,098	2	43.2	4.32
Fill and Compact from Stockpile	96.00	100%	10	CY	18,147	2	94.5	9.45
Reinforced Concrete								
Concrete Floor								
Concrete Forms	34.38	100%	10	SFC	159	2	2.3	0.23
Reinforcing Steel	0.07	100%	10	TON	10.7	6	24.8	2.48
Concrete Placement	23.13	100%	10	CY	96	1	4.1	0.41
Concrete Walls								
Concrete Forms	50.00	100%	10	SFC	903	2	9.0	0.90
Reinforcing Steel	0.09	100%	10	TON	85	6	150.7	15.07
Concrete Placement	15.00	100%	10	CY	550	1	36.7	3.67
Concrete Top Slab								
Concrete Forms	34.38	100%	10	SFC	53	2	0.8	0.08
Reinforcing Steel	0.07	100%	10	TON	3	6	6.3	0.63
Concrete Placement	23.13	100%	10	CY	32	1	1.4	0.14
Irrigation Pumps and Motors	0.03	100%	10	EA	4	1	160.0	16.00
Piping								
48" Steel Pipe	2.71	100%	10	LF	190	2	35.1	3.51
84" Steel Pipe	1.25	100%	10	LF	20	1	16.0	1.60
Hydraulic Gate	0.06	100%	10	EA	4	2	32.0	3.20
Pipe Wyes and Tees	1.50	100%	10	EA	3	1	2.0	0.20
Pipe Bends/Elbows	1.50	100%	10	EA	3	1	2.0	0.20
Pipe Reducers	1.00	100%	10	EA	2	1	2.0	0.20
Concrete Utility Vaults	0.10	100%	10	EA	4	1	40.0	4.00
Prefab Steel Building	0.01	100%	10	EA	1	1	100.0	10.00
Standby Generators	0.01	100%	10	EA	1	1	80.0	8.00
Aggregate Base Course	104.38	100%	10	CY	40	1	0.4	0.04

Typical Pump Station (Cont.)

Item	Prod. Rate	Prod. Index	Work Hrs/Day	UOM	Quantity	Crews (EA)	Duration (Hrs.)	Duration (Days)
Discharge Pipelines								
Clearing and Grubbing	0.13	100%	10	ACRE	0.6	1	5.0	0.50
Trench Excavation	50.00	100%	10	CY	6,000	2	60.0	6.00
84" Steel Pipe	1.25	100%	10	LF	1,000	4	200.0	20.00
Concrete Outlet Structures								
Structural Excavation	25.00	100%	10	CY	365	1	14.6	1.46
Structural Concrete	5.00	100%	10	CY	109	1	21.8	2.18
Bedding Stone	30.00	100%	10	CY	138	1	4.6	0.46
Riprap Placement	28.00	100%	10	CY	415	1	14.8	1.48
Feeder Canal								
Clearing and Grubbing	0.13	100%	10	ACRE	0.3	1	2.1	0.21
In Water Excavation	33.00	100%	10	CY	2,100	3	21.2	2.12
Channel Excavation	180.00	100%	10	CY	40,000	3	74.1	7.41
Trash Rack	0.03	100%	10	EA	1	1	40.0	4.00
Fish Screen								
Clearing and Grubbing	0.13	100%	10	ACRE	0.4	1	2.8	0.28
Channel Excavation	180.00	100%	10	CY	5,539	2	15.4	1.54
Structural Excavation	33.00	100%	10	CY	292	1	8.8	0.88
Reinforced Concrete								
Concrete Foundations								
Concrete Forms	43.75	100%	10	SFC	730	2	8.3	0.83
Reinforcing Steel	0.07	100%	10	TON	41.5	6	96.2	9.62
Concrete Placement	50.00	100%	10	CY	514	1	10.3	1.03
Concrete Floor								
Concrete Forms	34.38	100%	10	SFC	348	2	5.1	0.51
Reinforcing Steel	0.07	100%	10	TON	23.5	6	54.5	5.45
Concrete Placement	23.13	100%	10	CY	210	1	9.1	0.91
Concrete Footings								
Concrete Forms	60.63	100%	10	SFC	2,220	2	18.3	1.83
Reinforcing Steel	0.07	100%	10	TON	28	6	71.6	7.16
Concrete Placement	18.75	100%	10	CY	349	1	18.6	1.86
Concrete Walls								
Concrete Forms	50.00	100%	10	SFC	944	2	9.4	0.94
Reinforcing Steel	0.09	100%	10	TON	47	6	82.6	8.26
Concrete Placement	15.00	100%	10	CY	575	1	38.3	3.83
Fish Screens and Deadplates	0.02	100%	10	EA	1	1	60.0	6.00
Structural Steel Supports	0.83	100%	10	TON	50	1	60.0	6.00
Screen Cleaners	0.02	100%	10	EA	1	1	50.0	5.00
Fish Return Pump	0.02	100%	10	EA	1	1	50.0	5.00
14" HDPE Pipe	27.50	100%	10	LF	2,400	2	43.6	4.36
18" HDPE Pipe	17.50	100%	10	LF	50	1	2.9	0.29
Demobilization	0.10	100%	10	DAY	15	1	150.0	15.00

Multiple Pumps with Conservation Measures Construction Durations

TITLE: Yellowstone River - Multiple Pumps with Conservation Measures
SUBJECT: Estimated Construction Durations
MADE BY: SKV
CHECKED BY:

JOB NO.:
DATE: 3/20/2016

Existing Intake Dam Removal

Item	Prod. Rate	Prod. Index	Work Hrs/Day	UOM	Quantity	Crews (EA)	Duration (Hrs.)	Duration (Days)
Mobilization	0.10	100%	10	DAY	15	1	150.0	15.00
Site Preparation								
Staging Areas								
Clearing and Grubbing	0.13	100%	10	ACRE	2.0	2	8.0	0.80
Fine Grading	250.00	100%	10	SY	9,680	2	19.4	1.94
Aggregate Base Course	675.00	100%	10	SY	4,840	2	3.6	0.36
Temporary Fencing	25.00	100%	10	LF	2,000	2	40.0	4.00
Access/Haul Roads								
Clearing and Grubbing	0.13	100%	10	ACRE	0.7	2	2.8	0.28
Fine Grading	250.00	100%	10	SY	3,388	2	6.8	0.68
Aggregate Base Course	675.00	100%	10	SY	3,388	2	2.5	0.25
Erosion Control								
Silt Fence	43.75	100%	10	LF	3,000	2	34.3	3.43
Jute Mesh	300.00	100%	10	SY	5,000	2	8.3	0.83
Cofferdam - Phase 1								
Sheet Pile Cofferdam	69.13	100%	10	SF	35,800	2	259.0	25.90
Earthen Cofferdam								
Excavate at Borrow Site	130.00	100%	10	CY	6,636	2	25.5	2.55
Cycle Haul from Borrow Site	53.10	100%	10	CY	6,636	4	31.2	3.12
Place and Compact Embankment	240.00	100%	10	CY	6,636	1	27.7	2.77
Bedding Stone								
Place Bedding	30.00	100%	10	CY	556	2	9.3	0.93
Riprap Placement								
Place Riprap	25.00	100%	10	CY	1,416	2	28.3	2.83
Cofferdam - Phase 2								
Sheet Pile Cofferdam	69.13	100%	10	SF	56,800	2	410.8	41.08
Dam Removal								
Rock Removal	10.50	100%	10	CY	45,168	8	537.7	53.77
Rock Load and Haul	157.00	100%	10	CY	45,168	1	287.7	28.77
Timber Decking Removal	27.50	100%	10	SF	38,500	4	350.0	35.00
Timber Cribbing Removal	100.00	100%	10	LF	6,864	1	68.6	6.86
Timber Pile Demolition	75.00	100%	10	VLF	2,024	1	27.0	2.70
Misc. Material Load and Haul	78.00	100%	10	CY	1,200	1	15.4	1.54
Demobilization	0.10	100%	10	DAY	7	1	70.0	7.00

TITLE: Yellowstone River - Multiple Pumps with Conservation Measures
SUBJECT: Estimated Construction Durations
MADE BY: SKV
CHECKED BY:

JOB NO.:
DATE: 3/20/2016

Convert Laterals to Pipe

Item	Prod. Rate	Prod. Index	Work Hrs/Day	UOM	Quantity	Crews (EA)	Duration (Hrs.)	Duration (Days)
Mobilization	0.10	100%	10	DAY	15	1	150.0	15.00
Convert Laterals to Pipe								
Staging Areas								
Clearing and Grubbing	0.13	100%	10	ACRE	33.5	3	89.3	8.93
Fine Grading	250.00	100%	10	SY	162,140	4	162.1	16.21
Aggregate Base Course	675.00	100%	10	SY	81,070	2	60.1	6.01
Temporary Fencing	25.00	100%	10	LF	10,800	4	108.0	10.80
18" Pipe Laterals								
Fine Grading	250.00	100%	10	SY	1,226	1	4.9	0.49
Aggregate Base Course	104.38	100%	10	CY	235	1	2.3	0.23
18" RCP	16.50	100%	10	LF	3,678	2	111.5	11.15
Backfill	132.50	100%	10	CY	1,410	1	10.6	1.06
24" Pipe Laterals								
Fine Grading	250.00	100%	10	SY	18,910	2	37.8	3.78
Aggregate Base Course	104.38	100%	10	CY	2,718	2	13.0	1.30
24" RCP	12.50	100%	10	LF	42,547	8	425.5	42.55
Backfill	132.50	100%	10	CY	13,591	2	51.3	5.13
36" Pipe Laterals								
Fine Grading	250.00	100%	10	SY	97,987	3	130.6	13.06
Aggregate Base Course	104.38	100%	10	CY	15,025	3	48.0	4.80
36" RCP	9.00	100%	10	LF	176,376	12	1633.1	163.31
Backfill	132.50	100%	10	CY	105,172	3	264.6	26.46
48" Pipe Laterals								
Fine Grading	250.00	100%	10	SY	87,770	3	117.0	11.70
Aggregate Base Course	104.38	100%	10	CY	12,016	3	38.4	3.84
48" RCP	8.00	100%	10	LF	112,847	12	1175.5	117.55
Backfill	132.50	100%	10	CY	101,137	3	254.4	25.44
60" Pipe Laterals								
Fine Grading	250.00	100%	10	SY	51,107	3	68.1	6.81
Aggregate Base Course	104.38	100%	10	CY	7,619	3	24.3	2.43
60" RCP	6.00	100%	10	LF	51,107	12	709.8	70.98
Backfill	132.50	100%	10	CY	65,303	3	164.3	16.43
72" Pipe Laterals								
Fine Grading	250.00	100%	10	SY	7,593	2	15.2	1.52
Aggregate Base Course	104.38	100%	10	CY	1,164	2	5.6	0.56
60" RCP	6.00	100%	10	LF	6,834	8	142.4	14.24
Backfill	132.50	100%	10	CY	8,732	2	33.0	3.30
Line Remaining Laterals								
Earthwork	181.25	100%	10	SY	63,822	2	176.1	17.61
Geomembrane	8.13	100%	10	MSF	603	1	74.2	7.42
Shotcrete Placement	337.50	100%	10	SF	574,398	4	425.5	42.55

Line Open Canals

Item	Prod. Rate	Prod. Index	Work Hrs/Day	UOM	Quantity	Crews (EA)	Duration (Hrs.)	Duration (Days)
Mobilization	0.10	100%	10	DAY	30	1	300.0	30.00
Staging Areas								
Clearing and Grubbing	0.13	100%	10	ACRE	14.0	1	112.0	11.20
Fine Grading	250.00	100%	10	SY	67,760	2	135.5	13.55
Aggregate Base Course	675.00	100%	10	SY	33,880	1	50.2	5.02
Temporary Fencing	25.00	100%	10	LF	17,500	4	175.0	17.50
Access Roads								
Clearing and Grubbing	0.13	100%	10	ACRE	9.6	1	76.8	7.68
Fine Grading	250.00	100%	10	SY	46,667	2	93.3	9.33
Aggregate Base Course	675.00	100%	10	SY	23,334	1	34.6	3.46
Fill Canal								
Borrow Fill Excavate and Load	130.00	100%	10	CY	2,763,567	12	1771.5	177.15
Cycle Haul From Borrow Site	157.00	100%	10	CY	2,763,567	12	1466.9	146.69
Place and Compact Fill	224.00	100%	10	CY	2,763,567	12	1028.1	102.81
Line Main Canal								
Shape Embankments	181.25	100%	10	SY	2,413,817	6	2219.6	221.96
Geomembrane	8.13	100%	10	MSF	22,811	6	467.9	46.79
Shotcrete Placement	337.50	100%	10	SF	21,724,353	6	10728.1	1072.81

Durations per Typical Check Structure

Item	Prod. Rate	Prod. Index	Work Hrs/Day	UOM	Quantity	Crews (EA)	Duration (Hrs.)	Duration (Days)
Earthwork								
Structural Excavation	14.50	100%	10	CY	25	1	1.7	0.17
Structural Backfill	56.88	100%	10	CY	29	1	0.5	0.05
Reinforced Concrete								
Concrete Forms	49.38	100%	10	SFC	900	1	18.2	1.82
Reinforcing Steel	0.09	100%	10	TON	3.4	1	36.2	3.62
Concrete Placing	15.00	100%	10	CY	50	1	3.3	0.33
Remaining Check Structure Items								
Hydraulic Gates and Controllers	0.01	100%	10	EA	1	1	80.0	8.00
Riprap Placement	28.00	100%	10	CY	50	1	1.8	0.18

Flow Measuring Devices per 1-ea

Item	Prod. Rate	Prod. Index	Work Hrs/Day	UOM	Quantity	Crews (EA)	Duration (Hrs.)	Duration (Days)
Lateral Turnouts at Main Canal								
Cipolletti Weir								
Excavation	9.00	100%	10	CY	9	1	1.0	0.10
Reinforced Concrete Placement	4.00	100%	10	CY	4.5	1	1.1	0.11
Backfill	9.00	100%	10	CY	9	1	1.0	0.10
Parshall Flume								
Excavation	9.00	100%	10	CY	28	1	3.1	0.31
Reinforced Concrete Placement	8.28	100%	10	CY	27.9	1	3.4	0.34
Backfill	9.00	100%	10	CY	28	1	3.1	0.31
Sublateral Turnouts								
Cipolletti Weir								
Excavation	8.00	100%	10	CY	8	1	1.0	0.10
Reinforced Concrete Placement	4.00	100%	10	CY	8.0	1	2.0	0.20
Backfill	8.00	100%	10	CY	8	1	1.0	0.10
Parshall Flume								
Excavation	10.60	100%	10	CY	40	1	3.7	0.37
Reinforced Concrete Placement	8.28	100%	10	CY	19.8	1	2.4	0.24
Backfill	19.80	100%	10	CY	40	1	2.0	0.20

Attachment B.7
MCACES Construction Cost Estimate Summaries

Rock Ramp MCACES Summary

Lower Yellowstone Project, Montana

Estimated by CENWO-ED-C
Designed by Omaha District COE
Prepared by Gary Norenberg
Preparation Date 4/13/2011
Effective Date of Pricing 4/13/2011
Estimated Construction Time Days

Description	Quantity	UOM	ContractCost	ProjectCost	CostOverride
Project Cost Summary Report			**55,409,363**	**55,409,363**	
Rock Ramp Options	**1.00**	**LS**	**55,409,363**	**55,409,363**	
Coffer Dam Alternatives	**1.00**	**LS**	**3,850,361**	**3,850,361**	
3 Partial Coffer Dam Alternative	**1.00**	**LS**	**3,850,361**	**3,850,361**	
Crest Structure Alternatives	**1.00**	**LS**	**8,268,256**	**8,268,256**	
1 Concrete Crest Structure	**1.00**	**LS**	**8,268,256**	**8,268,256**	
Rock Ramp Alternatives	**1.00**	**LS**	**42,351,677**	**42,351,677**	
1 Original Design Rock Ramp	**1.00**	**LS**	**42,351,677**	**42,351,677**	
Project Costs	**1.00**	**LS**	**939,069**	**939,069**	
All Remaining Work	**1.00**	**LS**	**939,069**	**939,069**	

Bypass Channel MCACES Summary

Lower Yellowstone Project, Montana

Added Markups:

Contingencies from CSRA, 80% confidence - 28%

Escalation from TPCS

-Construction - 1.6%

-E&D, S&A - 2.9%

Estimated by CENWO-ED-C

Designed by Omaha & Portland Districts, COEÐ'A

Prepared by Gary Norenberg

Preparation Date 3/13/2015

Effective Date of Pricing 2/17/2015

Estimated Construction Time 720 Days

Description	Quantity	UOM	ContractCost	ProjectCost	CostOverride
Project Cost Summary Report			**48,487,112**	**48,487,112**	
Selected Plan - 15% Diversion Channel	**1.00**	**LS**	**48,487,112**	**48,487,112**	
1 Construction Costs	**1.00**	**LS**	**48,487,112**	**48,487,112**	
CWWBS 09 01 Bypass Channel	**1.00**	**LS**	**17,707,099**	**17,707,099**	
CWWBS 15 Intake Weir	**1.00**	**LS**	**12,065,928**	**12,065,928**	
CWWBS 16 Bank Stabilization Rock	**1.00**	**LS**	**18,714,085**	**18,714,085**	

Modified Side Channel MCACES Summary

Estimated by	Tetra Tech, Inc.
Designed by	Tetra Tech, Inc.
Prepared by	Tetra Tech, Inc
Preparation Date	5/19/2016
Effective Date of Pricing	5/19/2016
Estimated Construction Time	435 Days

Description	Quantity	UOM	ContractCost	ProjectCost	CostOverride
Project Cost Summary Report			**35,180,547**	**35,180,547**	
Yellowstone River - Modified Side Channel Alternative	**1.00**	**LS**	**35,180,547**	**35,180,547**	
08 Roads, Railroads and Bridges	**1.00**	**LS**	**1,041,844**	**1,041,844**	
08 01 Bridge	**1.00**	**LS**	**1,041,844**	**1,041,844**	
09 Channels and Canals	**1.00**	**LS**	**16,702,882**	**16,702,882**	
09 01 Channels	**1.00**	**LS**	**16,702,882**	**16,702,882**	
16 Bank Stabilization	**1.00**	**LS**	**17,435,821**	**17,435,821**	
16 01 Channel Armoring	**1.00**	**LS**	**17,435,821**	**17,435,821**	

Multiple Pump MCACES Summary

Estimated by	Tetra Tech, Inc.
Designed by	Tetra Tech, Inc.
Prepared by	Tetra Tech, Inc
Preparation Date	5/19/2016
Effective Date of Pricing	5/19/2016
Estimated Construction Time	800 Days

Description	Quantity	UOM	ContractCost	ProjectCost	CostOverride
Project Cost Summary Report			**84,277,276**	**84,277,276**	
Yellowstone River - Multiple Pump Alternative	**1.00**	**LS**	**84,277,276**	**84,277,276**	
04 Dams	**1.00**	**LS**	**6,599,764**	**6,599,764**	
04 01 Existing Timber Dam Removal	**1.00**	**LS**	**6,599,764**	**6,599,764**	
			15,535,502.33	*15,535,502.33*	
19 Buildings, Grounds & Utilities	**5.00**	**EA**	**77,677,512**	**77,677,512**	
			10,483,659.19	*10,483,659.19*	
19 01 Pump Station - Site 1	**1.00**	**EA**	**10,483,659**	**10,483,659**	
			12,650,555.78	*12,650,555.78*	
19 02 Pump Station - Site 2	**1.00**	**EA**	**12,650,556**	**12,650,556**	
			22,012,550.11	*22,012,550.11*	
19 03 Pump Station - Site 3	**1.00**	**EA**	**22,012,550**	**22,012,550**	
			17,835,852.83	*17,835,852.83*	
19 04 Pump Station - Site 4	**1.00**	**EA**	**17,835,853**	**17,835,853**	
			14,694,893.73	*14,694,893.73*	
19 05 Pump Station - Site 5	**1.00**	**EA**	**14,694,894**	**14,694,894**	

Multiple Pumps with Conservation Measures MCACES Summary

Estimated by	Tetra Tech, Inc.
Designed by	Tetra Tech, Inc.
Prepared by	Tetra Tech, Inc
Preparation Date	5/19/2016
Effective Date of Pricing	5/19/2016
Estimated Construction Time	2,750 Days

Description	Quantity	UOM	ContractCost	ProjectCost	CostOverride
Project Cost Summary Report			**313,059,999**	**313,059,999**	
Yellowstone River - Multiple Pumps with Conservation Measures Alternative	**1.00**	**LS**	**313,059,999**	**313,059,999**	
04 Dams	**1.00**	**LS**	**7,036,521**	**7,036,521**	
04 01 Existing Timber Dam Removal	**1.00**	**LS**	**7,036,521**	**7,036,521**	
09 Channels and Canals	**1.00**	**LS**	**195,852,565**	**195,852,565**	
09 02 Convert Laterals From Ditches to Pipe	**1.00**	**LS**	**62,146,232**	**62,146,232**	
09 03 Line Open Canals	**1.00**	**LS**	**130,070,099**	**130,070,099**	
09 04 Check Structures	**1.00**	**LS**	**2,648,406**	**2,648,406**	
09 05 Flow Measuring Devices	**1.00**	**LS**	**987,828**	**987,828**	
19 Buildings, Grounds and Utilities	**1.00**	**LS**	**18,702,727**	**18,702,727**	
19 01 Convert Fields From Flood Irrigation to Sprinklers	**1.00**	**LS**	**15,118,390**	**15,118,390**	
19 02 Renewable Energy Resources	**1.00**	**LS**	**3,584,337**	**3,584,337**	
20 Permanent Operating Equipment	**1.00**	**LS**	**91,468,186**	**91,468,186**	
20 01 Ranney Wells	**1.00**	**LS**	**91,468,186**	**91,468,186**	

Attachment B.8
Operations, Maintenance & Repair Cost Estimates

No Action OM&R Costs

NO ACTION ALTERNATIVE - ANNUAL O&M ASSUMPTIONS

No.	O&M Item Description	Cost Value		Assumptions/Notes
Main Canal, Laterals, Drains				
1	Main Canal, Laterals, Drains	$	1,875,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
Headworks				
2	Sediment Removal	$	10,000.00	Cost estimate fron 2015 EA
3	Daily Operations	$	77,000.00	Cost estimate from 2015 Operation Expenses. James Brower Email to David Trimpe on April 13, 2016. (Problem with Draft EIS O&M Numbers). Costs include: Daily gate adjustments, power costs, backup generator costs and debris/tree removal from screens.
4	Fish Screen Manifolds	$	2,040,000.00	$170,000 per unit - 12 fish screens - Expected Service life is 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
5	Fish Screen Cylinder Units	$	1,200,000.00	$50,000 per unit - 2 units per screen - 12 screens - Expected Service Life 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
6	Fish Screen External Brushes	$	240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
7	Fish Screen Internal Brushes	$	240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
8	Fish Screen Seal System	$	120,000.00	$10,000 per unit - 1 Unit per screen - 12 Screens - Expected Service Life 10 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
Diversion Dam				
9	Diversion Dam Maintenance	$	77,000.00	Average cost over the last 3 years (2013, 2014, 2015) and 2012 Rocking Event. James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures)) It is considered resonable and prudent that the LYP would not replace the existing diversion dam. They would just continue to rock. The blue book is a guide developed for financial purposes; it is helpful information that we are taking into consideration along with LYP's real world experience with these features and equipment to identify estimates based on best available information.
Rocking Structure				
10	Trolley Rehab	$	150,000.00	Replacement at 7 years and not again during the 50 years. The south rocking tower was replaced in the 1990s for approximately $35,000. This number represents replacement of both towers. Also considered is the inflation of costs since the 90's.
11	Cable Replacement	$	127,000.00	Assumes 1 replacement every 50 years. Shawn Higley Email to David Trimpe April 25, 2016 (SWR Enquiry).
Pumps				
12	Existing Pumps	$	235,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
Admin. Costs				
13	Administrative/Indirect Costs	$	61,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
ESA Monitoring Costs				
14	Passage and Entrainment Monitoring	$	400,000.00	Per David Trimpe BOR. Current Monitoring Costs. It is resonable to assume that Reclamation would be required to monitor for at least the first 8 Years.

Discount Rate (2016):	3.125%	
Net Present Value of O&M:	$	66,419,873
Average Annual O&M:	$	2,643,043
Cost Per Acre (56,799):	$	46.53

NO ACTION ALTERNATIVE - ESTIMATED O&M COSTS BY YEAR

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	O&M Annual Total	Discount Factor	Discounted O&M
0	End of Construction														$ -	1.0000	$ -
1	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000	$ 400,000	$ 2,735,000	0.9697	$ 2,652,121
2	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000	$ 400,000	$ 2,735,000	0.9403	$ 2,571,754
3	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000	$ 400,000	$ 2,735,000	0.9118	$ 2,493,822
4	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000	$ 400,000	$ 2,735,000	0.8842	$ 2,418,252
5	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 77,000			$ 235,000	$ 61,000	$ 400,000	$ 3,215,000	0.8574	$ 2,756,520
6	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000	$ 400,000	$ 2,735,000	0.8314	$ 2,273,912
7	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000	$ 150,000	$ 127,000	$ 235,000	$ 61,000	$ 400,000	$ 3,012,000	0.8062	$ 2,428,327
8	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000	$ 400,000	$ 2,735,000	0.7818	$ 2,138,187
9	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.7581	$ 1,770,155
10	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 77,000			$ 235,000	$ 61,000		$ 2,935,000	0.7351	$ 2,157,588
11	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.7128	$ 1,664,498
12	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.6912	$ 1,614,059
13	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.6703	$ 1,565,148
14	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.6500	$ 1,517,719
15	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 77,000			$ 235,000	$ 61,000		$ 2,815,000	0.6303	$ 1,774,267
16	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.6112	$ 1,427,130
17	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.5927	$ 1,383,884
18	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.5747	$ 1,341,948
19	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.5573	$ 1,301,283
20	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 77,000			$ 235,000	$ 61,000		$ 2,935,000	0.5404	$ 1,586,094
21	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.5240	$ 1,223,612
22	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.5082	$ 1,186,533
23	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.4928	$ 1,150,577
24	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.4778	$ 1,115,711
25	$ 1,875,000	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000		$ 77,000			$ 235,000	$ 61,000		$ 6,055,000	0.4633	$ 2,805,531
26	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.4493	$ 1,049,117
27	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.4357	$ 1,017,325
28	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.4225	$ 986,497
29	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.4097	$ 956,604
30	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 77,000			$ 235,000	$ 61,000		$ 2,935,000	0.3973	$ 1,165,975
31	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.3852	$ 899,506
32	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.3736	$ 872,248
33	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.3622	$ 845,817
34	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.3513	$ 820,186
35	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 77,000			$ 235,000	$ 61,000		$ 2,815,000	0.3406	$ 958,826
36	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.3303	$ 771,231
37	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.3203	$ 747,860
38	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.3106	$ 725,198
39	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.3012	$ 703,222
40	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 77,000			$ 235,000	$ 61,000		$ 2,935,000	0.2920	$ 857,136
41	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.2832	$ 661,248
42	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.2746	$ 641,210
43	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.2663	$ 621,780
44	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.2582	$ 602,938
45	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 77,000			$ 235,000	$ 61,000		$ 2,815,000	0.2504	$ 704,856
46	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.2428	$ 566,950
47	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.2354	$ 549,770
48	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.2283	$ 533,110
49	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 235,000	$ 61,000		$ 2,335,000	0.2214	$ 516,955
50	$ 1,875,000	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000	$ 120,000	$ 77,000			$ 235,000	$ 61,000		$ 6,175,000	0.2147	$ 1,325,681
Total Cost:	$ 47,118,893	$ 251,301	$ 1,935,016	$ 1,383,174	$ 813,632	$ 1,133,172	$ 1,133,172	$ 261,542	$ 1,935,016	$ 120,933	$ 102,390	$ 5,905,568	$ 1,532,935	$ 2,793,130		Net Present Value:	$ 66,419,873
Annual Cost:	$ 1,875,000	$ 10,000	$ 77,000	$ 55,041	$ 32,377	$ 45,092	$ 45,092	$ 10,408	$ 77,000	$ 4,812	$ 4,074	$ 235,000	$ 61,000	$ 111,147		Average Annual:	$2,643,043

Rock Ramp OM&R Costs

ROCK RAMP ALTERNATIVE - ANNUAL O&M ASSUMPTIONS

No.	O&M Item Description	Cost Value	Assumptions/Notes
Main Canal, Laterals, Drains			
1	Main Canal, Laterals, Drains	$ 1,875,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
Headworks			
2	Sediment Removal	$ 10,000.00	Cost estimate fron 2015 EA
3	Daily Operations	$ 77,000.00	Cost estimate from 2015 Operation Expenses. James Brower Email to David Trimpe on April 13, 2016. (Problem with Draft EIS O&M Numbers). Costs include: Daily gate adjustments, power costs, backup generator costs and debris/tree removal from screens.
4	Fish Screen Manifolds	$ 2,040,000.00	$170,000 per unit - 12 fish screens - Expected Service life is 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
5	Fish Screen Cylinder Units	$ 1,200,000.00	$50,000 per unit - 2 units per screen - 12 screens - Expected Service Life 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
6	Fish Screen External Brushes	$ 240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
7	Fish Screen Internal Brushes	$ 240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
8	Fish Screen Seal System	$ 120,000.00	$10,000 per unit - 1 Unit per screen - 12 Screens - Expected Service Life 10 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
Diversion Dam			
9	Diversion Dam Maintenance	$ 10,000.00	Estimate from 2015 EA
Rock Ramp			
10	Minor Rock Repairs	$ 128,000.00	Estimate from 2015 EA
11	Place Rock (Major Repair)	$ 250,000.00	Every 10 years, assumes 5% riprap placed (TT Estimate)
12	Coffer Dam (Major Repair)	$ 1,000,000.00	Every 10 years, coffer off section of river (TT Estimate)
13	Barge Cost (Major Repair)	$ 100,000.00	Every 10 Years (TT Estimate)
Pumps			
14	Existing Pumps	$ 235,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
Admin. Costs			
15	Administrative/Indirect Costs	$ 61,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
ESA Monitoring Costs			
16	Passage and Entrainment Monitoring	$ 500,000.00	Per David Trimpe BOR. Anticipated costs for entrainment and passage monitoring. Approximately $200,000 each. Hydrologic criteria monitoring would be another $100,000. It is resonable to assume that Reclamation would be required to monitor for at least the first 8 Years.

Discount Rate (2016)	3.125%
Net Present Value of O&M	$ 71,370,121
Average Annual O&M	$ 2,840,028
Cost Per Acre (56,799 acres)	$ 50.00

ROCK RAMP ALTERNATIVE - ESTIMATED O&M COSTS BY YEAR

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	O&M Annual Total	Discount Factor	Discounted O&M
0								End of Construction									$ -	1.000	$ -
1	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000	$ 500,000	$ 2,896,000	0.970	$ 2,808,242
2	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000	$ 500,000	$ 2,896,000	0.940	$ 2,723,144
3	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000	$ 500,000	$ 2,896,000	0.912	$ 2,640,625
4	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000	$ 500,000	$ 2,896,000	0.884	$ 2,560,606
5	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 10,000	$ 128,000				$ 235,000	$ 61,000	$ 500,000	$ 3,376,000	0.857	$ 2,894,560
6	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000	$ 500,000	$ 2,896,000	0.831	$ 2,407,769
7	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000	$ 500,000	$ 2,896,000	0.806	$ 2,334,806
8	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000	$ 500,000	$ 2,896,000	0.782	$ 2,264,054
9	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.758	$ 1,816,399
10	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 10,000	$ 128,000	$ 250,000	$ 1,000,000	$ 100,000	$ 235,000	$ 61,000		$ 4,346,000	0.735	$ 3,194,847
11	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.713	$ 1,707,982
12	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.691	$ 1,656,225
13	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.670	$ 1,606,036
14	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.650	$ 1,557,368
15	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,876,000	0.630	$ 1,812,715
16	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.611	$ 1,464,413
17	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.593	$ 1,420,036
18	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.575	$ 1,377,005
19	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.557	$ 1,335,278
20	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 10,000	$ 128,000	$ 250,000	$ 1,000,000	$ 100,000	$ 235,000	$ 61,000		$ 4,346,000	0.540	$ 2,348,608
21	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.524	$ 1,255,578
22	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.508	$ 1,217,530
23	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.493	$ 1,180,635
24	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.478	$ 1,144,858
25	$ 1,875,000	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000		$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 6,116,000	0.463	$ 2,833,795
26	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.449	$ 1,076,524
27	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.436	$ 1,043,902
28	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.422	$ 1,012,269
29	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.410	$ 981,594
30	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 10,000	$ 128,000	$ 250,000	$ 1,000,000	$ 100,000	$ 235,000	$ 61,000		$ 4,346,000	0.397	$ 1,726,517
31	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.385	$ 923,005
32	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.374	$ 895,035
33	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.362	$ 867,913
34	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.351	$ 841,612
35	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,876,000	0.341	$ 979,603
36	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.330	$ 791,378
37	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.320	$ 767,397
38	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.311	$ 744,143
39	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.301	$ 721,593
40	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 10,000	$ 128,000	$ 250,000	$ 1,000,000	$ 100,000	$ 235,000	$ 61,000		$ 4,346,000	0.292	$ 1,269,203
41	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.283	$ 678,523
42	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.275	$ 657,961
43	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.266	$ 638,023
44	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.258	$ 618,689
45	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,876,000	0.250	$ 720,130
46	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.243	$ 581,761
47	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.235	$ 564,132
48	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.228	$ 547,037
49	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000	$ 128,000				$ 235,000	$ 61,000		$ 2,396,000	0.221	$ 530,460
50	$ 1,875,000	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000	$ 120,000	$ 10,000	$ 128,000	$ 250,000	$ 1,000,000	$ 100,000	$ 235,000	$ 61,000		$ 7,586,000	0.215	$ 1,628,601
Total Cost:	$ 47,118,893	$ 251,301	$ 1,935,016	$ 1,383,174	$ 813,632	$ 1,133,172	$ 1,133,172	$ 261,542	$ 251,301	$ 3,216,650	$ 544,880	$ 2,179,521	$ 217,952	$ 5,905,568	$ 1,532,935	$ 3,491,412		Net Present Value:	$ 71,370,121
Annual Cost:	$1,875,000	$10,000	$77,000	$55,041	$32,377	$45,092	$45,092	$10,408	$10,000	$128,000	$21,682	$86,730	$8,673	$235,000	$61,000	$138,934		Average Annual:	$2,840,028

Bypass Channel OM&R Costs

BYPASS CHANNEL ALTERNATIVE - ANNUAL O&M ASSUMPTIONS

No.	O&M Item Description	Cost Value	Assumptions/Notes
Main Canal, Laterals, Drains			
1	Main Canal, Laterals, Drains	$ 1,875,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
Headworks			
2	Sediment Removal	$ 10,000.00	Cost estimate fron 2015 EA
3	Daily Operations	$ 77,000.00	Cost estimate from 2015 Operation Expenses. James Brower Email to David Trimpe on April 13, 2016. (Problem with Draft EIS O&M Numbers). Costs include: Daily gate adjustments, power costs, backup generator costs and debris/tree removal from screens.
4	Fish Screen Manifolds	$ 2,040,000.00	$170,000 per unit - 12 fish screens - Expected Service life is 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
5	Fish Screen Cylinder Units	$ 1,200,000.00	$50,000 per unit - 2 units per screen - 12 screens - Expected Service Life 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
6	Fish Screen External Brushes	$ 240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
7	Fish Screen Internal Brushes	$ 240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
8	Fish Screen Seal System	$ 120,000.00	$10,000 per unit - 1 Unit per screen - 12 Screens - Expected Service Life 10 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
Diversion Dam			
9	Diversion Dam Maintenance	$ 10,000.00	Estimate from 2015 EA
10	Rock Replacement (Major Repair)	$ 100,000.00	Every 5 Years - This cost is assuming a routine amont of scour behind new diversion structure. Already spending 77,000 for rock costs under no action.
11	Barge Cost (Major Repair)	$ 100,000.00	Every 5 Years - This cost is assuming a routine amont of scour behind new diversion structure
Bypass Channel			
12	Bypass Channel (Minor Repairs)	$ 57,000.00	Cost Estimate from 2015 EA. This includes minor repairs and riprap replacement in bypass channel
13	Coffer Dam (Major Repairs)	$ 500,000.00	Every 10 years (TT Estimate)
14	Riprap Repairs (Major Repairs)	$ 400,000.00	Assumes 2.5% Replacement every 10 Years
15	Channel Repairs	$ 150,000.00	Assumes 1% of excavation every 5 years
16	Bypass Channel Inspection	$ 3,000.00	$1,500 per inspection - twice a year. Lower cost than modified side channel because they bypass channel is much shorter.
Pumps			
17	Existing Pumps	$ 235,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
Admin. Costs			
18	Administrative/Indirect Costs	$ 61,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
ESA Monitoring Costs			
19	Passage and Entrainment Monitoring	$ 500,000.00	Per David Trimpe BOR. Anticipated costs for entrainment and passage monitoring. Approximately $200,000 each. Hydrologic criteria monitoring would be another $100,000. It is resonable to assume that Reclamation would be required to monitor for at least the first 8 Years.

Discount Rate (2016)	3.125%
Net Present Value of O&M	$ 70,333,034
Average Annual O&M	$ 2,798,759
Cost Per Acre (56,799 acres)	$ 49.27

BYPASS CHANNEL ALTERNATIVE - ESTIMATED O&M COSTS BY YEAR

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	O&M Annual Total	Discount Factor	Discounted O&M
0	End of Construction																			$ -	1.0000	$ -
1	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000	$ 500,000	$ 2,828,000.00	0.9697	$ 2,742,303
2	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000	$ 500,000	$ 2,828,000.00	0.9403	$ 2,659,203
3	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000	$ 500,000	$ 2,828,000.00	0.9118	$ 2,578,621
4	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000	$ 500,000	$ 2,828,000.00	0.8842	$ 2,500,481
5	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 10,000	$ 100,000	$ 100,000	$ 57,000			$ 150,000	$ 3,000	$ 235,000	$ 61,000	$ 500,000	$ 3,658,000.00	0.8574	$ 3,136,345
6	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000	$ 500,000	$ 2,828,000.00	0.8314	$ 2,351,233
7	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000	$ 500,000	$ 2,828,000.00	0.8062	$ 2,279,983
8	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000	$ 500,000	$ 2,828,000.00	0.7818	$ 2,210,893
9	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.7581	$ 1,764,848
10	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 10,000	$ 100,000	$ 100,000	$ 57,000	$ 500,000	$ 400,000	$ 150,000	$ 3,000	$ 235,000	$ 61,000		$ 4,178,000.00	0.7351	$ 3,071,347
11	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.7128	$ 1,659,508
12	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.6912	$ 1,609,220
13	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.6703	$ 1,560,456
14	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.6500	$ 1,513,169
15	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 10,000	$ 100,000	$ 100,000	$ 57,000			$ 150,000	$ 3,000	$ 235,000	$ 61,000		$ 3,158,000.00	0.6303	$ 1,990,457
16	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.6112	$ 1,422,852
17	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.5927	$ 1,379,735
18	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.5747	$ 1,337,925
19	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.5573	$ 1,297,382
20	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 10,000	$ 100,000	$ 100,000	$ 57,000	$ 500,000	$ 400,000	$ 150,000	$ 3,000	$ 235,000	$ 61,000		$ 4,178,000.00	0.5404	$ 2,257,819
21	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.5240	$ 1,219,944
22	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.5082	$ 1,182,976
23	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.4928	$ 1,147,128
24	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.4778	$ 1,112,366
25	$ 1,875,000	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000		$ 10,000	$ 100,000	$ 100,000	$ 57,000			$ 150,000	$ 3,000	$ 235,000	$ 61,000		$ 6,398,000.00	0.4633	$ 2,964,457
26	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.4493	$ 1,045,972
27	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.4357	$ 1,014,276
28	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.4225	$ 983,540
29	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.4097	$ 953,736
30	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 10,000	$ 100,000	$ 100,000	$ 57,000	$ 500,000	$ 400,000	$ 150,000	$ 3,000	$ 235,000	$ 61,000		$ 4,178,000.00	0.3973	$ 1,659,776
31	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.3852	$ 896,809
32	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.3736	$ 869,633
33	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.3622	$ 843,281
34	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.3513	$ 817,727
35	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 10,000	$ 100,000	$ 100,000	$ 57,000			$ 150,000	$ 3,000	$ 235,000	$ 61,000		$ 3,158,000.00	0.3406	$ 1,075,656
36	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.3303	$ 768,919
37	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.3203	$ 745,618
38	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.3106	$ 723,024
39	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.3012	$ 701,114
40	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 10,000	$ 100,000	$ 100,000	$ 57,000	$ 500,000	$ 400,000	$ 150,000	$ 3,000	$ 235,000	$ 61,000		$ 4,178,000.00	0.2920	$ 1,220,141
41	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.2832	$ 659,266
42	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.2746	$ 639,288
43	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.2663	$ 619,916
44	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.2582	$ 601,130
45	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 10,000	$ 100,000	$ 100,000	$ 57,000			$ 150,000	$ 3,000	$ 235,000	$ 61,000		$ 3,158,000.00	0.2504	$ 790,740
46	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.2428	$ 565,250
47	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.2354	$ 548,121
48	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.2283	$ 531,512
49	$ 1,875,000	$ 10,000	$ 77,000						$ 10,000			$ 57,000				$ 3,000	$ 235,000	$ 61,000		$ 2,328,000.00	0.2214	$ 515,405
50	$ 1,875,000	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000	$ 120,000	$ 10,000	$ 100,000	$ 100,000	$ 57,000	$ 500,000	$ 400,000	$ 150,000	$ 3,000	$ 235,000	$ 61,000		$ 7,418,000.00	0.2147	$ 1,592,534
Total Cost:	$ 47,118,893	$ 251,301	$ 1,935,016	$ 1,383,174	$ 813,632	$ 1,133,172	$ 1,133,172	$ 261,542	$ 251,301	$ 472,155	$ 472,155	$ 1,432,414	$ 1,089,760	$ 871,808	$ 708,233	$ 75,390	$ 5,905,568	$ 1,532,935	$ 3,491,412		Net Present Value:	$ 70,333,034
Annual Cost:	$ 1,875,000	$ 10,000	$ 77,000	$ 55,041	$ 32,377	$ 45,092	$ 45,092	$ 10,408	$ 10,000	$ 18,788	$ 18,788	$ 57,000	$ 43,365	$ 34,692	$ 28,183	$ 3,000	$ 235,000	$ 61,000	$ 138,934		Average Annual:	$ 2,798,759

Modified Side Channel OM&R Costs

MODIFIED SIDE CHANNEL ALTERNATIVE - ANNUAL O&M ASSUMPTIONS

No.	O&M Item Description	Cost Value	Assumptions/Notes
		Main Canal, Laterals, Drains	
1	Main Canal, Laterals, Drains	$ 1,875,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
		Headworks	
2	Sediment Removal	$ 10,000.00	Cost estimate fron 2015 EA
3	Daily Operations	$ 77,000.00	Cost estimate from 2015 Operation Expenses. James Brower Email to David Trimpe on April 13, 2016. (Problem with Draft EIS O&M Numbers). Costs include: Daily gate adjustments, power costs, backup generator costs and debris/tree removal from screens.
4	Fish Screen Manifolds	$ 2,040,000.00	$170,000 per unit - 12 fish screens - Expected Service life is 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
5	Fish Screen Cylinder Units	$ 1,200,000.00	$50,000 per unit - 2 units per screen - 12 screens - Expected Service Life 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
6	Fish Screen External Brushes	$ 240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
7	Fish Screen Internal Brushes	$ 240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
8	Fish Screen Seal System	$ 120,000.00	$10,000 per unit - 1 Unit per screen - 12 Screens - Expected Service Life 10 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
		Diversion Dam	
9	Diversion Dam Maintenance	$ 77,000.00	Average cost over the last 3 years (2013, 2014, 2015) and 2012 Rocking Event. James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures)) It is considered resonable and prudent that the LYP would not replace the existing diversion dam. They would just continue to rock. The blue book is a guide developed for financial purposes; it is helpful information that we are taking into consideration along with LYP's real world experience with these features and equipment to identify estimates based on best available information.
		Rocking Structure	
10	Trolley Rehab	$ 150,000.00	Replacement at 7 years and not again in 50. The south rocking tower was replaced in the 1990s for approximately $35,000. This number represents replacement of both towers and cable. Also considered is the inflation of costs since the 90's.
11	Cable Replacement	$ 127,000.00	Assumes 1 replacement every 50 years. Shawn Higley Email to David Trimpe April 25, 2016 (SWR Enquiry)
		Modified Channel	
12	Minor Channel Repairs	$ 100,000.00	This includes minor repairs and riprap replacement in the modified Channel. Slightly higher than the bypass channel because of additional length. Accounts for modifications needed for Boxelder Creek and runoff from county road 303.
13	Coffer Dam (Major Repair)	$ 500,000.00	Every 10 years (TT Estimate)
14	Riprap (Major Repair)	$ 450,000.00	Assumes 2.5% Replacement every 10 Years (TT estimate)
15	Channel Excavation (Major Repair)	$ 125,000.00	Assumes 1% of excavation every 5 years (TT estimate).
16	Channel Inspection	$ 5,000.00	$2,500 per inspection - twice a year. Higher cost than the bypass channel because this channel is much longer (TT estimate).
		Bridge Maintenance	
17	Bridge Maintenance	$ 25,000.00	Assumes 2.5% per year (TT estimate)
		Pumps	
18	Existing Pumps	$ 235,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
		Admin. Costs	
19	Administrative/Indirect Costs	$ 61,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
		ESA Monitoring Costs	
20	Passage and Entrainment Monitoring	$ 500,000.00	Per David Trimpe BOR. Anticipated costs for entrainment and passage monitoring. Approximately $200,000 each. Hydrologic criteria monitoring would be another $100,000. It is resonable to assume that Reclamation would be required to monitor for at least the first 8 Years.

Discount Rate (2016)	3.125%
Net Present Value of O&M	$ 73,045,804
Average Annual O&M	$ 2,906,708
Cost Per Acre (56,799 acres)	$ 51.18

MODIFIED SIDE CHANNEL ALTERNATIVE - ESTIMATED O&M COSTS BY YEAR

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	O&M Annual Total	Discount Factor	Discounted O&M
0	End of Construction																				$ -	1.0000	$ -
1	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000	$ 500,000	$ 2,965,000	0.9697	$ 2,875,152
2	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000	$ 500,000	$ 2,965,000	0.9403	$ 2,788,026
3	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000	$ 500,000	$ 2,965,000	0.9118	$ 2,703,540
4	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000	$ 500,000	$ 2,965,000	0.8842	$ 2,621,615
5	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 77,000			$ 100,000			$ 125,000	$ 5,000	$ 25,000	$ 235,000	$ 61,000	$ 500,000	$ 3,570,000	0.8574	$ 3,060,895
6	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000	$ 500,000	$ 2,965,000	0.8314	$ 2,465,136
7	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000	$ 150,000	$ 127,000	$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000	$ 500,000	$ 3,242,000	0.8062	$ 2,613,757
8	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000	$ 500,000	$ 2,965,000	0.7818	$ 2,317,998
9	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.7581	$ 1,868,707
10	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 77,000			$ 100,000	$ 500,000	$ 450,000	$ 125,000	$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 4,140,000	0.7351	$ 3,043,412
11	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.7128	$ 1,757,168
12	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.6912	$ 1,703,921
13	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.6703	$ 1,652,287
14	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.6500	$ 1,602,217
15	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 77,000			$ 100,000			$ 125,000	$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 3,070,000	0.6303	$ 1,934,991
16	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.6112	$ 1,506,585
17	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.5927	$ 1,460,931
18	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.5747	$ 1,416,660
19	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.5573	$ 1,373,731
20	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 77,000			$ 100,000	$ 500,000	$ 450,000	$ 125,000	$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 4,140,000	0.5404	$ 2,237,284
21	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.5240	$ 1,291,736
22	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.5082	$ 1,252,592
23	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.4928	$ 1,214,635
24	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.4778	$ 1,177,828
25	$ 1,875,000	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000		$ 77,000			$ 100,000			$ 125,000	$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 6,310,000	0.4633	$ 2,923,683
26	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.4493	$ 1,107,526
27	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.4357	$ 1,073,965
28	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.4225	$ 1,041,420
29	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.4097	$ 1,009,862
30	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 77,000			$ 100,000	$ 500,000	$ 450,000	$ 125,000	$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 4,140,000	0.3973	$ 1,644,680
31	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.3852	$ 949,586
32	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.3736	$ 920,810
33	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.3622	$ 892,907
34	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.3513	$ 865,849
35	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 77,000			$ 100,000			$ 125,000	$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 3,070,000	0.3406	$ 1,045,682
36	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.3303	$ 814,169
37	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.3203	$ 789,497
38	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.3106	$ 765,573
39	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.3012	$ 742,373
40	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 77,000			$ 100,000	$ 500,000	$ 450,000	$ 125,000	$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 4,140,000	0.2920	$ 1,209,043
41	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.2832	$ 698,063
42	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.2746	$ 676,909
43	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.2663	$ 656,397
44	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.2582	$ 636,506
45	$ 1,875,000	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 77,000			$ 100,000			$ 125,000	$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 3,070,000	0.2504	$ 768,706
46	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.2428	$ 598,515
47	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.2354	$ 580,378
48	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.2283	$ 562,791
49	$ 1,875,000	$ 10,000	$ 77,000						$ 77,000			$ 100,000				$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 2,465,000	0.2214	$ 545,736
50	$ 1,875,000	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000	$ 120,000	$ 77,000			$ 100,000	$ 500,000	$ 450,000	$ 125,000	$ 5,000	$ 25,000	$ 235,000	$ 61,000		$ 7,380,000	0.2147	$ 1,584,376
Total Cost:	$ 47,118,893	$ 251,301	$ 1,935,016	$ 1,383,174	$ 813,632	$ 1,133,172	$ 1,133,172	$ 261,542	$ 1,935,016	$ 120,933	$ 102,390	$ 2,513,008	$ 1,089,760	$ 980,784	$ 590,194	$ 125,650	$ 628,252	$ 5,905,568	$ 1,532,935	$ 3,491,412		Net Present Value:	$ 73,045,804
Annual Cost:	$1,875,000	$10,000	$77,000	$55,041	$32,377	$45,092	$45,092	$10,408	$77,000	$4,812	$4,074	$100,000	$43,365	$39,028	$23,486	$5,000	$25,000	$235,000	$61,000	$138,934		Average Annual:	$ 2,906,708

MULTIPLE PUMP STATIONS ALTERNATIVE - ANNUAL O&M ASSUMPTIONS

No.	O&M Item Description	Cost Value	Assumptions/Notes
		Main Canal, Laterals, Drains	
1	Main Canal, Laterals, Drains	$ 1,875,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
2	Sediment Removal	$ -	We do not anticipate a significant increase in sediment accumulation in the main canal and laterals as a result of this alternative. Water would be supplied from the Pump Stations only during the low-river-flow periods and should have comparatively low sediment loads. During high-river-flow periods when sediment loads are higher, water would be supplied only from the upstream end, which would not represent a change from the existing condition and is not expected to increase sedimentation.
		Headworks	
3	Sediment Removal	$ 10,000.00	Cost estimate fron 2015 EA
4	Daily Operations	$ 77,000.00	Cost estimate from 2015 Operation Expenses. James Brower Email to David Trimpe on April 13, 2016. (Problem with Draft EIS O&M Numbers). Costs include: Daily gate adjustments, power costs, backup generator costs and debris/tree removal from screens.
5	Fish Screen Manifolds	$ 2,040,000.00	$170,000 per unit - 12 fish screens - Expected Service life is 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
6	Fish Screen Cylinder Units	$ 1,200,000.00	$50,000 per unit - 2 units per screen - 12 screens - Expected Service Life 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
7	Fish Screen External Brushes	$ 240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
8	Fish Screen Internal Brushes	$ 240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
9	Fish Screen Seal System	$ 120,000.00	$10,000 per unit - 1 Unit per screen - 12 Screens - Expected Service Life 10 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
		Pumps	
10	Lateral Pumps	$ 50,000.00	Small Lateral Pumps (TT estimate) Lateral AA through FF
11	Large Pumps Rehab	$ 2,000,000.00	Rehab of 1 pump at each pumping facility is $100,000, four pumps per stations, five pumping stations. Rehab of individual pump every 4 years. Based on BRID #1 (assumes turbine pumps not submersible)
12	Large Pump Motors Rehab	$ 100,000.00	Estimate $5k per year, per motor (average)
13	Large Pumps Replacement	$ 4,400,000.00	Once at 35 years - Based on Reclamation and WAPA Blue Book - Life expectancy of structures and experience with life expectancy of LYP existing pumps. Estimate pump cost at $220,000 each.
14	Large Pump Motor Replacement	$ 4,400,000.00	Once at 50 years - Based on Reclamation and WAPA Blue Book - Life expectancy of structures and experience with life expectancy of LYP existing motors. Estimate motor cost at $220,000 each.
15	Pump House Maintenance	$ 10,000.00	Per Year - Tetra Tech Estimate
16	Pump and Motor Removal and Install	$ 200,000.00	Assumes 5 pumps would be pulled and replaced each year at 10,000 per pump. Pull and replace each pump every 4 years. (Assumes no gantry at each pump station)
17	Control Panel and Electronics	$ 5,000.00	Assume $1000/yr per site, average across all years.
18	Man Power to Maintain and Operate Pump sites	$ 240,000.00	4 workers at $60,000 per worker. Oversite and Operation during irrigation season - Maintenance activites on pumps during the off season
19	Vehicle	$ 64,152.00	Mileage - 54 cents by 180 miles by 165 Days by 4 vehicles. (Government Rate by Mileage by length of irrigation season by 4 people) (4th Person is night shift)
20	Power Costs	$ 163,317.00	Using Pick-Sloan rates, includes upfront capacity charge of $6,546,687.50 in year 1 plus $163,317 per year over duration of project.
21	Service discharge pipes and valves	$ 400,000.00	Estimate a 25 year life on gate and check valves, with a replacement cost of $10,000 each. Total: 40 valves @ $10,000 = $400,000 at 25 years and at 50 years.
22	Existing Pumps	$ 235,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
		Inlet Channel and Fish Screens	
23	Fish Screens	$ 20,000.00	Need to include service life for screen cleaning device (TT Help) How are ice concerns addressed? If its still removing screens we need to account for this cost. Also if screens are removed every year need to account for spring calibration (adjusting baffles ie flow velocity) Maintain fish screen cleaners every 5 years (1 site every year) at $20,000, based on costs for existing screen system. Screen cleaner replacement included in next line item.
24	Fish Screen and Cleaner Replacement	$ 6,904,000.00	Expected life 25 years for screens and cleaners - Assuming the same as headworks screen life.
25	Dewatering and Sediment Removal from Fish Screens	$ 150,000.00	Annual Cost - sediment removal, stop log removal and replacement, crane costs.
26	Sediment Removal from Feeder Canal	$ 300,000.00	Annual Cost - 2,800 cy ever year per pumping station. $60,000 per pumping station
27	Trash Rack Cleaning - Manual	$ 48,600.00	Assume manually cleaned every 2 weeks while in operation, 2 people for 8 hours at each site. Estimate $48,600 per year for 2 half-time staff for 6 months per year, using same rate as for ditch riders.
28	Bank Stabilization	$ 66,000.00	Every 5 Years - a total of 6,000-ft to be placed over 50-yrs (Previous estimate of 5000-ft was increased by 20% to include the ice protection berms)
		Admin. Costs	
29	Administrative/Indirect Costs	$ 61,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
		ESA Monitoring Costs	
30	Passage and Entrainment Monitoring	$ 1,000,000.00	Per David Trimpe BOR. Anticipated costs for entrainment monitoring and pump bypass channel monitoring at 5 sites. Also monitoring would be required at existing headworks. 8 Years consistent with all alternatives.

Discount Rate (2016)	3.125%
Net Present Value of O&M	$ 124,394,601
Average Annual O&M	$ 4,950,029
Cost Per Acre (56,799 acres)	$ 87.15

Multiple Pump OM&R Costs

MULTIPLE PUMP STATIONS ALTERNATIVE - ESTIMATED O&M COSTS BY YEAR

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0															End of Construction
1	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
2	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
3	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
4	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
5	$ 1,875,000	$ -	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 50,000		$ 100,000			$ 10,000
6	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
7	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
8	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
9	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
10	$ 1,875,000	$ -	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 50,000		$ 100,000			$ 10,000
11	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
12	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
13	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
14	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
15	$ 1,875,000	$ -	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 50,000		$ 100,000			$ 10,000
16	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
17	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
18	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
19	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
20	$ 1,875,000	$ -	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
21	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
22	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
23	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
24	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
25	$ 1,875,000	$ -	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000		$ 50,000		$ 100,000			$ 10,000
26	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
27	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
28	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
29	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
30	$ 1,875,000	$ -	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 50,000		$ 100,000			$ 10,000
31	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
32	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
33	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
34	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
35	$ 1,875,000	$ -	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 50,000		$ 100,000	$ 4,400,000		$ 10,000
36	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
37	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
38	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
39	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
40	$ 1,875,000	$ -	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
41	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
42	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
43	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
44	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
45	$ 1,875,000	$ -	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 50,000		$ 100,000			$ 10,000
46	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
47	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
48	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000	$ 2,000,000	$ 100,000			$ 10,000
49	$ 1,875,000	$ -	$ 10,000	$ 77,000						$ 50,000		$ 100,000			$ 10,000
50	$ 1,875,000	$ -	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000	$ 120,000	$ 50,000		$ 100,000		$ 4,400,000	$ 10,000
Total Cost:	$ 47,118,893	$ -	$ 251,301	$ 1,935,016	$ 1,383,174	$ 813,632	$ 1,133,172	$ 1,133,172	$ 261,542	$ 1,256,504	$ 11,783,070	$ 2,513,008	$ 1,498,698	$ 944,614	$ 251,301
Annual Cost:	$1,875,000	$0	$10,000	$77,000	$55,041	$32,377	$45,092	$45,092	$10,408	$50,000	$468,883	$100,000	$59,638	$37,589	$10,000

Year	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	O&M Annual Total	Discount Factor	Discounted O&M
0																$ -	1.0000	$ -
1		$ 5,000	$ 240,000	$ 64,152	$ 6,710,005		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000	$ 1,000,000	$ 10,955,757	0.9697	$ 10,623,764
2		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000	$ 1,000,000	$ 4,409,069	0.9403	$ 4,145,901
3		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000	$ 1,000,000	$ 4,409,069	0.9118	$ 4,020,268
4	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000	$ 1,000,000	$ 6,609,069	0.8842	$ 5,843,653
5		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600	$ 66,000	$ 61,000	$ 1,000,000	$ 4,955,069	0.8574	$ 4,248,444
6		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000	$ 1,000,000	$ 4,409,069	0.8314	$ 3,665,752
7		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000	$ 1,000,000	$ 4,409,069	0.8062	$ 3,554,669
8	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000	$ 1,000,000	$ 6,609,069	0.7818	$ 5,166,883
9		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.7581	$ 2,584,402
10		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600	$ 66,000	$ 61,000		$ 4,075,069	0.7351	$ 2,995,680
11		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.7128	$ 2,430,145
12	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 5,609,069	0.6912	$ 3,877,245
13		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.6703	$ 2,285,095
14		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.6500	$ 2,215,850
15		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600	$ 66,000	$ 61,000		$ 3,955,069	0.6303	$ 2,492,841
16	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 5,609,069	0.6112	$ 3,428,210
17		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.5927	$ 2,020,452
18		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.5747	$ 1,959,226
19		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.5573	$ 1,899,855
20	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600	$ 66,000	$ 61,000		$ 6,275,069	0.5404	$ 3,391,090
21		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.5240	$ 1,786,457
22		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.5082	$ 1,732,322
23		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.4928	$ 1,679,827
24	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 5,609,069	0.4778	$ 2,680,129
25		$ 5,000	$ 240,000	$ 64,152	$ 163,317	$ 400,000	$ 235,000	$ 20,000	$ 6,904,000	$ 150,000	$ 300,000	$ 48,600	$ 66,000	$ 61,000		$ 14,499,069	0.4633	$ 6,718,017
26		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.4493	$ 1,531,697
27		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.4357	$ 1,485,282
28	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 5,609,069	0.4225	$ 2,369,735
29		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.4097	$ 1,396,629
30		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600	$ 66,000	$ 61,000		$ 4,075,069	0.3973	$ 1,618,885
31		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.3852	$ 1,313,267
32	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 5,609,069	0.3736	$ 2,095,289
33		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.3622	$ 1,234,881
34		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.3513	$ 1,197,460
35		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600	$ 66,000	$ 61,000		$ 8,355,069	0.3406	$ 2,845,846
36	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 5,609,069	0.3303	$ 1,852,628
37		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.3203	$ 1,091,866
38		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.3106	$ 1,058,779
39		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.3012	$ 1,026,695
40	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600	$ 66,000	$ 61,000		$ 6,275,069	0.2920	$ 1,832,568
41		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.2832	$ 965,414
42		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.2746	$ 936,159
43		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.2663	$ 907,790
44	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 5,609,069	0.2582	$ 1,448,360
45		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600	$ 66,000	$ 61,000		$ 3,955,069	0.2504	$ 990,321
46		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.2428	$ 827,739
47		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.2354	$ 802,656
48	$ 200,000	$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 5,609,069	0.2283	$ 1,280,621
49		$ 5,000	$ 240,000	$ 64,152	$ 163,317		$ 235,000	$ 20,000		$ 150,000	$ 300,000	$ 48,600		$ 61,000		$ 3,409,069	0.2214	$ 754,747
50		$ 5,000	$ 240,000	$ 64,152	$ 163,317	$ 400,000	$ 235,000	$ 20,000	$ 6,904,000	$ 150,000	$ 300,000	$ 48,600	$ 66,000	$ 61,000		$ 19,019,069	0.2147	$ 4,083,111
Total Cost:	$ 1,178,307	$ 125,650	$ 6,031,218	$ 1,612,145	$ 10,452,472	$ 271,211	$ 5,905,568	$ 502,602	$ 4,681,094	$ 3,769,511	$ 7,539,023	$ 1,221,322	$ 311,622	$ 1,532,935	$ 6,982,824		Net Present Value:	$ 124,394,601
Annual Cost:	$46,888	$5,000	$240,000	$64,152	$415,935	$10,792	$235,000	$20,000	$186,275	$150,000	$300,000	$48,600	$12,400	$61,000	$277,867		Average Annual:	$ 4,950,029

Multiple Pumps with Conservation Measures OM&R Costs

MULTIPLE PUMPS WITH CONSERVATION MEASURES ALTERNATIVE - ANNUAL O&M ASSUMPTIONS

No.	O&M Item Description	Cost Value	Assumptions/Notes
Main Canal, Laterals, Drains			
1	Main Canal, Laterals, Drains	$ 980,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
2	Sediment Removal	$ -	We do not anticipate a significant increase in sediment accumulation in the main canal and laterals as a result of this alternative. Water supplied from the Ranney Wells is groundwater and should be relatively sediment-free. Water supplied by gravity feed is from the upstream end, the same as it is currently and should not result in an increase.
Conservation Measures			
3	Additional Ditch Riders	$ 583,200.00	12 Ditch Riders at $48,600 per year (6 months working)--assumes a SCADA system implemented. Without SCADA # of ditch rides may double
4	Vehicles	$ 129,600.00	20000 miles per season by .54, per employee
5	Piped Laterals	$ 750,000.00	Replace Approximately 5000 lf every 15 years
6	Lined Lateral	$ 100,000.00	Replace Approximately 1000 lf every 10 years
7	Lined Open Canals	$ 825,000.00	Replace Approximately 2500 lf every 10 years
8	Remove Sediment and inspect check structures	$ 45,000.00	Assumes $5,000 per check structure every year. 9 Check structures in total
9	Flow Measuring devices inspection and sediment removal	$ 30,000.00	$250 per device per year. 120 devices
10	Operate and Maintain Center Pivots	$ 300,000.00	$60 per acre on 5,000 acres. NDSU Cost (This needs to be pulled out. Cannot be spread across the entire district. O&M costs would be bore by the individual users. Note: This cost isn't included in the cost calculations on this sheet, to the right.)
11	Wind Turbine Maintenance	$ 50,000.00	Windustry.com - Would Start after 5 years
12	O&M of SCADA System and Flow Measuring Devices	$ 105,000.00	Estimate $15k per site annually for maintenance and replacement
13	Technicians for SCADA System	$ 120,000.00	2 Technicians - 60,000 per year (Work all year round)
14	Transportation	$ 32,400.00	30,000 miles per employee by 2 emplyees by .54 cents
Headworks			
15	Sediment Removal	$ 10,000.00	Cost estimate fron 2015 EA
16	Daily Operations	$ 77,000.00	Cost estimate from 2015 Operation Expenses. James Brower Email to David Trimpe on April 13, 2016. (Problem with Draft EIS O&M Numbers). Costs include: Daily gate adjustments, power costs, backup generator costs and debris/tree removal from screens.
17	Fish Screen Manifolds	$ 2,040,000.00	$170,000 per unit - 12 fish screens - Expected Service life is 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
18	Fish Screen Cylinder Units	$ 1,200,000.00	$50,000 per unit - 2 units per screen - 12 screens - Expected Service Life 25 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
19	Fish Screen External Brushes	$ 240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
20	Fish Screen Internal Brushes	$ 240,000.00	$10,000 per unit - 2 units per screen - 12 screens - Expected Service Life 5 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
21	Fish Screen Seal System	$ 120,000.00	$10,000 per unit - 1 Unit per screen - 12 Screens - Expected Service Life 10 years. Information Obtained from ISI. Jim Forseth Email to David Trimpe April 21, 2016 (Schedule of Values)
Pumps			
22	Lateral Pumps	$ 50,000.00	Small Lateral Pumps (TT estimate) Laterals AA - FF
23	Ranney Well Pumps Rehab	$ 2,100,000.00	Pump rehab every 10 years @ $50,000 per pump, or $2,100,000 for 42 pumps
24	Ranney Well Pump Motors Rehab	$ 126,000.00	Estimate average $3,000 per pump per year
25	Ranney Well Pump Replacement	$ 6,300,000.00	Replace pumps every 35 years @ $150,000 per pump
26	Ranney Well Pump Motor Replacement	$ 6,300,000.00	Replace motors every 50 years @ $150,000 per pump
27	Pump and Motor Removal and Install	$ 42,000.00	Rough estimate per Layne Construction: Remove pumps and motors and inspect every 5-10 years @ $5-10k each. Assume average annual cost of $1,000 per well or $42,000 per year total.
28	Inspection and Maintenance of Ranney Well Screens	$ 672,000.00	Rough estimate per Layne Construction: Inspect each well every 7 years at $7500, maintain wells every 15 years at $100-250k. Layne recommends assuming $16,000 per well annually. 42 Ranney Wells @ $16,000 per year per well = $672000 / year
29	Control Panel and Electronics	$ 7,000.00	Assume $1000 per site per year, average across all years.
30	Man Power to Maintain and Operate Pump sites	$ 240,000.00	4 workers at $60,000 per worker. Oversite and Operation during irrigation season - Maintenance activites on pumps during the off season
31	Vehicle	$ 64,152.00	Mileage - 54 cents by 180 miles by 165 Days by 4 vehicles. (Government Rate by Mileage by length of irrigation season by 4 people) (4th Person is night shift)
32	Power Costs	$ 67,914.00	Using Pick-Sloan rates, includes upfront capacity charge of $5,508,644.73.50 in year 1 plus $67,914 per year over first 5 years until wind generation is complete
33	Service discharge pipes and valves	$ 252,000.00	Estimate a 25 year life on gate and check valves, with a replacement cost of $3,000 each. Total: 84 valves @ $3,000 = $252,000 at 25 years and at 50 years.
34	Existing Pumps	$ 235,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
Admin Costs			
35	Administrative/Indirect Costs	$ 61,000.00	Average cost over the last 3 years (2013, 2014, 2015). James Brower Email to David Trimpe on March 17, 2016 (Attached District OM Numbers High Priority Questions/Information (Conservation Measures))
ESA Monitoring Costs			
36	Passage and Entrainment Monitoring	$ 200,000.00	Per David Trimpe BOR. Anticipated costs for entrainment monitoring at the headworks.

Discount Rate (2016)	3.125%
Net Present Value of O&M	$ 114,768,141
Average Annual O&M	$ 4,566,963
Cost Per Acre (56,799 acres)	$ 80.41

MULTIPLE PUMPS WITH CONSERVATION MEASURES ALTERNATIVE - ESTIMATED O&M COSTS BY YEAR

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	O&M Annual Total	Discount Factor	Discounted O&M
0																		End of Construction																			$ -	1.0000	$ -
1	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -		$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152	$ 5,576,559		$ 235,000	$ 61,000	$ 200,000	$ 9,385,911	0.9697	$ 9,101,489
2	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -		$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152	$ 67,914		$ 235,000	$ 61,000	$ 200,000	$ 3,877,266	0.9403	$ 3,645,841
3	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -		$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152	$ 67,914		$ 235,000	$ 61,000	$ 200,000	$ 3,877,266	0.9118	$ 3,535,361
4	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -		$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152	$ 67,914		$ 235,000	$ 61,000	$ 200,000	$ 3,877,266	0.8842	$ 3,428,228
5	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152	$ 67,914		$ 235,000	$ 61,000	$ 200,000	$ 4,407,266	0.8574	$ 3,778,761
6	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000	$ 200,000	$ 3,859,352	0.8314	$ 3,208,711
7	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000	$ 200,000	$ 3,859,352	0.8062	$ 3,111,477
8	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000	$ 200,000	$ 3,859,352	0.7818	$ 3,017,190
9	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.7581	$ 2,774,141
10	$ 980,000	$ -	$ 583,200	$ 129,600		$ 100,000	$ 825,000	$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 50,000	$ 2,100,000	$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 7,284,352	0.7351	$ 5,354,899
11	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.7128	$ 2,608,559
12	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.6912	$ 2,529,511
13	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.6703	$ 2,452,860
14	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.6500	$ 2,378,531
15	$ 980,000	$ -	$ 583,200	$ 129,600	$ 750,000			$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 4,889,352	0.6303	$ 3,081,711
16	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.6112	$ 2,236,561
17	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.5927	$ 2,168,787
18	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.5747	$ 2,103,066
19	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.5573	$ 2,039,337
20	$ 980,000	$ -	$ 583,200	$ 129,600		$ 100,000	$ 825,000	$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 50,000	$ 2,100,000	$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 7,284,352	0.5404	$ 3,936,513
21	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.5240	$ 1,917,613
22	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.5082	$ 1,859,504
23	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.4928	$ 1,803,155
24	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.4778	$ 1,748,514
25	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000		$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152		$ 252,000	$ 235,000	$ 61,000		$ 7,631,352	0.4633	$ 3,535,920
26	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.4493	$ 1,644,149
27	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.4357	$ 1,594,326
28	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.4225	$ 1,546,013
29	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.4097	$ 1,499,165
30	$ 980,000	$ -	$ 583,200	$ 129,600	$ 750,000	$ 100,000	$ 825,000	$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 50,000	$ 2,100,000	$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 8,034,352	0.3973	$ 3,191,773
31	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.3852	$ 1,409,683
32	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.3736	$ 1,366,965
33	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.3622	$ 1,325,542
34	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.3513	$ 1,285,374
35	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 50,000		$ 126,000	$ 6,300,000		$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 10,439,352	0.3406	$ 3,555,780
36	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.3303	$ 1,208,653
37	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.3203	$ 1,172,027
38	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.3106	$ 1,136,511
39	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.3012	$ 1,102,071
40	$ 980,000	$ -	$ 583,200	$ 129,600		$ 100,000	$ 825,000	$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000			$ 240,000	$ 240,000	$ 120,000	$ 50,000	$ 2,100,000	$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 7,284,352	0.2920	$ 2,127,318
41	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.2832	$ 1,036,291
42	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.2746	$ 1,004,888
43	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.2663	$ 974,437
44	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.2582	$ 944,909
45	$ 980,000	$ -	$ 583,200	$ 129,600	$ 750,000			$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000			$ 240,000	$ 240,000		$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 4,889,352	0.2504	$ 1,224,258
46	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.2428	$ 888,509
47	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.2354	$ 861,585
48	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.2283	$ 835,476
49	$ 980,000	$ -	$ 583,200	$ 129,600				$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000						$ 50,000		$ 126,000			$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152			$ 235,000	$ 61,000		$ 3,659,352	0.2214	$ 810,159
50	$ 980,000	$ -	$ 583,200	$ 129,600		$ 100,000	$ 825,000	$ 45,000	$ 30,000	$ -	$ 50,000	$ 105,000	$ 120,000	$ 32,400	$ 10,000	$ 77,000	$ 2,040,000	$ 1,200,000	$ 240,000	$ 240,000	$ 120,000	$ 50,000	$ 2,100,000	$ 126,000		$ 6,300,000	$ 42,000	$ 672,000	$ 7,000	$ 240,000	$ 64,152		$ 252,000	$ 235,000	$ 61,000		$ 17,076,352	0.2147	$ 3,666,038
Total Cost:	$ 24,627,475	$ -	$ 14,655,861	$ 3,256,858	$ 958,462	$ 217,952	$ 1,798,105	$ 1,130,853	$ 753,902	$ -	$ 1,071,203	$ 2,638,658	$ 3,015,609	$ 814,214	$ 251,301	$ 1,935,016	$ 1,383,174	$ 813,632	$ 1,133,172	$ 1,133,172	$ 261,542	$ 1,256,504	$ 4,576,994	$ 3,166,390	$ 2,145,863	$ 1,352,516	$ 1,055,463	$ 16,887,411	$ 175,911	$ 6,031,218	$ 1,612,145	$ 5,651,635	$ 170,863	$ 5,905,568	$ 1,532,935	$ 1,396,565		Net Present Value:	$ 114,768,141
Annual Cost:	$980,000	$0	$583,200	$129,600	$38,140	$8,673	$71,552	$45,000	$30,000	$0	$42,626	$105,000	$120,000	$32,400	$10,000	$77,000	$55,041	$32,377	$45,092	$45,092	$10,408	$50,000	$182,132	$126,000	$85,390	$53,821	$42,000	$672,000	$7,000	$240,000	$64,152	$224,895	$6,799	$235,000	$61,000	$55,573		Average Annual:	$ 4,566,963

Lower Yellowstone Intake Diversion Dam Fish Passage Project, Montana

FINAL - APPENDIX C

Lower Yellowstone Intake Fish Passage EIS Section 404(b)(1) Analysis

OCTOBER 2016

Contents

LIST OF TABLES

FIGURES

List of Acronyms and Terms

AAHUs – Average annual habitat units
Anthropogenic—Related to human activities
ARM—Administrative Rules of Montana
BRT – Biological Review Team
CEA—Cumulative Effects Assessment
CE/ICA – Cost effectiveness and incremental cost analysis
CFR—Code of Federal Regulations
cfs—cubic feet per second
CWA—Clean Water Act
dBA—A-weighted decibels; an expression of the relative loudness of sounds in air as perceived by the human ear
EA—Environmental Assessment
EPA— U.S. Environmental Protection Agency
ESA—Endangered Species Act
fps—feet per second
GIS—Geographic information system
HEC-RAS—Hydrologic Engineering Center River Analysis System
ITA—Indian trust assets
IWR – U.S. Army Corps of Engineers Institute for Water Resources
LYP—Lower Yellowstone Irrigation Project
MFWP—Montana Fish, Wildlife and Parks
MTDEQ—Montana Department of Environmental Quality
NHPA—National Historic Preservation Act
NRCS—Natural Resources Conservation Service
NRHP—National Register of Historic Places
O&M – Operation and maintenance
PED/CM – Planning, engineering and design/construction management
ppm—parts per million
Reclamation—Bureau of Reclamation
Service – U.S. Fish and Wildlife Service
SHPO— State Historic Preservation Office
TDS— Total dissolved solids
Corps—U.S. Army Corps of Engineers
USGS—U.S. Geological Survey
YRCDC—Yellowstone River Conservation District Council

1.0 Introduction

This Clean Water Act Section 404(b)(1) Analysis has been prepared to evaluate compliance with the Section 404(b)(1) Guidelines for the Lower Yellowstone Intake Diversion Dam Fish Passage Project.

Section 404 of the Clean Water Act (CWA) regulates the discharge of dredged and fill material into waters of the United States per 40 Code of Federal Regulations (CFR) Parts 230 and 232. The Yellowstone River is a navigable waterbody and a water of the U.S. Section 404(b)(1) requires that alternatives be considered that could avoid or minimize adverse impacts to aquatic resources and waters of the U.S. for any project that results in the discharge of dredged or fill material. This document evaluates the alternatives that have been considered and documents the potential effects on characteristics of the aquatic ecosystem.

The purpose of the proposed action is to improve fish passage for pallid sturgeon and other native fish at Intake Diversion Dam, continue the viable and effective operation of the Lower Yellowstone Project (LYP), and contribute to ecosystem restoration. The proposed project is located between the communities of Glendive and Sidney in Section 36, Township 18 North, Range 56 East in Dawson County, Montana (Figure 1-1).

The U.S. Army Corps of Engineers (Corps) and the U.S. Bureau of Reclamation (Reclamation) have prepared a Final Environmental Impact Statement (EIS) to analyze direct, indirect, and cumulative effects associated with alternative actions to improve fish passage at the Lower Yellowstone Intake Diversion Dam, in Dawson County, Montana.

1.1 BACKGROUND

The LYP was authorized by the Secretary of the Interior on May 10, 1904. Construction of the LYP began in 1905 and included Intake Diversion Dam, which is a wood and stone diversion weir that spans the Yellowstone River and diverts water into the main irrigation canal. The LYP was authorized to provide a dependable water supply sufficient to irrigate over 58,000 acres of land on the west bank of the Yellowstone River. Reclamation and the four irrigation districts that support the LYP hold unadjudicated water rights in the state of Montana totaling 1,374 cubic feet per second (cfs).

The U.S. Fish and Wildlife Service (Service) listed the pallid sturgeon as endangered under the Endangered Species Act (ESA) in 1990. The best available science suggests that Intake Diversion Dam impedes upstream migration of pallid sturgeon and their access to spawning and larval drift habitats. The lower Yellowstone River is considered by the Service to provide one of the best opportunities to contribute to recruitment and recovery of pallid sturgeon.

Section 7(a)(2) requires each Federal agency to consult on any action authorized, funded, or carried out by the agency to ensure it does not jeopardize the continued existence of any endangered or threatened species. The Revised Pallid Sturgeon Recovery Plan (USFWS 2014a) specifically identifies providing passage at Intake Diversion Dam as important to protect and restore pallid sturgeon populations. By improving passage at Intake Diversion Dam, approximately 165 river miles of potential spawning and larval drift habitat would become accessible in the Yellowstone River and additional miles in major tributaries such as the Powder River.

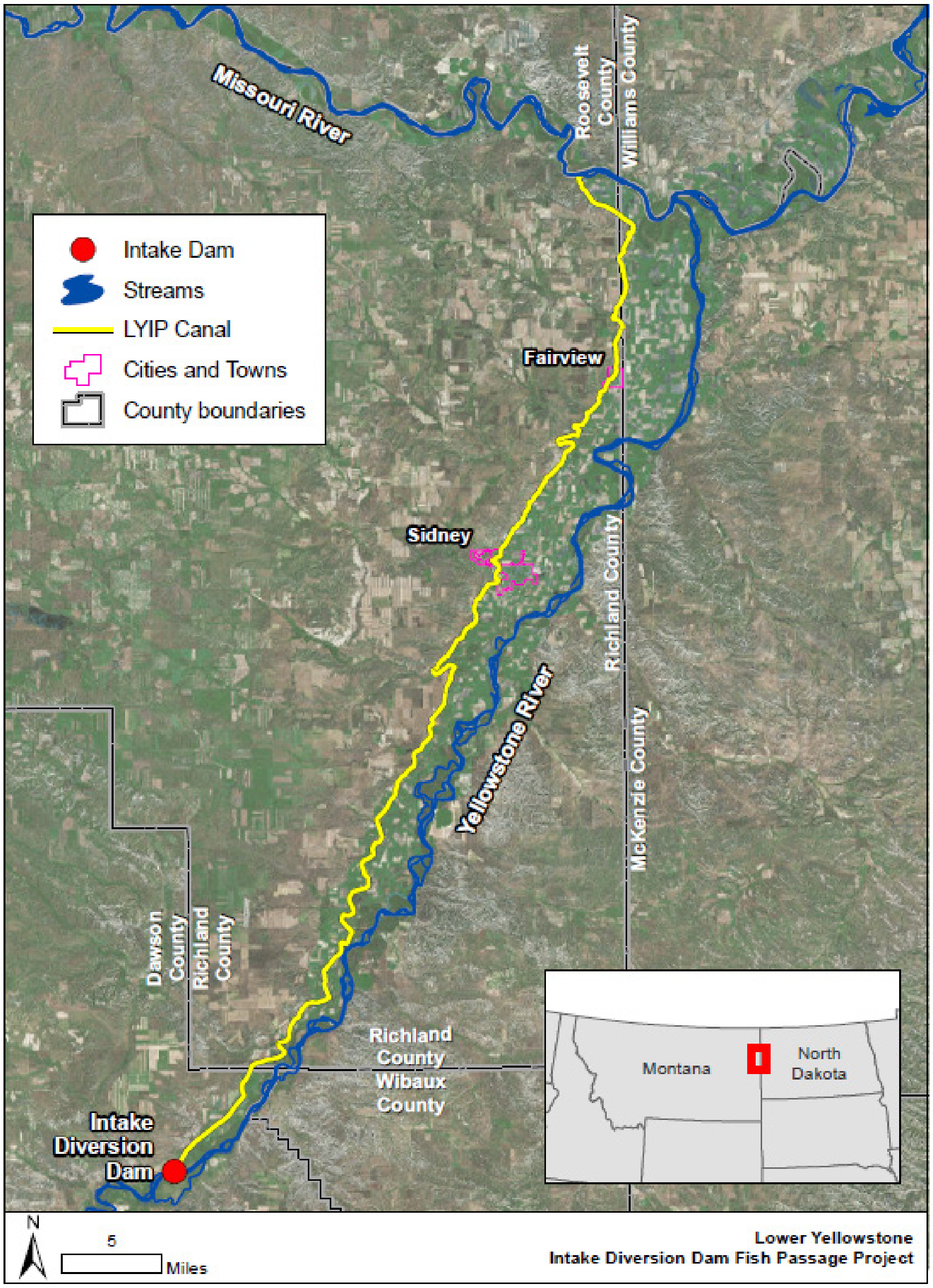

Figure 1.1 Overview of the Study Area

Section 3109 of the 2007 Water Resources Development Act authorized the Corps to use funding from the Missouri River Recovery and Mitigation Program to assist Reclamation in the design and construction of fish passage improvements at Intake Diversion Dam for the purpose of ecosystem restoration.

The Reclamation Act/Newlands Act of 1902 (Pub. L. 161) authorized Reclamation to construct and maintain the facilities associated with the LYP, which includes actions or modifications necessary to comply with Federal law such as the ESA.

1.2 PROBLEMS, OPPORTUNITIES, CONSTRAINTS AND OBJECTIVES

It is important to identify up front the planning goals, objectives, and constraints for the project in order to formulate a range of alternatives that can meet the goals and objectives. When identifying and evaluating alternatives it is also important to obtain input from Federal and state agencies, Tribes, cooperating entities, and the public.

This section summarizes the problems and opportunities assessed during the plan formulation process. The existing and expected future without-project conditions in the study area were evaluated using data and information from on-going research on pallid sturgeon being conducted by a variety of agencies and from information developed for the Missouri River Management Plan and overall pallid sturgeon recovery program. In the planning setting, a problem can be thought of as an undesirable condition, while the objective is the statement of overcoming the problem, and the opportunity is the means for overcoming that problem. Identification of problems and opportunities gives focus to the planning effort. Problems and opportunities can also be viewed as local and regional resource conditions that could be modified in response to public concerns.

1.2.1 Problems and Opportunities

1. *Intake Diversion Dam is a barrier to upstream fish passage.*

Intake Diversion Dam has impeded upstream migration of pallid sturgeon and other native fish for more than 100 years. The best available science suggests that the weir is likely a total barrier to the endangered pallid sturgeon, due to turbulence and high velocities at the existing weir and in the rock rubble field immediately downstream from the weir (Helfrich et al. 1999, White and Mefford 2002, Bramblett and White 2001, Fuller et al. 2008; Delonay et al. 2014). Opportunities exist for modifications to the existing weir and/or construction of a fish passage project that would provide the opportunity for pallid sturgeon and other fish species to pass upstream of the Intake Diversion Dam.

2. *Fish passage is only intermittently provided by the existing side channel.*

During high flows occurring in 2014 and 2015, seven wild adult pallid sturgeon utilized the existing side channel around Joe’s Island to successfully bypass the weir (Rugg 2014, 2015; Rugg et al. 2016). While this evidence suggests that pallid sturgeon can use this side channel to bypass the weir, the side channel only conveys flows when river flows exceed 20,000 cfs, which does not occur every year. Passage in 2014 and 2015 only occurred at flows greater than 40,000 cfs in the river, which is approaching a 2-year flood (50% probability of occurrence in any given year). Tracking of radio-tagged pallid sturgeon over several years indicates that pallid sturgeon migrate up to Intake Diversion Dam, but do not pass the weir and return downstream to spawn in the lower Yellowstone River, such as near river mile (RM) 10 (Delonay et al. 2014, 2015; Bramblett 1996; Allen et al. 2015, Elliott et al. 2015).

Modifying the existing side channel or existing weir or constructing another type of fishway would provide the opportunity for pallid sturgeon and other fish to pass upstream of Intake Diversion Dam on an annual basis.

3. *Larval drift distances are insufficient for survival when spawning occurs below the Intake Diversion Dam.*

If spawning occurs below Intake Diversion Dam, newly hatched pallid sturgeon (free embryos) likely drift into Lake Sakakawea before they are able to settle into suitable habitat. Biologists believe that like other river spawning species, pallid sturgeon need a river environment to survive (Braaten et al. 2008). The model developed by Kynard et al. (2007) indicates that total drift distance is a limitation on natural recruitment. If these young fish reach the lake environment, their survival rate is believed to be very low because of unsuitable habitat (Kynard et al. 2007). Recent research indicates oxygen levels and substrate conditions in the headwaters of reservoirs such as Fort Peck and Lake Sakakawea are unsuitable for free embryos or larval pallid sturgeon to survive (Guy et al. 2015; Bramblett & Scholl 2016).

Improvements to fish passage at Intake Diversion Dam would provide the opportunity for pallid sturgeon to spawn in potentially suitable habitats for up to 165 additional miles of the Yellowstone River upstream of the weir. The distance between the next upstream barrier on the Yellowstone River, Cartersville Diversion Dam, and Lake Sakakawea is about 258 miles. This substantial increase in free-flowing river habitat likely would provide adequate drift distance for at least a portion of the larvae to settle out into suitable rearing habitats prior to reaching Lake Sakakawea. Access to tributaries, such as the Tongue and Powder Rivers, would provide additional spawning habitat and could increase larval drift distance even further. Five wild adult pallid sturgeon were documented in the Powder River in 2014 and spawning appeared to have occurred (Rugg 2014).

1.2.2 Constraints and Other Considerations

1. *Provide water to the Lower Yellowstone Project through a viable and effective operation.*

Reclamation has contractual obligations to deliver the water right to continue viable and effective operation of the LYP. The Lower Yellowstone Irrigation Districts operate and maintain the irrigation system and will inherit that responsibility for any modifications, so consideration of long-term operation and maintenance costs and feasibility and the capabilities of the irrigation districts was a critical constraint during project formulation.

2. *Provide adequate passage to endangered pallid sturgeon through proper engineering.*

Any passageway recommended would be designed to meet physical and biological criteria developed by the Service's Biological Review Team (BRT) to maximize the potential for effective upstream passage of pallid sturgeon, including appropriate depths, velocities, and attraction flows.

1.2.3 Objectives

1. Improve Fish Passage

Since Intake Diversion Dam is an impediment to successful upstream and downstream movement of pallid sturgeon and other native fishes, modifications are needed to allow fish passage at this structure.

2. Continue Viable and Effective Operation of the Lower Yellowstone Project

The LYP diverts water from the Yellowstone River into the main irrigation canal on the north side of the river immediately upstream of the Intake Diversion Dam. The system conveys water to irrigate over 58,000 acres within the LYP. Water rights are jointly held by the districts and Reclamation. Any proposed modifications need to maintain the viable and effective operation of the LYP by meeting the full water right obligation to the irrigation districts in a manner that is affordable and sustainable over the long-term.

3. Ecosystem Restoration

Improvements to fish passage at Intake Diversion Dam will support migration for numerous fish species and contribute to the sustainability of fish populations in the Yellowstone River. This project will support ecosystem functions by restoring access to a large area of suitable habitat throughout the Lower Yellowstone River ecosystem.

1.3 DEVELOPMENT AND EVALUATION OF ALTERNATIVES

This section presents the plan formulation process used in the development and screening of alternatives to meet the project objectives. Alternatives screened out earlier in the study are described in the Lower Yellowstone Intake Diversion Dam Fish Passage Project EIS (Corps and Reclamation 2016).

1.3.1 No Action

Under the No Action Alternative, Reclamation would continue present operation of Intake Diversion Dam and headworks to divert water from the Yellowstone River for irrigation purposes, as authorized. Under this scenario, Reclamation would be obligated to reinitiate consultation with the Service under Section 7(a)(2) of the ESA, to evaluate the impacts to pallid sturgeon from the LYP. Continued O&M would include annual placement of rock on the existing weir crest and maintenance of the headworks, screens, irrigation canals, pipes, and pumps. In addition, the trolley system that is used to place rock on the weir crest will likely require repair or replacement in 5-10 years. The continued annual placement of rock on the existing weir crest would require a Section 10 permit under the Rivers and Harbors Act.

1.3.2 Rock Ramp Alternative

The Rock Ramp Alternative would leave the existing rock and timber crib structure at Intake Diversion Dam in place, but incorporate it into a replacement concrete weir and bury it under a shallow-sloped, un-grouted boulder and cobble rock ramp. The rock ramp would mimic natural riffles and cascades and would have reduced velocities compared to existing conditions so that migrating fish could swim up the ramp and pass over the weir, thereby improving fish passage.

The new concrete weir would be located approximately 28 feet upstream of the existing weir, and would be constructed to an elevation of 1991.0 feet. A low-flow notch would be constructed at an elevation of 1989 feet and would have an 85 foot bottom width and an approximately 125 foot top width to concentrate flows during low flows. The downstream side of the weir would tie directly into a low-flow channel in the rock ramp to provide a seamless transition and unimpeded fish passage as fish migrate upstream.

The rock ramp would be constructed downstream of the replacement weir by placing large rock and cobble over a length of 1,200 feet with a slope ranging from 0.2 to 0.7 percent with a deeper low-flow channel designed into the ramp that would connect to the low-flow notch on the concrete weir.

1.3.3 Bypass Channel Alternative

The Bypass Channel Alternative would construct a 11,150 foot long bypass channel with a slope of 0.07 percent on Joe's Island from the inlet of the existing side channel and rejoin the river just downstream of the rock rubble field below the existing weir. It would also leave the existing Intake Diversion Dam in place and incorporate it into the replacement concrete weir with rock/cobble fill placed upstream and downstream of the replacement weir. The replacement weir would be at the same average height of the existing weir, with rock placed on top, to continue providing sufficient head to divert the full water right through the headworks and screens. The replacement weir would include a low-flow notch at elevation 1889 feet. Construction work and the primary elements of this alternative would be located on Joe's Island and at the weir location. Additional features in this alternative include buried rock grade controls at the upstream and downstream ends of the bypass channel to maintain desired flow splits and channel elevations, placement of fill and grading along both the right and left banks at the downstream outlet to reduce the eddy that forms below the weir and to direct flows from the channel towards the main river channel, and two additional buried grade controls and bank armoring in select locations in the channel. The upper 1.5 miles of the existing side channel would be filled with the excavated material to ensure the appropriate flow volumes into the bypass channel when river flows are in the 30,000 to 63,000 cfs range. This alternative is designed to meet the Service's BRT criteria for flow volumes, depths, and velocities at all but the lowest flows in the river (Table 1-1).

Table 1.1Service's BRT Design Criteria for a Bypass Channel

Criteria	7,000 – 14,999 cfs	15,000 – 63,000 cfs
Bypass Channel Flow Split	≥12%	13% to ≥15%
Bypass Channel Cross-sectional Velocities (measured as mean column velocity)	2.0 – 6.0 ft/s	2.4 – 6.0 ft/s
Bypass Channel Depth (minimum cross-sectional depth for 30 contiguous feet at measured cross-section)	≥4.0 ft	≥6.0 ft
Bypass Channel Fish Entrance (measured as mean column velocity)	2.0 – 6.0 ft/s	2.4 – 6.0 ft/s
Bypass Channel Fish Exit (measured as mean column velocity)	≤6.0 ft/s	≤6.0 ft/s

This alternative also includes continued O&M of the LYP irrigation system.

1.3.4 Modified Side Channel Alternative

The Modified Side Channel Alternative is intended to improve passage for pallid sturgeon around Intake Diversion Dam by modifying the existing side channel around Joe's Island to meet the BRT criteria. Pallid sturgeon were documented to have passed upstream of Intake Diversion Dam through the side channel during both the 2014 and 2015 spring runoff seasons (Rugg 2014, 2015) at flows greater than 40,000 cfs (approximately a 2-year flood event). The intent behind this alternative is that with more frequent flow in the side channel, the side channel would have sufficient attraction flows and would be passable during all years as well as providing year-round fish habitat.

The proposed features for the Modified Side Channel Alternative are summarized as follows:

- 6,000 feet of new channel at three bend cutoffs,
- 14,600 feet of channel modification to lower the existing side channel,
- Three backwater areas at the bend cutoffs,
- 4,500 feet of bank protection,
- Five buried grade control structures,
- One 150 foot single span bridge, and
- Placement of 50,000 cubic yards of channel cobble substrate to simulate a natural channel bed and bed/bank edges.

Required water surface elevations for diversions into the irrigation canal would be met through continued routine rock placement on the existing weir as described for the No Action alternative. Note that the continued placement of rock on the existing weir will likely also require repair or replacement of the trolley system by the LYP, similar to the No Action Alternative. This alternative also includes continued O&M of the LYP irrigation system. Rock for the existing weir is quarried on private land located south and east of Joe's Island and transported to the site by driving across Joe's Island. Because the Modified Side Channel Alternative would result in a deeper channel with essentially year-round water, a bridge would be constructed to provide for vehicle and equipment access to Joe's Island. This alternative includes a 150-foot prefabricated clear span truss bridge with abutments set outside of the main channel banks to minimize encroachment into the side channel. The new bridge would be set with a low chord elevation two feet above the 100-year water surface in accordance with the State of Montana and the National Flood Insurance Program criteria.

1.3.5 Multiple Pump Alternative

The Multiple Pump Alternative would remove the Intake Diversion Dam and the rock rubble field downstream of the weir and construct five pumping stations on the Yellowstone River to deliver water to the LYP. The pumping stations would be designed to fully meet the LYP's water right with a total diversion capacity of 1,374 cfs. The pumping stations would be constructed at various locations along the Lower Yellowstone River between the headworks and about 20 miles downstream.

The five sites should be located on the outside of meander bends to minimize the chances they would be blocked by bar formation and maximize the depth of flow from the Yellowstone River towards the pumps. Both of these factors would improve reliability of the diversion and reduce maintenance associated with sediment removal. The downside is that the outside of the bends are also the most likely areas to erode in the immediate future. To minimize this potential two additional factors were accounted for in siting the pumping stations; the bends were evaluated and the stations were sited at bends that have been relatively stable over many years and the pumping stations were set back approximately 1,000 feet from the channel bank where possible. This placed them at or just inside the outer edge of the channel migration zone (CMZ) (DTM Consulting and AGI 2009). The five potential locations have been numbered from upstream to downstream along the river and are generally located as described in Table 1-2 below.

Table 1.2 Pump Station Locations

Site	Approximate Location
Site 1	Just downstream of Intake Diversion Dam
Site 2	8 miles downstream from Site 1, near Idiom Island
Site 3	3 miles downstream from Site 2, near Mary's Island
Site 4	0.2 miles upstream of Savage
Site 5	0.3 miles downstream of Savage

Each of the five pumping stations would be designed for a capacity of 275 cfs. Water would be drawn from the river through a feeder canal to a fish screen structure. The motors and electrical equipment in both the fish screen structure and the pump station would be located above the 100-year flood elevation. Fish not screened out would be returned to the river through a fish-friendly return pump at the end of the canal, while irrigation water would pass through the fish screen and flow into the pumping station. Discharge pipes would convey the irrigation water to the main irrigation canal.

1.3.6 Multiple Pumps with Conservation Measures Alternative

The Multiple Pumps with Conservation Measures Alternative includes four primary components including removal of Intake Diversion Dam and removal of the rock rubble field downstream of the weir, implementation of water conservation measures, supplemental irrigation water supply using Ranney wells, and use of wind energy to more affordably provide electricity for Ranney well pumping. The removal of the weir would allow natural fish passage on the Yellowstone River, and the other components would provide a continued, but reduced, water supply to the LYP of only 608 cfs. This reduced volume of water would not meet the crop irrigation needs during peak demand times (i.e. August and September) and thus, may not maintain the viable and effective operation of the LYP. The components of this alternative are described in the subsections below.

1.3.6.1 Conservation Measures

Installing water conservation measures throughout the system is proposed to reduce the amount of water needed by the project; both by reducing inefficiency and losses in the delivery system and on individual farms. Table 1-3 below includes a proposed list of conservation measures and the estimated amount of water that could be conserved. These were proposed by Defenders of Wildlife (Defenders) and Natural Resources Defense Council (NRDC) by letter dated February 17, 2016 (Defenders and NRDC 2016). Although the conservation estimates are based upon a conservation plan (LYIP 2009) and a value planning study (Reclamation 2005, 2013), the estimates included in those documents were not field verified. In fact, the value planning study noted that "cost and demand reduction estimates are currently at a low level of confidence and need to be field evaluated and refined."

The concept as proposed has been further developed into a conceptual design and cost estimate to allow alternative comparison.

Table 1.3 Water Conservation Measures and Estimated Savings (cfs)

Component	Description	Estimated conservation (cfs)
Check Structures	Installation of check structures in the canal for water control	61.5
Flow measuring devices	Measuring devices installed on the canals	18.5
Laterals to pipe	Convert laterals to pipe	255.8
Sprinklers	Install center pivot sprinklers	160
Lining main canal/laterals	Line main canal and laterals with concrete	200
Control over checking	Operational change to water levels in the canals	20.6
Groundwater pumping	Install groundwater pumps	49.5
	Total Savings	**765.9 cfs**

The conceptual alternative proposes that diversion requirements could be reduced by 766 cfs by the conservation measures described above. This would leave the required water delivery to the project of 608 cfs. The alternative proposes that this 608 cfs be accomplished through gravity diversions during high flows and then supplemented with pumping during most of the irrigation season. It is proposed that seven pumping stations using Ranney Well technology, which pump shallow groundwater, could provide up to 608 cfs when gravity diversions are insufficient to provide this volume. Due to the significant electricity needed to use these pumping stations, an alternate source of energy using a wind farm is proposed.

1.3.7 Alternatives Analysis

For an ecosystem restoration project such as this fish passage project, there is no monetary measure of benefits to compare alternatives in a traditional cost-benefit ratio. However, if benefits can be quantified in some dimension, cost effectiveness and incremental cost analysis can be used as one consideration in selecting a preferred plan. For this purpose, the potential benefits of the alternatives have been quantified using the Fish Passage Connectivity Index (FPCI), which is described below (also see Appendix D of the EIS for more details).

Cost effectiveness analysis evaluates which alternatives are the least-costly way of attaining the project objectives. Incremental analysis is then used to evaluate the change in cost from each measure or alternative to the next to determine their incremental costs and incremental benefits.

This type of analysis helps identify which measures or alternatives provide the most benefit for the lowest cost and can be used as one element in selecting a preferred plan.

Following completion of the cost effectiveness analysis, all of the alternatives were further compared and ranked using a number of factors including cost, constructability, sustainability, practicability, effects to the LYP, cost effectiveness, and the range of potential environmental impacts.

1.3.7.1 Fish Passage Connectivity Index

The FPCI was developed to evaluate ecosystem outputs (i.e. benefits) of alternative measures for fish passage improvements on the Upper Mississippi River for cost effectiveness and incremental analysis (Corps 2010). The model has subsequently been approved for use in this study. The FPCI is a simple arithmetic index that is calculated as:

$$\epsilon = \frac{\Sigma\, i \ldots n\ [(E_i \times U_i \times D_i)/25]}{n}$$

Where,

- ϵ = Fish Passage Connectivity Index.
- i = a migratory fish species that occurs in the reach below the dam.
- n = number of fish species included in the index.
- E_i = Chance of encountering the fishway entrance is a calculated value ranging from 1 to 5, where 5 = highly likely; 3 = moderate probability; 1 = unlikely.
- U_i = Potential for species i to use the fish passage pathway or fishway (5 = Good, 3 = Moderate, 1 = Poor, 0 = None) considering adult fish swimming performance and behavior (i.e. bottom oriented, shoreline oriented) and hydraulic conditions within the fish passageway.
- D_i = Duration of availability for fish passage is an estimation of the fraction of the time during the typical upriver migration period for fish species i that the passage pathway is available. This is based on the anticipated depths and velocities available in the passage pathway during the typical flows in the migration season.

Although the model was developed to measure benefits of fish passage in the Upper Mississippi River, the model is applicable (with slight adjustments) to fish passage projects on other large river systems, especially those with very similar fish communities. This model, with minor adjustment, was used as a planning tool for comparing benefits of alternative measures for providing fish passage at Intake Diversion Dam. Additional background and data used for this calculation is provided in Appendix D of the Intake EIS.

A total of fourteen native fish species were included in the FPCI for the Intake Diversion Dam project including shovelnose sturgeon, pallid sturgeon, paddlefish, goldeye, smallmouth buffalo, blue sucker, white sucker, river carpsucker, shorthead redhorse, channel catfish, smallmouth bass, walleye, sauger, and freshwater drum. The FPCI is calculated as an index value (between zero and 1) for each species. The index value is then multiplied by the potential acres of suitable habitat upstream of Intake Diversion Dam for each species to yield habitat units. The habitat units are then averaged across all 14 species to yield average annual habitat units (AAHUs) for each alternative, which are used in the cost effectiveness and incremental cost analysis described below.

1.3.7.2 Cost Effectiveness, Incremental Cost Analysis (CE/ICA)

The CE/ICA analysis utilized the Corps IWR Planning Suite model. The Corps-certified model provides a systematic method for testing all possible combinations of ecosystem restoration measures to identify combinations of measures (alternative plans) which are cost effective, and then ranks cost effective plans according to their efficiency to identify "best buy" plans. Because this analysis considered six complete alternatives that were mutually exclusive, no alternatives were created from the combination of measures in the model. Instead, the software identified which plans were cost effective, and then ranked the cost effective plans by efficiency to identify "best buy" plans. The CE/ICA model required the following inputs:

- Average annual habitat units for each alternative: Because habitat benefits are non-monetary, the outputs are referred to as "units" of output. In order to compare action alternatives to the No Action Alternative, AAHUs are typically converted to "net AAHUs," which is the change in habitat units as compared to no action. Thus, the No Action Alternative is always entered as zero net AAHUs, and each alternative is entered as the additional AAHUs that would be generated compared to no action. AAHUs were developed using the FPCI Model.
- Average annual cost for each alternative: Costs used in the analysis included construction, Planning, Engineering , and Design/Construction Management (PED/CM), real estate, monitoring and adaptive management, interest during construction, and Operations and Maintenance (O&M). Annualized costs are presented at an FY16 price level, amortized over a 50-year period of analysis using the FY16 Federal interest rate for Corps of Engineers projects of 3.125%.

Cost Effectiveness Analysis

Cost effectiveness analysis is a form of economic analysis designed to compare costs and outcomes (or effects) of two or more courses of action. This type of analysis is useful for environmental restoration projects where the benefits are not measured in monetary terms but in environmental output units such as the AAHUs developed in this study. The purpose of the cost effectiveness analysis is to ensure that the least cost alternative is identified for each possible level of environmental output; and that for any level of investment, the maximum level of output is identified. Per IWR 95-R-01, an alternative is ***not*** to be considered cost effective if any of the following rules are met:

- The same output level could be produced by another plan at less cost;
- A larger output level could be produced at the same cost; or
- A larger output level could be produced at less cost.

Table 1-4 provides the results of the cost effectiveness analysis sorted by increasing output.

Table 1.4 Cost Effectiveness by Alternative

Alternative	Total First Cost[1] ($1,000s)	Annual Cost ($1,000s)	Net AAHUs	Cost per AAHU ($)	Cost Effective?
No Action	$0	$0	0	$0	Yes
Rock Ramp	$90,454	$3,903	4,333	$901	No
Bypass Channel	$57,044	$2,527	7,417	$341	Yes
Modified Side Channel	$54,441	$2,494	6,795	$367	Yes
Multiple Pump	$132,028	$7,868	11,456	$687	Yes
Multiple Pumps with Conservation Measures	$477,925	$23,247	11,456	$2,029	No

1 – Includes construction, design, construction management and real estate costs

As shown in the table, alternatives were identified as cost effective only when no other alternative provided *the same output* for less cost, and no other alternative provided *larger output* at the same or less cost. The No Action, Bypass Channel, Modified Side Channel, and Multiple Pump alternatives were identified as cost effective. The Rock Ramp Alternative is not cost effective because the bypass channel alternative provides greater output for less cost. The Multiple Pumps with Conservation Measures Alternative is not cost effective because the Multiple Pump Alternative provides the same level of output for less cost.

Figure 1-2 provides a graph of the total output and annualized costs for each of the alternatives while differentiating the cost effective plans from the non-cost effective ones. Per IWR 95-R-01, any alternatives that are not found to be cost effective "should be dropped from further analysis" in the CE/ICA process. Therefore, the Rock Ramp, Modified Side Channel, and Multiple Pumps with Conservation Measures alternatives were dropped from further analysis and are not included in the ICA analysis that follows.

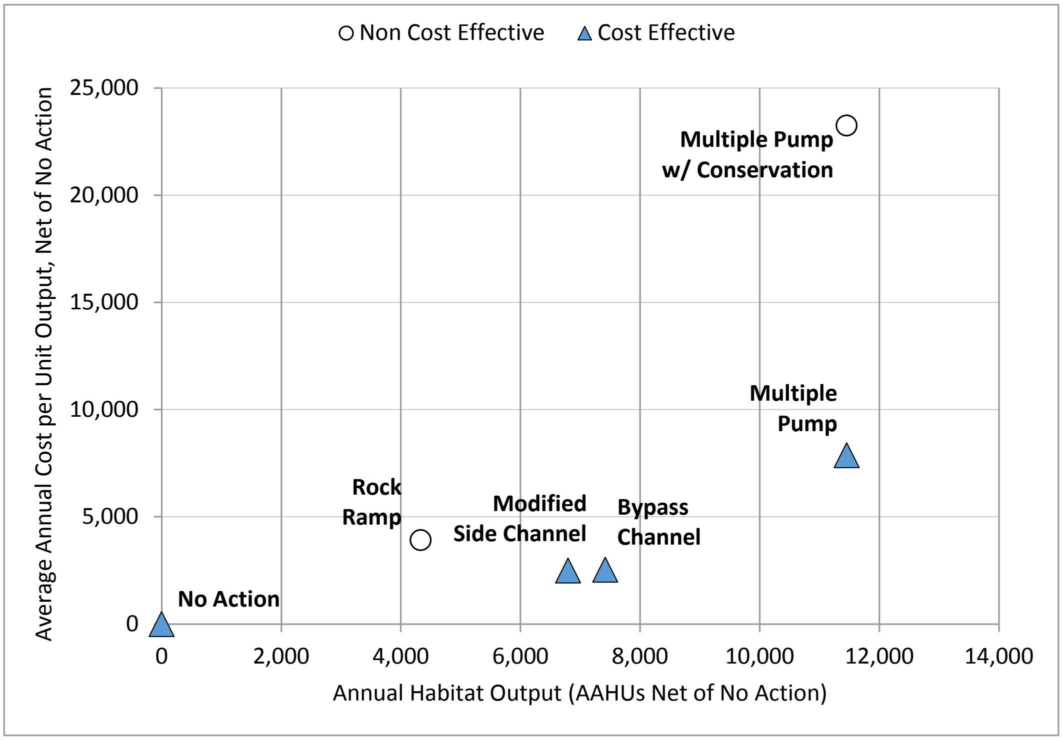

Figure 1.2 Cost Effective Analysis Graph

Incremental Cost Analysis

Subsequent incremental cost analysis of the cost effective plans is conducted to reveal changes in costs as output levels are increased. Only plans that were deemed as cost effective in the CE analysis have been advanced to ICA. These cost effective plans are the No Action, Bypass Channel, Modified Side Channel, and Multiple Pump alternatives. During the ICA, the cost effective plans are examined sequentially (by increasing scale in terms of net AAHUs produced) to ascertain which plans are most efficient in the production of additional environmental benefits.

The first step is to “smooth out fluctuations in incremental costs per unit as project scale increases such that incremental cost per habitat unit are continuously increasing.” This is first completed by calculating the incremental cost per unit for each plan over the “baseline condition,” which is the No Action Alternative. Once the incremental costs per unit are calculated and sorted by increasing output, the alternative with the lowest incremental cost per unit will be selected as the first “best buy” alternative. Table 1-5 shows the calculation of the incremental costs per unit with the no action alternative set as the baseline for the cost effective alternatives.

Table 1.5 Identification of the First Best Buy Plan

Alternative	Annual Cost ($1000)	Net AAHUs	Incremental Output	Incremental Cost	Incremental Cost per Unit Output
No Action	$0	0	0	n/a	n/a
Modified Side Channel	$2,494	6,795	6,795	$2,494	$367
Bypass Channel	$2,527	7,417	7,417	$2,527	$341
Multiple Pump	$7,868	11,456	11,456	$7,868	$687

Table 1-5 indicates that the Bypass Channel Alternative is the first best buy alternative because it has the lowest incremental cost per unit of output. At this step of the ICA the incremental cost per unit is equal to the average annual cost per unit values calculated in Table 1-4 because the complete alternatives are being compared, not combinations of measures.

After selection of this best buy alternative, all alternatives with lower average annual output are removed from further iterations of the incremental cost analysis. Thus, the No Action and Modified Side Channel alternatives are removed from further analysis and are not considered best buy plans.

Next, the incremental process should be started anew by comparing the next alternative with the first best buy plan. Thus, the Bypass Channel Alternative is set as the new baseline. However, for this study only the Multiple Pump Alternative is remaining, and it is therefore a best buy plan as well since, no other plans can produce more output for lower incremental cost per unit. Thus the calculations and values in Table 1-6 show the incremental cost per unit output between the Bypass Channel and No Action, and then between the Multiple Pump Alternative and the Bypass Channel Alternative.

Table 1.6 Incremental cost analysis summary

Best Buy Alternative	Annual Cost ($1000)	Net AAHUs	Incremental Output	Incremental Cost	Incremental Cost per Unit Output
No Action	$0	0	0	n/a	n/a
Bypass Channel	$2,527	7,417	7,417	$2,527	$341
Multiple Pump	$7,868	11,456	4,039	$5,341	$1,322

This table shows that the most efficient plan above no action is the Bypass Channel Alternative that provides 7,417 additional habitat units at a cost of $341 each. If more output is desired, the next most efficient plan available is the Multiple Pump Alternative that provides an additional 4,039 habitat units, at a cost of $1,322 dollars for each additional unit. Figure 1-3 provides a visual representation of this increase in incremental cost. The figure graphically illustrates the incremental cost and output differences between the two best buy action alternatives. The width of each box in the chart represents the incremental output of that plan, and the height of each box shows the incremental cost per unit of that output. The relatively wide box for the Bypass Channel Alternative shows that it provides about 65% of the total output possible at a cost of approximately $341 per unit. The box for the Multiple Pump Alternative shows that to achieve the remaining 35% of total possible output would be nearly four times as expensive per unit as the first 65%. Such breakpoints in incremental cost per unit typically require a higher level of justification based upon benefits or other considerations not accounted for with the fish passage index if the study team is to recommend the larger output plan that has much higher costs.

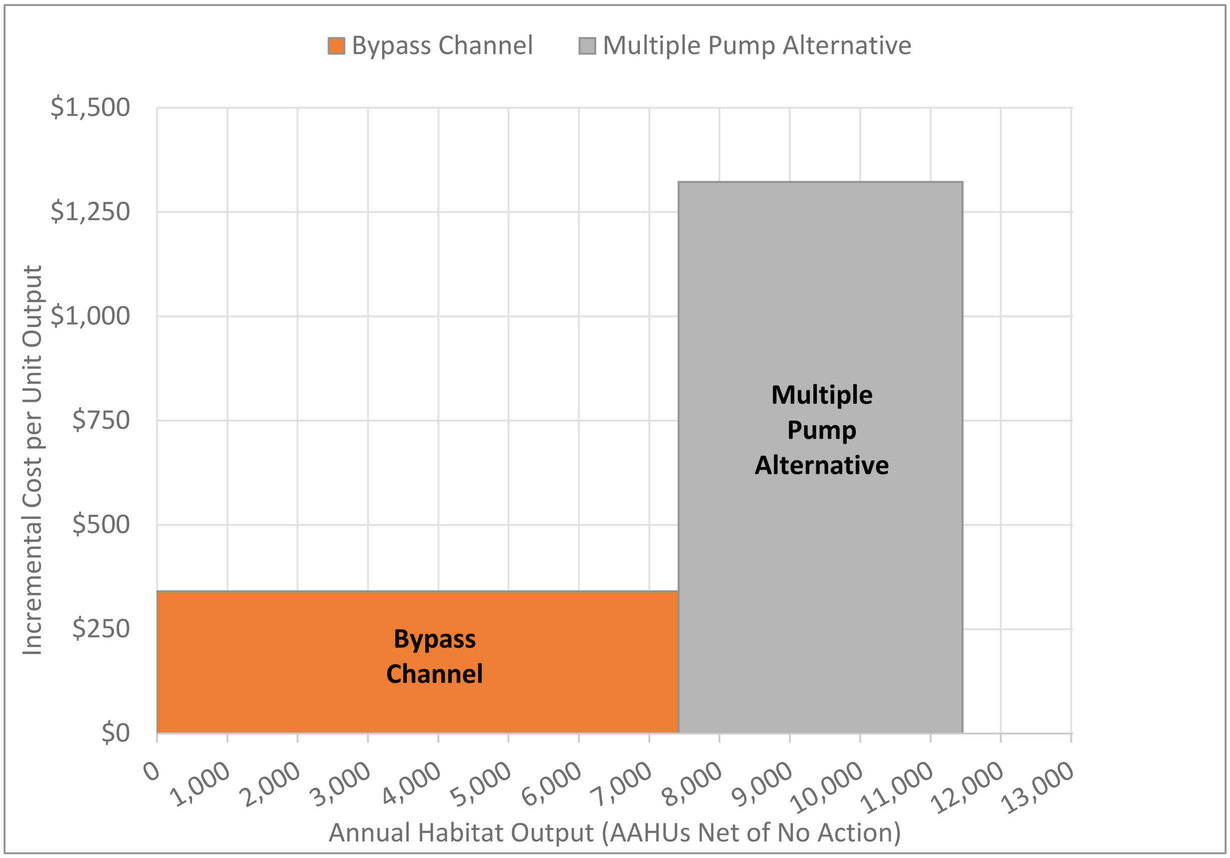

Figure 1.3 Incremental Cost Analysis Chart

Summary of Conclusions
Following completion of the CE/ICA, the project team further evaluated the alternatives in a multi-objective scoring matrix (Table 2-30 in the Intake EIS) based on other factors such as practicability, constructability, risk, total costs, and overall environmental impacts. The results of this comparison were:

- The No Action Alternative ranked lowest as it does not meet the project purpose and need and maintains the fish passage barrier, although it requires no construction and maintains the existing operation of the LYP.
- The Rock Ramp Alternative ranked and is tied for the second lowest as it has very difficult construction and future O&M as it may not withstand ice damage. While it maintains the existing operation of the LYP, it is not cost effective with a high total cost ($83.6 million), requires relocation of the fishing access and has the largest adverse changes to the river channel and substrate by placing such a large quantity of very large rock in the river.
- The Bypass Channel Alternative ranked highest as it is fairly easily constructed, would have reduced O&M with a replacement weir that will maintain the existing operation of the LYP, is cost effective and a best buy with the lowest incremental cost and low total cost (~$56 million), meets the Service's BRT criteria for pallid sturgeon passage and is

designed using the best available science regarding pallid sturgeon passage. It has adverse impacts to the existing side channel and wetlands from placement of fill, but results in a net increase of 39 acres of side channel habitat and maintains 30 acres of the existing side channel as backwater habitat, providing more diversity of riverine habitat and reducing future placement of rock in the river.

- The Modified Side Channel Alternative ranked in the middle as it is easily constructed, would have the same O&M as the No Action Alternative and maintain the existing operation of the LYP. It is cost effective with a relatively low total cost (~$55 million), meets the Service's BRT criteria for pallid sturgeon passage but is located where pallid sturgeon may have difficulty finding it, would change the existing function of the side channel and would have continued rock placement at the weir.
- The Multiple Pump Alternative ranked second highest as it is easily constructed, would remove the weir and rock rubble field, thus restoring natural channel conditions and fish passage to the river. It was considered both a cost effective and a best buy plan as it provided more benefits at a lower cost than the Multiple Pumps with Conservation Measures Alternative. However, it has a very high total cost (~$133 million) and would have very high O&M costs and effort required for operating and maintaining large pumps and requiring over 10 gigawatts of electricity. While it would deliver the full water right for the LYP, it may be too costly for some farmers to remain viable. Further, it also has the potential for substantial adverse cultural resources impacts and would have the highest potential for entrainment of fish because of the multiple surface water pumps.
- The Multiple Pumps with Conservation Measures Alternative ranked and is tied for the second lowest as it has difficult and complex construction that could take approximately 8 years to construct. While it would remove the weir and rock rubble field returning more natural channel conditions and fish passage to the river, these elements could not be constructed until the other features are complete, possibly too late for wild pallid sturgeon population to spawn and contribute to recovery. It would have high O&M costs, is not cost effective with very high total cost (~$482 million), would not deliver the full water right for the LYP and thus, would not meet crop needs even with water conservation. This alternative has the potential for substantial cultural resources impacts, would substantially reduce wetlands that exist from irrigation seeps or surface flows, and would have the most adverse effects to existing farmland, incomes, and cropping patterns.

Specific to the analysis required under the Section 404(b)(1) guidelines, a comparison of effects to waters of the U.S. is shown in Table 1-7.

Table 1.7 Effects on Waters of the U.S. from each Alternative

Alternative	Temporary Impacts	Permanent Impacts (over 50-year planning horizon)
No Action	• No effect	• Continued placement of rock on the weir crest and movement of that rock downstream would increase quantities of riprap over the existing 5 acre rock rubble field and likely expand the size of the rock rubble field by up to 2 acres
Rock Ramp	• 24 acres of river disturbed during construction • 31 acres of grassland disturbed during construction • 8 acres of riparian habitat disturbed/cleared during construction	• 24 acres of river filled with riprap and cobbles and concrete for replacement weir and ramp; would remain riverine, with changed substrate • 39 acres restored/reseeded to grassland
Bypass Channel	• 3 acres of river disturbed/filled during construction for replacement weir • Up to 45 acres of riparian forest disturbed during construction • Up to 200 acres of grassland disturbed during construction	• 2 acres of river filled with riprap and cobbles and concrete for replacement weir; would remain riverine • 2 acres of river filled to reduce downstream eddy and at scour hole; converted to uplands • 66 acres of existing side channel filled and converted to uplands (25 acres seasonally inundated; 41 acres backwater) • 1 acre of palustrine emergent filled; converted to uplands • 64 acres of new perennial side channel created from grassland and riparian forest • ~30 acres of existing side channel converted to perennial backwater channel with fringing palustrine emergent wetland • 200 acres restored/reseeded to grassland • 10 acres of riparian forest restored/replanted
Modified Side Channel	• 52 acres of existing channel disturbed/excavated during construction • 80 acres grassland disturbed in spoil area	• 0.75 acre palustrine emergent filled • 0.75 acre palustrine emergent converted to channel • 52 acres of existing riverine/side channel filled • 8 acres of new palustrine emergent created (backwaters) • 47 acres of new channel created from grassland • 14 acres riparian forest converted to riverine due to channel widening and bend cutoffs • 9 acres of riparian scrub shrub lost to access roads and bend cutoffs • 65 acres of grassland converted due to channel widening • 83 acres of grassland converted due to channel cutoffs

Alternative	Temporary Impacts	Permanent Impacts (over 50-year planning horizon)
Multiple Pump	• ~20 acres of river disturbed during construction for weir and rock removal • ~20 acres of floodplain disturbed for pump station construction	• 0.1 acre palustrine emergent converted to backwater canal • 0.5 acre palustrine scrub/shrub converted to backwater canal • 8 acres of upland converted to backwater canal • 0.6 acre of river filled for bank protection • 10 acres of riparian forest converted to grassland at pump sites • 2 acres of riparian scrub shrub converted to grassland at pump sites
Multiple Pumps with Conservation Measures	• ~20 acres of river disturbed during construction for weir and rock removal • ~ 2 acres of riparian disturbed for Ranney well construction	• 0.5 acre riverine (lateral canals) filled for access roads • Unidentified loss of wetland acres from >50% reduction in irrigation canal flows • 1.2 acres of riparian forest converted for pump construction • 0.2 acres of riparian scrub shrub converted for pump construction

All of the alternatives have temporary and permanent effects on the Yellowstone River and wetlands. The Bypass Channel Alternative results in the largest increase in waters of the U.S. with 64 acres of new perennial side channel created that would have much greater functionality for many fish species, mussels, and macroinvertebrates as water would be present year-round. There would be 66 acres of less functional existing seasonal or backwater side channel habitat filled. The evaluation of other factors indicates that the Bypass Channel Alternative balances all factors the best and is highly cost effective with a much lower total cost than the other best buy alternative (Multiple Pump Alternative). The new bypass channel would provide year-round functional side channel habitat for a variety of fish, mussels, and macroinvertebrates and the lower half of the existing side channel would remain as backwater habitat that may transition to palustrine emergent wetland habitat providing a higher diversity of habitat types in the vicinity of Joe's Island for fish and macroinvertebrates that use backwater habitats as well as waterfowl and wildlife.

Therefore, the recommended plan is the Bypass Channel Alternative, since it meets the project objectives of improving fish passage and maintaining reliable irrigation diversions at a reasonable cost to maintain viable and effective operation of the LYP, and is constructible, operable, and has a similar scale of environmental impacts as the other alternatives.

2.0 Summary of Proposed Action

The proposed action is to construct a replacement concrete weir for the existing Intake Diversion Dam rock weir, to excavate a new bypass channel to provide fish passage upstream of the weir, and to fill portions of the existing side channel in order to meet the Service's BRT fish passage criteria to maximize potential fish use of the new bypass channel. Details are provided below in Sections 2.3-2.6.

2.1 PURPOSE AND NEED

The purpose of the proposed action is to improve passage of the endangered pallid sturgeon and other native fish at Intake Diversion Dam in the lower Yellowstone River while continuing a viable and effective operation of the Lower Yellowstone Project. Both Reclamation and the Corps have a general responsibility under Section 7(a)(1) of the ESA to use their authorities to conserve and recover federally listed species and ecosystems upon which they depend. Both agencies also need to avoid jeopardizing the pallid sturgeon in funding or carrying out any agency action per 7(a)(2) of the ESA.

2.2 WATER DEPENDENCY OF THE PROPOSED ACTION

As the purpose of the project is to provide fish passage, the project will necessarily occur in the Yellowstone River and its associated floodplain habitats, including wetlands. Measures of the proposed project that will occur within the waters of the U.S. include; 1) construction of a replacement concrete weir with cobble/rock fill, 2) connection of a constructed bypass channel to the Yellowstone River after a bypass channel is excavated in the dry, and 3) infill of the upper portion of the existing side channel.

Measures that will not require excavation or fill in waters of the U.S. include; 1) excavation of the new bypass channel, 2) relocation of the historic south rocking tower and boiler building on Joe's Island, 3) clearing and grubbing for staging areas and access, and 4) revegetation after construction completion.

2.3 DESCRIPTION OF PROPOSED PROJECT

The recommended restoration plan is presented in this section by key design element.

2.3.1 Replacement Concrete Weir

A replacement concrete weir is proposed approximately 28 feet upstream from the existing timber and rock weir with a crest elevation of 1991.0 feet (NAVD 88) in order to provide sufficient water surface elevations to divert the full irrigation diversion through the headworks and screens. A rendering of the replacement weir is shown in

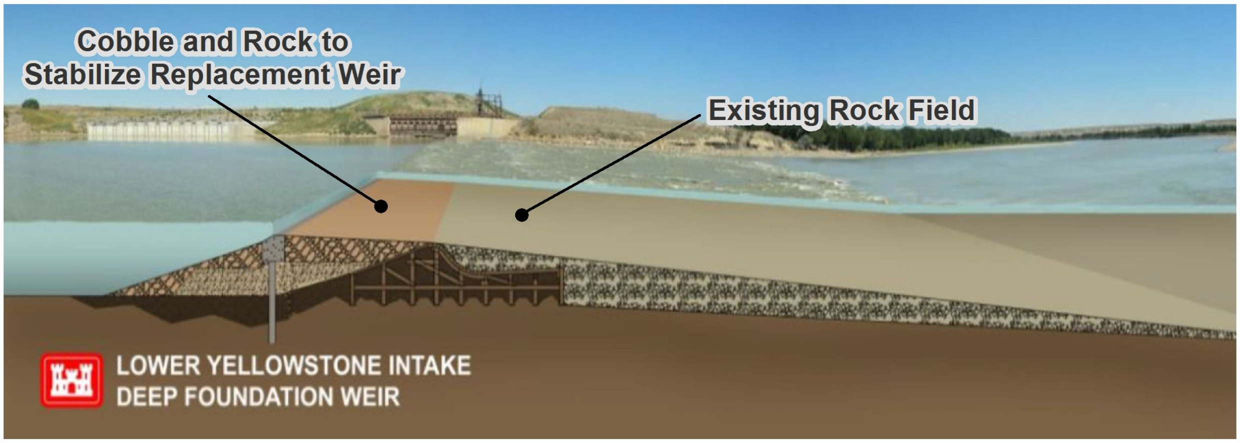

Figure 2.1 Rendering of replacement concrete weir

The weir structure would consist of a deep foundation of driven piles with a concrete cap. The concrete weir would require approximately 680 cubic yards of concrete, which would be trucked from Glendive and pumped to the site. The top of the structure would allow for a smooth crest surface for ice and water to pass over. Rock fill would be placed between the new weir and the existing weir to stabilize both structures. Cobble fill would also be placed upstream of the weir structure and sloped to pass flows and ice more smoothly over the weir crest. The weir crest will include a low-flow notch for fish passage at elevation 1889 feet with a bottom width of 85 feet and a top width of 125 feet. It is likely that occasional maintenance of the riprap between the old and new weirs would be necessary over the long term. However, the rock placed between weirs would not be subject to the same level of displacement experienced with the current weir since it will not be subject to direct impact from ice flows.

Construction of the replacement weir would begin on the north side of the river with up to one-half of the weir being constructed at a time. The immediate construction area would be dewatered, as needed, using a sheet pile coffer dam, with piles driven below grade into coarse alluvium material to reduce under seepage. Once the weir section is complete, the coffer dam sheet piles would be removed. Coffer dam installation and removal would occur during summer, but would not occur during the pallid sturgeon migration period (mid-April to July) to minimize fish impacts. During construction of the replacement weir and bypass channel, the LYP would need to maintain the existing weir. During construction, additional rock would continue to be placed on top of the existing weir to maintain diversions into the main canal. Rock would be placed on top of the existing weir as has occurred historically up to elevation 1991.0 ft. Once construction of the replacement weir is completed, there will be no need to place rock on the weir crest to maintain diversions into the main canal.

An access road and staging area would be constructed along the north side of the river to allow access for heavy equipment during construction. Following completion, the road would likely be left in place for long-term operation and maintenance use. In addition, the road between Highway 16 and Intake FAS will be resurfaced. Existing access roads to Joe’s Island would be improved as needed to facilitate construction access. Access by motor vehicles across the newly constructed bypass channel would be limited at most flows.

2.3.2 Excavation of New Bypass Channel

The bypass channel is designed to meet criteria developed by the Service's Biological Review Team (BRT) to divert 13-15% of total Yellowstone River flows (Table 1-1). As shown in the table, the bypass is designed for cross-sectional velocities between 2 and 6 feet/second and minimum depths of 4 to 6 feet, depending on the flow.

While the channel will typically divert 13% of the total flow from the main channel during typical spring and summer discharges, diversion percentages would vary from 10% at extreme low flows (below 7,000 cfs) on the Yellowstone River to 16% at extreme high flows (Table 2-1). The geometry of natural side channels on the Yellowstone River near Intake varies greatly. The geometry of the proposed bypass channel falls within the range of all parameters evaluated for observed natural side channels.

Table 2.1 Analysis of Bypass Channel Flow Splits

Discharge at Sidney, Montana USGS Gage (return period) cfs	Split Flows			
	Flow into the bypass channel cfs	Flow remaining in the Yellowstone River cfs	Percent of flow in the bypass channel versus Yellowstone River percent	USFWS and BRT criteria percent
7,000	1,100	5,900	16	≥12
15,000	2,200	12,800	15	13 to ≥ 15
30,000	4,100	25,900	14	13 to ≥ 15
54,200 (2-yr)	7,500	46,700	14	13 to ≥ 15
63,000	8,700	54,300	14	13 to ≥ 15
74,400 (5 yr)	10,700	53,700	14	-
87,600 (10 yr)	12,900	74,700	15	-
128,300 (100 yr)	20,000	108,300	16	-

The excavation of the bypass channel would remove approximately 869,000 cubic yards of earthen material from Joe's Island. The proposed bypass channel alignment extends approximately 11,150 feet in length at a slope of approximately 0.07 percent. The channel cross section would have a bottom width of 40 feet, a top width of 150-250 feet, and side slopes varying from 1V:8H to 1V:4H. The excavated material would be disposed of in one of three locations. The majority of the excavated material would likely be disposed of in the upstream portion of the existing side channel. Some material would likely be disposed of in the spoil area on the south side of the new channel. Additionally some material would be placed to even out low banks along the channel.

The construction work zone would be isolated by coffer dams at the upstream and downstream ends of the proposed bypass channel, which would be constructed early in the construction sequence. The coffer dams will consist of sheet piles driven below grade into the coarse alluvium material to prevent under seepage. Some of the rock placement on the new channel side slopes will be placed after the coffer dam removal. Grade control structures are included at the downstream and upstream ends of the bypass channel as well as at two intermediate locations to prevent channel bed erosion that could affect passage success. The proposed grade control structures would be composed of buried riprap covered with gravel/cobble.

Additionally, bank riprap is proposed at four outside bends where velocities are higher to minimize the risk of major changes in the bypass channel planform that might reduce the capability to meet the Service's BRT criteria. Approximately 110,000 CY of riprap would be required for the bypass channel.

Modeling indicates the bypass channel could be subject to bed erosion. Therefore, construction of an armor layer is proposed. The armor layer would consist of large gravel to cobbles, similar in size to the naturally occurring coarse channel material found on Yellowstone River point and mid-channel bars and similar to what would be expected to occur naturally over time. Approximately 28,000 cubic yards of armor layer material would be screened from the alluvial material excavated from the bypass channel and placed in the channel bottom to achieve final design grade.

To ensure the desired 13-15 percent split of flows into the constructed bypass channel the placement of fill in the upstream end of the existing side channel is required. Material excavated from the bypass channel would be placed as fill in approximately the first 1.5 miles of the existing side channel. This fill material would be compacted, sloped and reseeded for stability. This plug would not allow any water to be diverted into the upstream end of and flow through the existing side channel under most flow conditions. It is possible that under extreme flood conditions water could flow overland into the lower part of the side channel; however, the only water that would regularly enter the high flow channel would be via a backwater effect at the downstream end. This would maintain similar backwater conditions as currently occurs in the lower portion of the side channel when river flows are below 20,000 cfs.

2.4 CONSTRUCTION METHODS

Both in-water and upland construction would be required for the various actions. Specific equipment used would depend on contractor preferences and experience. Equipment may include, but is not limited to, the following:

- Cranes: for lifting and placing materials
- Pile installation equipment: vibratory driving of piles
- Excavators: long-reach excavators for excavating channel and placing rock
- Dozers: for grading of slopes and access routes

2.4.1 General Construction Sequencing

The likely sequencing of construction elements will be:

a) Site Preparation
   a. Close Joe's Island and provide detours, signage, fencing, etc.
   b. Conduct pre-construction biological surveys and relocate fish and wildlife from the construction work zones

- c. Establish erosion controls in channel and spoils area
- d. Prep haul roads and staging areas

b) Weir Construction
- a. Establish haul roads, access ramp, and barge inlet
- b. Install sheet pile coffer dam
- c. Install support pilings for new weir
- d. Pour concrete for new weir
- e. Place rock and cobble fill upstream and downstream of new weir
- f. Remove sheet pile

c) Bypass Channel Inlet Structure
- a. Install coffer dam around upstream inlet
- b. Excavation and riprap placement

d) Bypass Channel Outlet Structure
- a. Install coffer dam around outlet
- b. Excavate outlet
- c. Import and place outlet riprap

e) Channel Excavation
- a. Excavate channel from outlet to downstream outer bend protection
- b. Excavate channel between inlet and outlet
- c. Screening and placement of channel bottom armor
- d. Haul and place excavated material in existing side channel
- e. Place instream bypass channel protection and grade controls

f) Site Restoration
- a. Mulch, seed, and revegetate all disturbed areas
- b. Remove north side access crossings and culverts
- c. Demobilization of equipment, fencing, signage, etc.

2.4.2 Sediment Quality

In 2009, when the initial alternatives were evaluated for fish passage at the Intake Dam, a series of representative sediment samples were collected at points upstream and downstream of the Intake Diversion Dam to determine if the proposed soils and sediment disturbance would introduce contaminants into the water column (Corps 2009). This analysis was conducted in accordance with the guidance prepared jointly by EPA and the Corps for the evaluation of dredged material proposed for discharge into inland waters of the United States (1998). A total of eight locations were sampled and evaluated for potential contamination via an elutriate analysis. Three samples were taken downstream of the weir and five were taken from upstream of the weir. Two of the upstream samples came from an island and the rest were from the riverbed.

Results showed that no pesticides or PCBs were in the samples and that, in general, nutrient concentrations in the samples were similar to ambient concentrations in the river. This means that sediment disturbance under any proposed alternative would not be likely to introduce pesticides, PCBs, or nutrients into the water (Corps 2009).

Arsenic, lead, zinc, iron, manganese, aluminum, and ammonia were detected in one or more samples; although at levels below Montana water quality standards, except for iron and manganese, which were present at levels well above state standards. However, in the case of iron, manganese, and aluminum, these minerals likely represent a natural condition associated with the geology and soils in the basin (Corps 2009). Similarly, for arsenic, lead and zinc, the levels detected appear to be associated with the geology and soils in the basin (Corps 2009).

2.5 TIMING OF DISCHARGE AND FILL

In-water work would be minimized with coffer dams, which will allow the construction of the weir and bypass channel to occur isolated from the river. The placement of fill into waters of the U.S. would occur at the existing Intake Diversion Dam to create the replacement weir, as well as at the upstream end of the existing side channel. This work would largely occur during summer low flows or other periods outside of the spring runoff and fish migratory period (mid-April to July).

2.6 SOURCES AND GENERAL CHARACTERISTICS OF DREDGE/FILL MATERIALS

All fill material will come from two sources: 1) on-site reuse of materials excavated from the new bypass channel; or 2) a commercial source that meets the standards for suitability of clean material. This would generally mean that any materials imported to the project area would have low or non-detectable levels of contaminants that are not expected to have significant adverse impacts on water quality or biota in the short or long term.

3.0 Evaluation Criteria

The 404(b)(1) Guidelines require evaluation of the aquatic impacts associated with the discharge of dredged or fill material. The purpose of the CWA Section 404 as per 40 CFR Section 230.1(a) "is to restore and maintain the chemical, physical, and biological integrity of waters of the United States through the control of discharges of dredged or fill material." Specifically, 40 CFR Section 230.1(c) states that "dredged or fill material should not be discharged into the aquatic ecosystem, unless it can be demonstrated that such a discharge will not have an unacceptable adverse impact."

Section 230.11 of Subpart B of the Guidelines provides the following four conditions that must be satisfied in order to make a finding that a proposed discharge complies with the requirements described in 40 CFR Section 230:

1. No discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge that would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental impacts (see Sections 4, 5, and 6).
2. No discharge of dredged or fill material shall be permitted if it violates any water quality standards, jeopardizes any endangered or threatened species, or disturbs any marine sanctuaries (see Sections 4, 5, and 6).
3. No discharge of dredged or fill material shall be permitted that would result in significant degradation of any waters of the United States, including adverse effects on human health or welfare, effects on municipal water supplies, aquatic organisms, wildlife, or special aquatic sites (see Sections 4, 5, 6 and 7).
4. No discharge of dredged or fill material shall be permitted unless appropriate and practicable steps have been taken that would minimize potential adverse impacts (see Sections 8, 9, and 10).

The potential impacts of the proposed actions are evaluated based on conditions set forth in 40 CFR Subpart B Section 230.11, and the factual determination and discussion of conditions for compliance are provided in Sections 11 and 12. Findings of compliance or non-compliance with the restrictions on discharge, pursuant to 40 CFR 230.12, are provided in Section 13.

Sections 4, 5, 6, and 7 below describe the potential effects of the selected Bypass Channel Alternative on aquatic habitats, and fish and wildlife. The Intake EIS describes the potential impacts of each of the alternatives, but specifies the selected alternative as the most cost effective, practicable, and beneficial. In the following sections, the effects of the selected alternative are compared to the potential effects of taking no action.

4.0 Potential Impacts on Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C)

4.1 SUBSTRATE

4.1.1 Existing Conditions

The Yellowstone River channel boundaries are generally within alluvium consisting primarily of sand and gravel. Channel bed materials consist of gravel, cobble, and sand. The channel migrates within the alluvial materials and occasionally comes in contact with bedrock.

4.1.2 Potential Impacts

4.1.2.1 No Action Alternative

The No Action Alternative would not have any new construction elements and would therefore have no impact on substrate. The continued operation of the existing weir requires annual placement of rock on the weir crest. This activity would continue for the No Action Alternative and would thus, continue increasing the volume of rock present in the river, causing a larger rock/rubble field over time.

4.1.2.2 Proposed Bypass Channel Alternative

There would likely be some minor erosion and scour of the channel substrate and/or banks due to the placement of coffer dams around the weir construction area. The coffer dam could temporarily cause a rise in water surface elevations, primarily along the right bank on Joe's Island as a result of confining the flows, including for the 100-year and other flood flows, if they were to occur during construction. The coffer dam could also cause additional head at the headworks and screens and may slightly affect velocities. Based on 2D modeling results, the area of influence from the screen extends approximately 50 feet into the Yellowstone River during river flows of 24,000 to 25,000 cfs (C. Svendson personal communication 2016). This is a relatively small area of influence, as the Yellowstone River would still be 400-500 feet wide even with a portion of the channel coffer dammed. At a higher water surface elevation, this area of influence would be expected to decrease, thus any effects on velocities is likely to be minimal.

The coffer dams at the proposed bypass channel location would not affect any river flows unless there was a flow higher than a 2-year event during construction, which could overtop the coffer dams and could cause some minor erosion/scouring at the coffer dam locations.

The new weir will include the placement of riprap and cobbles both upstream and downstream of the new weir to stabilize the structure. This will be a permanent addition of coarser substrate to the river channel. This material will be far more stable than the rock that is currently placed on the weir crest, so will not likely move downstream.

The placement of fill into the existing side channel would change its substrate to a mix of both coarse and fine materials placed to match the surrounding elevation on Joe's Island. Conversely, the excavation of the new bypass channel would change the current island surface to a coarse cobble/gravel channel. The following actions are recommended to minimize effects to surface water during construction and during the long-term operation and maintenance:

- Design coffer dams to obstruct the least amount of the channel or floodway to minimize the potential for affecting flood flows or ice jams or causing scour.

4.2 SUSPENDED PARTICULATES/ TURBIDITY

4.2.1 Existing Conditions

Based on measurements at the Sidney gage (USGS Gage No. 06329500) and at the study area, silt and clay are the predominant suspended load. Bed material loads (sediment sizes found in appreciable quantities in the channel bed) are predominantly sand with small amounts of gravel. Near Sidney, the median suspended sediment concentration is 82 mg/L, but the concentration varies greatly from 1 mg/L to over 4,700 mg/L. Suspended sediment concentration is generally highest in the spring and early summer, corresponding with runoff. Streambank erosion and runoff from adjacent agricultural lands also affect suspended sediment concentrations. Nearly a third of the annual sediment load in the Yellowstone River near Sidney comes from the Powder River Basin (though it contributes less than 5% of the annual Yellowstone stream flow).

The lower Yellowstone River is a naturally turbid, or highly sediment-laden, system, and the warmwater fishery has adapted to these conditions. Sedimentation or siltation has occurred behind the weir, however, which may be reducing the natural turbidity in downstream reaches. Turbidity data collected at the Sidney gage between 1998 and 2001 ranged from to 2.8 to 1,600 nephelometric turbidity units (NTUs). The median value was 65 NTUs. (USGS 2016)

4.2.2 Potential Impacts

4.2.2.1 No Action Alternative

Under the No Action Alternative, there would be no changes to the existing Intake Diversion Dam configuration, and there would be negligible effects to suspended particulates or turbidity from continued annual placement of rock on the crest of the weir.

4.2.2.2 Proposed Bypass Channel Alternative

Construction of the replacement concrete weir, excavation of the new bypass channel, and installation of a temporary bridge or culverts spanning the main irrigation canal all have the potential to re-suspend or release sediment into the water column. Excavation of a new bypass channel will be isolated from the river, with coffer dams used at the upstream and downstream ends of the bypass to keep flows from entering the channel throughout the construction period, ensuring that only negligible effects will result to water quality. Construction staging and access would be located on Joe's Island adjacent to the proposed Bypass Channel. Silt fences and other erosion control measures would ensure that sediment and contaminants did not wash into the water from staging and access zones. Stockpile areas will not be located in wetlands and will be covered as appropriate during construction to prevent erosion and reseeded at the completion of construction to prevent wind and water erosion.

Measures to minimize effects include:

- Conduct all filling activities while isolated from the river (i.e. behind coffer dams) to the maximum extent practicable.
- Implement erosion control measures to reduce the potential for sediment-laden stormwater runoff during construction.

4.3 WATER QUALITY

4.3.1 Existing Conditions

The Administrative Rules of Montana designate the Yellowstone River as Class B-3 waters (ARM 17.30.611). Water quality standards for Class B-3 waters (ARM 17.30.625) include Montana numeric water quality standards from Circular DEQ-7 (MTDEQ 2012). Class B-3 waters are suitable for the following beneficial uses:

- Drinking water, including culinary use and food processing purposes after conventional treatment.
- Primary contact recreation, including bathing, swimming, and recreation
- Aquatic life, including the growth and propagation of nonsalmonid fishes and associated aquatic life, waterfowl, and furbearers
- Agricultural use, including industrial water supply.

The river currently supports the beneficial uses for agriculture, drinking water, and recreation, while not fully supporting beneficial uses for aquatic life (MTDEQ 2014). Causes for non-support of aquatic life result from the presence of the Intake Diversion Dam, which is a fish passage barrier, the alteration in streamside vegetation cover, presence of chromium, copper, lead, and high levels of nitrogen, phosphorous, sediment, TDS, and pH. Many of these are currently listed as 303(d) impairments, shown in Table 4-1.

The Yellowstone River is designated water quality Category 5, defined as waters where one or more applicable beneficial uses have been assessed as being impaired or threatened. The Yellowstone River between the Intake Diversion Dam and the North Dakota border has eight water quality parameters that are consistently not meeting regulatory state water quality standards: chromium, copper, lead, nitrogen, phosphorous, sedimentation or siltation, TDS, and pH. Each of these has been reported as a separate 303(d) listing under the CWA.

Table 4.1 CWA Section 303(d) listed impairments and causes in the Yellowstone River study area

Impairment	Probable Source	Total Maximum Daily Load Study Completed
Chromium (total)	Sources are unknown	No
Copper	Natural or unknown sources	No
Fish Passage Barrier	Impacts from hydrostructure flow regulation and modification	No
Lead	Sources are unknown	No
Sedimentation/Siltation	Rangeland grazing, irrigated crop production, streambank modifications and destabilization, hydrostructure flow regulation and modification, and unknown sources	No
Total Dissolved Solids	Natural or unknown sources	No
pH	Natural or unknown sources	No
Nitrogen (Total)	Irrigated crop production, streambank modification and destabilization, and unknown sources	No
Phosphorous (Total)	Irrigated crop production, rangeland grazing, streambank modifications and destabilization, and unknown sources	No
Alteration in Streamside or Littoral Vegetative Covers	Irrigated crop production, rangeland grazing, streambank modifications and destabilization	No

4.3.2 Potential Impacts

4.3.2.1 No Action Alternative

No construction activities or changes in operation and maintenance would occur under this alternative and therefore, no impacts would result. Continued rocking maintenance of the weir would result in temporary slight increases in turbidity each year, which would not be a significant effect on water quality.

4.3.2.2 Proposed Bypass Channel Alternative

No substantial changes in water quality are anticipated to result from construction, aside from minor increases in turbidity, which are discussed above. Measures to avoid contamination of water during construction would be employed and only clean fill materials used. Since placement of rock on the weir crest would no longer be necessary, minor turbidity increases associated with maintenance of the weir would be reduced as compared to no action.

The proposed Bypass Channel Alternative will create a fish passable channel around Intake Diversion Dam, thus greatly reducing the fish passage barrier that is one of the 303(d) listings for the lower Yellowstone River.

Measures to minimize effects to water quality include:

- Implementation of a pollutant prevention plan during construction addressing all potential contaminants that may be present on site.

4.4 CURRENT PATTERNS, WATER CIRCULATION, AND FLUCTUATIONS

4.4.1 Existing Conditions

The Yellowstone River is one of the longest free-flowing rivers in the lower 48 states, draining about 70,000 square miles as it flows more than 600 miles from its origin east of Yellowstone National Park, Wyoming, through Montana to the confluence with the Missouri River in North Dakota (Chase 2014). At the Missouri River confluence, the Yellowstone River contributes more than 50% of the average annual flow (Corps 2010).

The Intake Diversion Dam is located near the town of Intake in Dawson County, Montana. Built over 100 years ago, it is the most downstream and largest in a series of six diversion structures on the Yellowstone River downstream of Billings, Montana.

The Corps analyzed the flow records at the Sidney Montana gage (USGS Gage No. 06329500) located 36 miles downstream of the Intake Diversion Dam, and at the Glendive Montana gage (USGS Gage No. 06327500) located 18 miles upstream of the Intake Diversion Dam. Flows at the Sidney gage are affected by operations at Yellowtail Dam, which is located on the Bighorn River in south central Montana, approximately 90 miles upstream of the confluence with the Yellowstone River. Yellowtail Dam regulates 28% of the base flows upstream of Sidney, and reservoir operations can alter the flow regime (Corps 2006). Thus, two periods were assessed:

- The full period of record—Water years 1911 – 2005
- The period following the construction of Yellowtail Dam—Water years 1967 – 2005.

USGS analyzed the Yellowstone River flow records for two scenarios:

- Unregulated stream flow, representing flow conditions that might have occurred if there had been no water-resources development in the basin
- Regulated stream flow, representing flow conditions if the level of water resources development that existed in 2002 was in place during the entire study period.

The period of study was water years 1928 – 2002. Daily stream flows were modified to represent unregulated and regulated stream flow conditions. Statistical summaries were calculated for each set of conditions.

The Corps recommended using the flow frequency and flow duration values for the regulated conditions developed by USGS for the design and evaluation of the proposed bypass channel (Corps 2015a). The regulated flow frequency values are provided in Table 4-2 (highlighted in green) and the flow duration values are provided in Table 4-3. Table 4-2 also provides discharges developed by the Corps using post-Yellowtail Dam data through 2005 for use in the evaluation of construction timelines.

Table 4.2 Flow Frequency

Percent Chance Exceedance	Return Period (yrs)	Discharges (cfs) for various scenarios. Recommended values are Annual Post Yellowtail Dam; seasonal values used in evaluation of various construction timelines to lower risk. Study was conducted using data through 2005.						2013 USGS Study **	
		Seasonal: Aug-Feb	Seasonal: Aug-Mar	Annual (period of record)	Annual-Post Yellowtail Dam	Winter (1Jan-15Apr) Post Yellowtail Bulletin 17b	Winter (1Jan-15Apr) Post Yellowtail Top Half	Unregulated	**Regulated**
0.2	500	128,507	192,400*	192,400	114000	249000	213000	174800	**156200**
0.5	200	96,637	172,300*	172,300	105000			157600	**140200**
1	100	77,223	148,907	156,900	97200	128000	123000	144900	**128300**
2	50	61,117	114,710	141,400	89400	94600	94100	132300	**116200**
5	20	43,967	78,968	120,600	78700	61500	62800		
10	10	33,515	57,696	104,200	70100	43100	43800	103000	**87600**
20	5	24,764	40,334	86,900	60600			89800	**74400**
50	2	14,982	21,709	60,400	45300	14900	12300	69600	**54200**
80	1.25	9,961	12,688	41,200	33300				
90	1.11	8,334	9,886	33,400	28200				
95	1.05	7,314	8,171	28,000	24500				
99	1.01	5,949	5,925	19,800	18600				

* Discharges reduced to not exceed annual discharges

** "Streamflow Statistics for Unregulated and Regulated Streamflow Conditions for Selected Locations on the Yellowstone, Tongue, and Powder Rivers, Montana and Wyoming 1928-2002" (USGS)

Source: Corps 2015a

Table 4.3 Flow Duration

Regulated Data from "Streamflow Statistics for Unregulated and Regulated Streamflow Conditions for Selected Locations on the Yellowstone, Tongue, and Powder Rivers, Montana and Wyoming 1928-2002" (USGS 2013)					
	Discharge (cfs)				
Percent Time Flow Equaled or Exceeded		Fall (OCT-DEC)	Winter (JAN-MAR)	Spring (APR-JUN)	Summer (JUL-SEP)
1	56,800	13,700	35,300	66,600	55,500
2	49,500	12,500	25,000	60,500	46,200
5	36,900	11,300	17,000	52,000	35,300
10	25,800	10,400	12,400	43,500	26,900
15	18,700	9,740	10,500	36,800	21,100
20	14,500	9,230	9,500	31,600	16,600
25	12,200	8,840	8,800	27,500	13,700
30	10,700	8,510	8,250	23,800	12,000
40	9,030	7,890	7,500	18,000	9,700
50	7,990	7,300	6,810	14,300	8,230
60	7,070	6,730	6,130	11,500	6,860
70	6,210	6,050	5,560	9,110	5,680
75	5,780	5,660	5,250	8,230	5,150
80	5,350	5,300	4,970	7,500	4,600
85	4,880	4,850	4,560	6,640	4,010
90	4,270	4,320	4,120	5,860	3,460
95	3,440	3,490	3,510	5,220	2,550
98	2,520	2,610	2,830	4,530	1,940
99	2,060	2,200	2,560	3,620	1,550

Source: Corps 2015a

Daily flows were also calculated by the Corps for the period of record at Sidney, Montana for the 5th, 10th, 25th, 75th, 90th, and 95th percentiles. The resulting hydrographs show a spring time pulse in mid-March through mid-April, which occurs in about 50% of the years, and a larger rise starting in early May, peaking in late June and receding by early August (Figure 4-1).

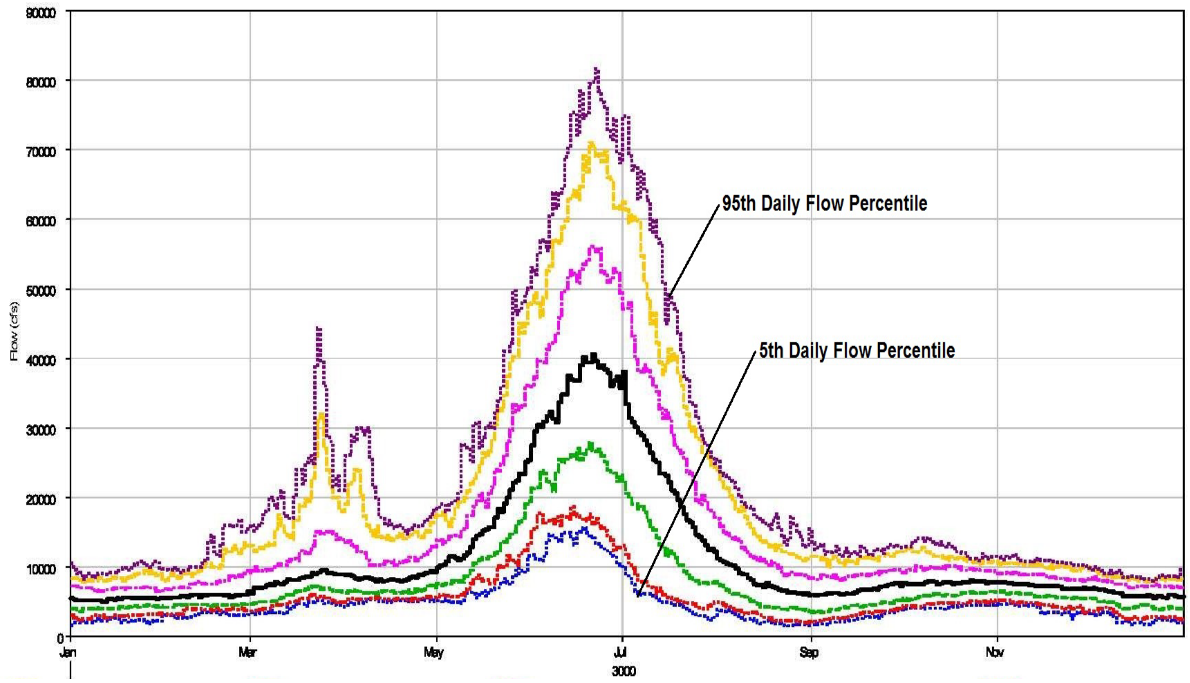

Figure 4.1 5th, 10th, 25th, 50th, 75th, 90th, and 95th, Daily flow Percentiles for Period of Record Water Years 1911 1934, and Water Years 1934-2005, Sidney, MT (USGS Gage No. 06329500) (Corps 2006)

The first rise is generally driven by snowmelt and rain in the plains region of the watershed. The second rise is primarily driven by mountain snowmelt (Corps 2006).

In 2011 and 2012 the Corps Engineering Research and Development Center/Cold Regions Research and Engineering Laboratory provided an assessment of ice impacts and design guidance on the Intake Diversion Dam and headworks structure and the proposed bypass channel (Tuthill and Carr 2012; Reclamation and Corps 2015). The report notes that ice breakup on the Lower Yellowstone River typically progresses downstream from warmer to colder climates (southwest to northeast) in a series of ice jams and releases. These jams tend to increase in severity as the breaking front encounters stronger, thicker ice. Jams in the main channel push flow and ice into side channels and onto the overbanks, leaving behind ice pieces. Historically when these jams form, the wide floodplains in the lower Yellowstone River system serve as a relief mechanism for collecting and storing ice. The overbank velocities of the ice pieces are low, (typically less than 2 feet/second at 40,000 cfs as calculated using HEC-RAS).

The main canal was constructed beginning in 1905. The canal is 71.6 miles long and conveys water along the north side of the Yellowstone River until it discharges to the Missouri River near the confluence of the Yellowstone and Missouri Rivers (Reclamation 2013). The canal has a design capacity of 1,400 cfs. The canal slope is 0.0002 feet/foot. The channel has a bottom width of 30 feet and 1.5H:1V side slopes. The canal is approximately 10 feet deep at the design capacity. Diversions are made into the canal typically from May through the end of September. Water diverted at the Intake Diversion Dam is measured daily at a bridge on the main canal, 2.8 miles downstream of the headworks. The annual diversions range from approximately 234,000 acre-feet to 378,000 acre-feet, with an average of 327,000 acre-feet.

The hydrologic assessment prepared by the Corps (Corps 2006) included the development of a 5-year moving average of flow. The analysis indicates an overall increase in flows during the winter but an overall annual decrease in flow. The report notes that while this may intuitively seem to be due to irrigation diversions and reservoir operation—with higher summer flows diverted or held in storage and winter flows augmented with reservoir releases—the trends are not pronounced enough to determine if these trends are due to irrigation and reservoir operations or other factors such as climatic trends. More recent analysis in the CEA indicate a similar pattern of hydrologic trends, with decreasing August flows over the period of record (Corps and YRCDC 2015). The CEA also notes that there is strong evidence of decreasing annual flow, decreasing annual minimum discharge, and decreasing peak discharge.

4.4.2 Potential Impacts

4.4.2.1 No Action Alternative

Under the No Action Alternative, river flows are not impeded by the Intake Diversion Dam. High flow events would overtop the banks and flows would occur through the existing side channel. The No Action Alternative would maintain the continued barrier of upstream passage of pallid sturgeon due to factors such as high velocities, turbulent flows, and low depths over the weir.

Climate change effects that may occur for the No Action Alternative include potential declines in snowpack in the mountains, potential increases in precipitation falling as rain, and increased air temperatures (Reclamation 2016). In addition, more extreme weather events such as floods and droughts are likely to occur more frequently. These factors would likely continue the trend of earlier and lower peak flows from snowmelt and potentially higher peak flows in winter and early spring from rainfall.

4.4.2.2 Proposed Bypass Channel Alternative

During construction of the proposed Bypass Channel Alternative, when the coffer dams are in place, the river flow would have roughly half the width, and approaching double the depth, with increased velocities through the reach. For example, during a flow of 15,000 cfs, the existing depth and velocity over the weir is 2.6 feet and 7.6 feet/second; if the width were reduced by 300-350 feet, the depth could potentially be 4 feet and the velocity could be 9.9 feet/second (similar to depths and velocities at a doubled flow, 30,000 cfs under existing conditions) during the two years of constructing the new weir. There could likely be some erosion and scour of the channel substrate and/or banks, primarily along the right bank on Joe's Island as a result of confining the flows and it could temporarily cause a rise in water surface elevations, including for flood flows. The coffer dam could also cause minor changes to water surface and velocities at the headworks and screens at the Main Canal.

During ice break-up, the presence of the various coffer dams would likely affect where ice would flow and deposit in the floodplain and could cause the potential for an ice damming effect at the weir as there would be a reduced width for flow, temporarily raising water surface elevations upstream of the weir. This effect could extend for up to 1.8 miles to the first side channel, which is the existing side channel, where ice is often pushed out of the main channel as the ice dam moves upstream.

Once the new weir is completed, it would maintain the same water surface elevation at the Main Canal headworks to fully divert the 1,374 cfs without the need for rock. There would not be any effects to flood water surface elevations from the new weir. Modeling of the low-flow notch in the weir indicates that there would be increased depths of flow through this notch as compared to the existing weir and reduced velocities. This may facilitate passage by native fish species that currently occasionally pass upstream of the weir.

The completed bypass channel would divert 13-15% of the river flow, thus reducing flow slightly in the main channel over the approximately half-mile distance between the upstream and downstream ends of the channel. Further, the bypass channel is designed to provide optimal depths and velocities for pallid sturgeon migration over the range of flows in the river from 7,000 to 63,000 cfs. Depths will range from 4 to 10 feet and velocities will range from 2 to 6 feet/second.

A long-term advantage of a bypass channel that functions over a wide range of flows is that even with projected climate change effects on flows, the bypass channel would likely convey appropriate percentages of the river’s flow and provide suitable depths and velocities for fish passage.

4.5 SALINITY

Salinity is not applicable for the Yellowstone River.

5.0 Potential Impacts on Biological Characteristics of the Aquatic Ecosystem (Subpart D)

5.1 THREATENED AND ENDANGERED SPECIES

5.1.1 Existing Conditions

Based on letters from the U.S. Fish and Wildlife Service, nine species that are listed under the Endangered Species Act (ESA) may occur within the proposed study area (USFWS 2016a, USFWS 2016b, Table 5-1). Of those species, only five are known or reasonably likely to be present, including the northern long-eared bat, least tern, piping plover, whooping crane, and pallid sturgeon.

Table 5.1 Federally Listed or Proposed Species in Montana and North Dakota and Presence in Study Area

Common Name	Scientific Name	MT[b]	ND[b]	ESA Status	Likely Presence in Study Area
Mammals					
Black-footed ferret	*Mustela nigripes*		X	Endangered	Not present
Gray wolf[a]	*Canis lupus*		X	Endangered	Not likely to be present
Northern long-eared bat	*Myotis septentrionalis*		X	Threatened	Potentially present
Birds					
Least tern	*Sternula antillarum*	X	X	Endangered	Likely to be present
Piping plover	*Charadrius melodus*	X	X	Threatened	Likely to be present
Rufa Red knot	*Calidris canutus rufa*		X	Threatened	Not present
Whooping crane	*Grus americana*	X	X	Endangered	Likely to be present
Fish					
Pallid sturgeon	*Scaphirhynchus albus*	X	X	Endangered	Present
Insects					
Dakota skipper	*Hesperia dacotae*		X	Threatened	Not present

a. Gray wolf has been delisted in Montana and is considered in recovery; it remains endangered in North Dakota.
b. Checked boxes indicate the species is federally listed for protection within that state, according to USFWS 2016a and USFWS 2016b.

5.1.2 Potential Impacts

5.1.2.1 No Action Alternative

The No Action Alternative would have no new construction, thus there would be no effects on Federal or state listed species or species of concern. Operational effects would occur from the continued operation and maintenance of the LYP.

Federally Protected Species

Northern Long-Eared Bat

The No Action Alternative would be unlikely to have any operational effects on northern long-eared bats from rock replacement at the weir or operation and maintenance of the headworks, screens, or irrigation system as they are not known to be present in any of these locations.

Least Tern

The No Action Alternative would be unlikely to have any operational effects on least terns as all activities would occur in highly disturbed areas where least terns have not been observed.

Piping Plover

The No Action Alternative would be unlikely to have any operational effects on piping plovers as all activities would occur in highly disturbed areas where piping plovers have not been observed.

Whooping Crane

The No Action Alternative would be unlikely to have any operational effects on whooping crane as all activities would occur in highly disturbed areas where whooping cranes are unlikely to occur and work primarily occurs after the spring migration and before the fall migration of whooping cranes.

Pallid Sturgeon

Under the No Action Alternative, the presence of the Intake Diversion Dam would continue to block pallid sturgeon passage, most likely due to high velocities and turbulence. The existing side channel is available for passage when river flows exceed 20,000 cfs (approximately 7 days in 5 out of 10 years). This barrier to fish passage limits access to additional potential spawning habitat that may be far enough upstream to allow suitable drift distance for sturgeon larvae to settle out before reaching Lake Sakakawea, thus contributing to the lack of recruitment in the Great Plains population of pallid sturgeon.

Several of the future O&M activities would result in short-term disturbance and turbidity in the Yellowstone River, including lowering and raising screens, screen cleaning/maintenance, gate maintenance, inspections, installing/removing supplemental pumps, and frequent replacement of rock on the existing weir. The majority of these activities would occur outside of the pallid sturgeon migratory and spawning season (i.e. either before April 15 or after July 1), thus adult pallid sturgeon are unlikely to be present and would be unlikely to experience disturbance.

Operation and maintenance of the headworks and screens would continue, as would the continued annual rock replenishment at the weir crest, and other ongoing maintenance activities of the irrigation system. These maintenance measures do not reflect a change in current conditions. Previous issues with fish mortality resulting from being entrained by the headworks into the Main Canal have been substantially reduced by the replacement of the headworks and the installation of the new fish screens (installed in 2011). The screens are designed to prevent entrainment of most fish larger than 40 mm. Monitoring data from 2012-2014 has indicated that entrainment is significantly reduced. There does appear to have been a change in the species composition and size of entrained fish in 2012 with 99 percent of the larval fish captured in the canal belonging to the Cyprinidae and Catostomidae families (predominantly minnows and carp) and <10 mm (typically in the 4-8 mm size range; Horn and Trimpe 2012). Raw data from 2013 and 2014 monitoring indicates similar results as in 2012. Free embryo or larval pallid sturgeon could be present upstream of Intake Diversion Dam for the No Action Alternative (i.e. a small number of adult pallid sturgeon have passed through the existing side channel), none are known to have been entrained at the headworks/screens.

With the existing Intake Diversion Dam in place, upstream and downstream passage occurs for some species, including the limited passage of pallid sturgeon in 2014 and 2015. All tagged fish in recent monitoring passed downstream over the weir with no reported problems (Rugg 2014, 2015; Rugg et al. 2016). One fish was initially believed to have died since it could not be found; however, later monitoring found this fish upstream of the Yellowstone River confluence on the Missouri River, unharmed. No pallid sturgeon larvae have ever been sampled in the vicinity of Intake Diversion Dam, so it is not known if the ongoing presence of the weir would affect downstream passage of larvae. The existing weir and rock rubble field have similar velocity and turbulence characteristics to bluff pools and rapids that drifting embryos encounter naturally on the Yellowstone River. A preliminary laboratory evaluation of the potential effects of riprap on white sturgeon larvae indicated no differences in injury or mortality to fish drifting past riprap versus a control group (Kynard et al. 2014). Intuitively, considering that free embryos and larvae are neutrally buoyant and are present in the lower part of the water column where velocities are lower, it is less likely they would be adversely affected when drifting past the existing weir.

Rock replenishment occurs during summer low flows and is not known to pose an immediate direct threat to protected fish or wildlife in the area, since they would easily be able to move away from the activity. Over time, indirect effects of continued rock placement could include the continued accumulation of large rock that is not natural within the river downstream of the dam that may slightly raise the elevation of the river bed and create a larger zone of turbulence, resulting in further limitations on fish passage conditions, damage to aquatic habitat, or a reduction in the availability of habitat.

From a recovery perspective, the No Action Alternative continues the present barrier to pallid sturgeon passage and would not contribute to recovery and may hinder recovery. Adult pallid sturgeon were observed to pass upstream of the Intake Diversion Dam via the existing side channel in 2014 and 2015 (Rugg 2014, 2015) when river flows generally ranged from 40,000 to 70,000 cfs. Pallid sturgeon presumably have passed through this route in previous years as 2014 was the first year that fish movement was tracked in the existing side channel with radio telemetry equipment. However, to date, there has been no documented recruitment of wild pallid sturgeon from the Yellowstone River.

Under No Action, the lack of recruitment of wild pallid sturgeon implies the potential for decline to fewer than 50 wild adults by 2023 (assuming a 5-percent adult mortality per year), which may be too low for effective reproduction. An estimated 43,000 juvenile hatchery-produced pallid turgeon are estimated to be present in the Upper Missouri River below Fort Peck Dam (Rotella 2015). It is unclear if future recruitment based entirely on hatchery-derived fish would create a sustaining naturally spawning population..

The No Action Alternative was evaluated using a Fish Passage Connectivity Index (FPCI; see Appendix D of the EIS). The resulting index value for an alternative is based on the probability of fish encountering the fish passageway, the potential for the species to use the passageway considering adult swimming performance and hydraulic conditions, and duration of time that the passageway is available during the migration period. The No Action Alternative merited a low index score of 0.08 (out of a maximum scope of 1.0) because there is very little potential for pallid sturgeon and other benthic oriented fish to pass over the existing dam because of its high velocities, shallow depths, and turbulent flows.

If no action were taken, Reclamation would need to reinitiate ESA consultation for their operation and management of the Intake Diversion Dam and the LYP. A future biological opinion would likely require other future activities to reduce the effects on listed species, but these are unknown at this time. Reclamation is continuing to conduct monitoring of entrainment at the headworks for the No Action Alternative and would continue to fund various other studies including the telemetry and tracking of pallid sturgeon and other fish species for at least 8 more years. To date, there have been no known adverse effects to pallid sturgeon from the various monitoring studies and protocols to avoid and minimize harm to pallid sturgeon would continue to be implemented.

Species of Concern
The No Action Alternative would be unlikely to have any operational effects on wildlife species of concern as the vast majority are not present in proximity to the weir, quarry, or irrigation system.

Under the No Action Alternative, the presence of the Intake Diversion Dam would continue to at least partially block passage for native fish species of concern, due to high velocities and turbulence. The existing side channel is available for passage when river flows exceed 20,000 cfs (approximately 7 days in 5 out of 10 years). However, many of the fish species of concern have been documented to occur in similar numbers both upstream and downstream of the weir (Helfrich et al. 1999; Rugg 2014, 2015).

Operation and maintenance of the headworks and screens would continue, as would the continued annual rock replenishment at the weir crest, and other ongoing maintenance activities of the irrigation system. These maintenance measures do not reflect a change in current conditions. Previous issues with fish mortality resulting from being entrained by the headworks into the Main Canal have been substantially reduced by the replacement of the headworks and the installation of the new fish screens (installed in 2011). The screens are designed to prevent entrainment of most fish larger than 40 mm. Monitoring data from 2012-2014 has indicated that entrainment is significantly reduced. There does appear to have been a change in the species composition and size of entrained fish in 2012 with 99 percent of the larval fish captured in the canal belonging to the Cyprinidae and Catostomidae families (predominantly minnows and carp) and <10 mm (typically in the 4-8 mm size range; Horn and Trimpe 2012). Raw data from 2013 and 2014 monitoring indicates similar results as in 2012. Larvae or juveniles of the fish species of concern are now much less likely to be entrained at the headworks/screens.

With the existing Intake Diversion Dam in place, upstream and downstream passage occurs for some species of concern. In 2014 and 2015, a large number of fish passed downstream over the weir with no reported problems (Rugg 2014, 2015; Rugg et al. 2016). Shovelnose sturgeon larvae have presumably passed downstream of the weir since it was constructed and there is no known effect on larvae. The existing weir and rock rubble field have similar velocity and turbulence characteristics to bluff pools and rapids that drifting embryos encounter naturally on the Yellowstone River. A preliminary laboratory evaluation of the potential effects of riprap on white sturgeon larvae indicated no differences in injury or mortality to fish drifting past riprap versus a control group (Kynard et al. 2014). Intuitively, considering that free embryos and larvae are neutrally buoyant and are present in the lower part of the water column where velocities are lower, it is less likely they would adversely affected when drifting past the existing weir.

Rock replenishment occurs during summer low flows and is not known to pose a direct threat to protected fish or wildlife in the area, since they would easily be able to move away from the activity. Over time, indirect effects of continued rock placement could include the continued accumulation of large rock that is not natural within the river downstream of the dam that may slightly raise the elevation of the river bed and create a larger zone of turbulence, resulting in further limitations on fish passage conditions, damage to aquatic habitat, or a reduction in the availability of habitat.

5.1.2.2 Proposed Bypass Channel Alternative

During construction of the Bypass Channel Alternative, the new weir would require installation and removal of coffer dams and placement of rock and cobbles in the river. These activities would likely result in minor effects to pallid sturgeon and other sensitive fish species from elevated noise levels from pile driving for coffer dams (would occur outside of the pallid sturgeon migration season) and moderate effects on pallid sturgeon and state fish species of concern by further reducing passage over the Intake Diversion Dam during the construction period of 28 months and by blocking the existing side channel for alternate passage.

Construction of the bypass channel and stockpile of excavation materials, however, would expand the potential area of impact to Joe’s Island, where more types and area of habitat are available, such as for terrestrial wildlife.

The effects on federal and state listed species and actions that could be taken to avoid and minimize effects on each of these protected species are provided below.

Federally Protected Species
Federally protected terrestrial species that may occur in the bypass channel area include the northern long-eared bat, least tern, piping plover, whooping crane and pallid sturgeon. There is no known permanent population of terns, plovers, or cranes within the proposed project footprint for the Bypass Channel Alternative, but each have been observed in the area regularly and recently. If these species did arrive in the area during construction, they would be expected to naturally relocate to avoid disturbance. The construction of this alternative does not occur in areas considered critical habitat for any of the federally protected terrestrial species. Furthermore, though the project reach has been known to support migrating and/or nesting of least tern, piping plover, and whooping crane, the construction and access footprint of the Bypass Channel Alternative is relatively small in comparison to the surrounding available habitat and generally not located in potentially suitable habitats for these species (i.e. most of the

construction footprint is main channel, the adjacent river banks, grassy or disturbed uplands (including existing dirt roads), and the existing side channel. Therefore, only minor effects on any of these species would occur, limited to temporary disturbance from noise and human presence for an estimated 28 months.

Construction of the bypass channel and filling in the upper portion of the existing side channel would have a direct effect on species using Joe's Island and the existing side channel habitats, which differ from those that may be present in the main river channel or immediately around the Intake Diversion Dam. Species that may be present at Joe's Island and in the existing side channel include the northern long-eared bat and pallid sturgeon. Of these species, it is highly unlikely that northern long-eared bats would be present, since they are very rare in the area and there are no suitable hibernacula within a suitable distance.

Northern Long-Eared Bat
Construction of the bypass channel would only have the potential to disturb this bat species if it were found roosting under the existing Main Canal bridge or in trees to be cleared during construction, which is considered unlikely. Also, trees would only be removed from September 15 – January 31st, further reducing the chances of impacts to the species. Pre-construction surveys should be conducted to document if this bat is present. If found onsite, consultation with the Service would determine appropriate actions to protect individuals.

The Bypass Channel Alternative would be unlikely to affect northern long-eared bats from operation and maintenance of the bypass channel, headworks, screens, or irrigation system as they are not known to be present in any of these locations. Noise and disturbance on Joe's Island could potentially disturb individuals, if present, but this would be short-term and focused near the bypass channel and would not require removal of trees.

Least Tern
Interior least terns have been regularly reported to use the sandy shorelines of the Yellowstone River for nesting and foraging. Pre-construction surveys should be conducted to identify if any birds/nests are present. If active nests are found, they should be protected during the nesting season with temporary fencing or flagging for a ¼-mile buffer around the nest to prevent access and disturbance.

Operation and maintenance of the Bypass Channel Alternative would be unlikely to affect least terns as all activities would occur in disturbed areas where least terns have not been observed. Noise and disturbance on Joe's Island could potentially disturb individuals that might pass through the area or be on sand/gravel bars in proximity to the site. The work would occur during low flows and would generally occur after the nesting season for least tern.

Piping Plover
Piping plovers have been regularly reported to use the sandy shorelines of the Yellowstone River, including areas near the Intake Diversion Dam. However, effects on plovers could be minimized by conducting pre-construction surveys and by protecting nests with temporary fencing or flagging within ¼ mile of any active plover nests during the nesting season.

Operation and maintenance of the Bypass Channel Alternative would be unlikely to affect piping plovers as all activities would occur in disturbed areas where piping plovers have not been observed. Noise and disturbance on Joe's Island could potentially disturb individuals that might pass through the area or be on sand/gravel bars in proximity to the site. The work would occur during low flows and would generally occur after the nesting season for piping plover.

Whooping Crane

Whooping cranes are rare visitors to the Yellowstone River corridor and would be unlikely to occur. However, whooping crane sighting reports would be monitored before and during construction to determine if cranes are in the construction area. If any are sighted, construction managers would consult with the Service to determine if any actions to minimize effects are warranted.

Operation and maintenance of the Bypass Channel Alternative would be unlikely to affect whooping crane as all activities would occur in disturbed areas where whooping cranes are unlikely to occur and work primarily occurs after the spring migration and before the fall migration of whooping cranes.

Pallid Sturgeon

Operation and maintenance of the existing diversion structure would be required until the construction of the new weir was completed. This would include the annual placement of rock on the existing weir crest up to elevation 1991.0 feet. This rock is needed to maintain water surface elevations so the LYP can divert their full water right down to 3,000 cfs in the Yellowstone River. The physical placement of rock would not affect adult pallid sturgeon as this activity occurs outside of pallid sturgeon migration (migration period April 15 – July 1). The Intake Diversion Dam is already impassable to pallid sturgeon so the continued maintenance and rocking activities during construction does not represent a loss of habitat or change in accessibility to habitat.

This annual placement of rock would continue to affect the 12-26 percent (25 to 32 individuals) of spawning ready wild adult pallid sturgeon that migrate up to Intake Diversion Dam. It is likely that some or all of these fish would continue to spawn in habitats downstream of Intake Diversion Dam, but any resulting free embryos/larvae would almost certainly perish due to inadequate drift distance downstream before entering Lake Sakakawea.

The rock would also continue to prevent upstream passage by juvenile pallid sturgeon, although it is not known if juveniles are motivated to move upstream. Rugg (2014, 2015) documented three individual juvenile pallid sturgeon that had passed upstream of Intake Diversion Dam, including one documented to have passed through the existing side channel. Thus, it is presumed the annual placement of rock affects at least a small number of juvenile pallid sturgeon that are motivated to find suitable habitat upstream. It is not possible to know how many individuals this affects as a very small percentage of these juveniles are tagged and tracked each year. However this effect appears to be minor as there appears to be suitable habitat available below Intake Diversion Dam and in the Missouri River as many hatchery juvenile pallid sturgeon are surviving and maturing successfully in the GPMU (Rotella 2015).

During construction, there would be temporary and minor increases in turbidity on multiple occasions over the 28 month construction period from installation and removal of coffer dams, dewatering for new weir construction, placement of rock and cobbles at the new weir, connection of the bypass channel to the river and placement of rock at the upstream/downstream ends of the bypass channel. But these increases in turbidity should rapidly mix and be diluted, and pallid sturgeon are adapted to high turbidity environments.

Elevated noise levels from sheet pile driving for coffer dams may disturb pallid sturgeon and other fish and wildlife species. Noise attenuates through water in a straight line and dissipates when it encounters land. Thus, in a meandering river, the distance that noise would propagate is limited to the first bend upstream and downstream of the construction. It is anticipated that any fish within close proximity would immediately flee the area once construction equipment was mobilized to the site and activities such as moving rocks began to occur. Thus, injury is not anticipated. To minimize the potential for effects on pallid sturgeon and other native migratory fish species, no sheet pile driving or other in-river work would occur during the pallid sturgeon migration period (April 15 – July 1) to minimize the potential that any adult pallid sturgeon would be present in the vicinity and that if any larval pallid sturgeon were possibly present, they would drift downstream past the work zone before pile driving began. Juvenile pallid sturgeon have been stocked upstream of Intake Diversion Dam for monitoring studies (Jaeger et al. 2004, 2005, 2006), but most of these fish appear to have migrated downstream of the dam. Due to the turbulence around Intake Diversion Dam and the rock rubble field, juveniles would be unlikely to be present in the immediate vicinity. Any present upstream of the dam could move away upstream to avoid pile driving noise. Vibratory driving would be also used if practicable to minimize noise levels.

During construction, the existing side channel would be blocked off at the upstream end and about 1.5 mile downstream and filled using materials excavated for the new bypass channel. Because excavated materials need to be deposited almost immediately after excavation begins, it is anticipated that infill of the existing side channel would be concurrent with excavation of the bypass and occur over most of the 28-month construction duration. The bypass channel would be constructed in the dry, with cofferdams at the up and down stream ends of the bypass. This means there would be a period of time when the bypass channel is not completed and the existing side channel is also blocked, which would likely prevent pallid sturgeon passage upstream of the Intake Diversion Dam. As the existing side channel only begins to convey flows when river flows are above 20,000 cfs, and passage has only been documented at flows above 40,000 cfs (approaching a 2-year flood; Rugg 2014, 2015), which does not occur every year, it is likely that the blockage of the side channel would only prevent passage in one runoff season during construction. To date, only one female and 6 males have been documented to have migrated upstream through the existing side channel, although other non-telemetered fish may have passed in previous years or even in 2014 and 2015. Of the telemetered wild adult pallid sturgeon that migrate to Intake Diversion Dam, (estimated 12 to 26 percent of total wild adults, up to 32 fish; Braaten et al. 2015), 50 and 14 percent passed through the existing side channel in 2014 and 2015, respectively. This could translate to 5 to 16 fish being blocked from migrating upstream through the existing side channel during construction in the estimated one year when passage could be possible. This would be considered a short-term adverse effect during the two years of construction. To offset this effect, a catch and haul program would be implemented to provide passage for the adult pallid sturgeon that migrate up to the Intake Diversion Dam and may have passed using the existing side channel. The catch and haul program would be discontinued once construction was completed.

Operation and maintenance of the Bypass Channel Alternative would no longer require the placement of rock on top of the weir crest as the replacement weir would be high enough to fully divert the 1,374 cfs water right into the Main Canal down to flows of 3,000 cfs in the river. This would result in much less future maintenance occurring in the river channel as periodic supplementation of rock at the replacement weir would occur much less frequently and require much less rock placement, thus reducing disturbance to fish species in the river.

Several of the future O&M activities would result in short-term disturbance and turbidity in the Yellowstone River, including lowering and raising screens, screen cleaning/maintenance, gate maintenance, inspections, installing/removing supplemental pumps, occasional replacement of rock on the outside bends or at buried sills in the bypass channel and removal of sediment and debris, and infrequent replacement of rock at the replacement weir. The majority of these activities would occur outside of the pallid sturgeon migratory and spawning season (i.e. either before April 15 or after July 1), thus adult pallid sturgeon are unlikely to be present and would be unlikely to experience disturbance.

Even though there should be improved adult passage and spawning upstream, it would be highly unlikely that eggs would be present during future O&M as it would occur after eggs have hatched and any drifting eggs would already be dead. Free embryos/larvae could be present, but the future O&M activities would occur before or after drifting occurs, thus, effects to free embryos/larvae are not expected or negligible.

Juveniles may be present as they have been documented in the Yellowstone River both upstream and downstream of Intake Diversion Dam, but not in immediate proximity to the weir (Jaeger et al. 2006, 2008; Rugg 2014, 2015). As the immediate work areas at the headworks and on the replacement weir are likely to be unsuitable habitat due to higher velocities and do not include bluff or terrace pools, there are not likely to be any juvenile pallid sturgeon present that could be disturbed by localized and short-term in-water work at the headworks or weir.
Irrigation diversions of up to 1,374 cfs would continue to occur from approximately April 15 to October 15. The screens at the headworks were designed to minimize entrainment of fish, including pallid sturgeon, larger than 40 mm into the Main Canal. A small percentage of pallid sturgeon less than 40 mm, could potentially be impinged on the screen or entrained through the screen into the Main Canal. If spawning occurs near or upstream of the Powder River, similar to the presumed spawning that occurred in 2014 (approximately 80 miles upstream from Intake), the free embryos would be approximately 9-12 mm in size when drifting through the Intake area (P. Braaten, personal communication 2015). Work done by Mefford and Sutphin (2008) showed that pallid sturgeon free embryos (13-18 mm) could pass directly through a 1.75 mm wedgewire screen, which is the current design of these screens. Thus, if free embryos encounter the screen at Intake, they can be impinged or entrained.

Information from drift studies (Kynard et al., 2002, 2007; Braaten, 2008, 2010, 2012), indicates that most pallid sturgeon free embryos drift in the lower 0.5 m (1.6 feet) of the water column, but a few will be caught in the upper portions of the water column, depending on turbulence and secondary currents (P. Braaten, personal communication 2015). When in use, the headworks screens are located approximately 2 feet above the river bottom and have an approach velocity of 0.4 meters per second (1.3 feet/second) and a sweeping velocity of 2-4 feet/second, which helps sweep small non-swimming fish past the screens and reduces the chance of larvae and small fish being impinged upon the screens or entrained into the canal.

The vast majority of pallid sturgeon free embryos drift in or adjacent to the thalweg where velocities are high. Although a few free embryos will drift in regions of lower velocity (for example, along inside bends), most will be concentrated in the higher velocity regions. On river bends (similar to where the Intake screens are located), very high concentrations of drifting free embryos can be found in the region that extends from about mid-channel through the thalweg to the outside bend of the channel (Braaten et al. 2012).

Free embryo pallid sturgeon drift occurs during mid-June through mid-July each year, which is typically the peak run off months for the Yellowstone River. During June the average discharge is 38,200 cfs and in July is 22,000 cfs. Because the LYP is diverting only 3- 6 percent of the average total river flows during this time, a corresponding small percentage of the total number of pallid sturgeon free embryos would likely be impinged or entrained.

Based on 2D modeling results, the area of influence from the screen extends approximately 50 feet into the Yellowstone River during river flows of 24,000 to 25,000 cfs (Figure 12; C. Svendson personal communication 2016). This is a relatively small area of influence as the Yellowstone River is approximately 700 feet wide at Intake. As flows increase in the Yellowstone River during runoff conditions, this area of influence would be expected to decrease, decreasing the likelihood of entrainment. Additionally the thalweg is located approximately 100 -150 feet away from the headworks which is outside of the area of influence further reducing that chances of entrainment or impingement.

It is impossible to estimate the number of pallid sturgeon free embryos that could be entrained but some factors are reasonable to predict: the percentage of larvae passing near the screens will be small given their expected distribution across the river and in the water column and the relatively small amount of water being diverted relative to the total volume of river water indicate relatively few larvae would encounter the screens.

Overall, because free embryo or larval pallid sturgeon would likely only be present drifting in the river from mid-June to mid-July, when typically less than 5% of the river flow is being diverted into the headworks, a small percentage of the total number of pallid sturgeon free embryo and larvae could be impinged or entrained. However, pallid sturgeon free embryos would likely be larger than 8 mm by the time they reached the headworks and the vast majority would be drifting below the level of the screens, as recent monitoring indicates most larval fish that have been entrained since the screens were installed were in the 4-8 mm size range (Horn & Trimpe 2012, Reclamation unpublished data). The mortality of pallid sturgeon from egg to age-0 has been estimated at over 99.9% (Caroffino et al. 2010; Rotella 2012; Delonay et al. 2016). These fish have evolved to produce very large numbers of eggs to compensate for the low survival of eggs/free embryos (i.e. R-selection), so the potential entrainment of pallid sturgeon larvae would be a minor adverse effect.

Adult and juvenile pallid sturgeon have swimming capabilities much greater than the approach or sweeping velocities of the screens and are thus unlikely to be impinged and are much too large to be entrained. Thus, the diversions into the Main Canal are unlikely to affect adult and juvenile pallid sturgeon.

If the LYP is not able to divert their entire water right due to debris in or near the headworks, plugged screens, or gate failure, they may lift screens one at a time until they are able divert their full water right down to river flows of 3,000 cfs measured at the Sidney gage. Under such circumstances, adult and juvenile pallid sturgeon are subject to entrainment into the Main Canal, resulting in an increased risk of potential injury or mortality. This action would only be undertaken in an emergency situation and would require coordination with the Service. Also, before any screens are lifted, the Service and MFWP would be contacted and methods to minimize effects to sturgeon would be identified.

Also, it is very likely that the LYP would need to divert unscreened water into the Main Canal during the start of the irrigation season to sluice sediment away from the gates and screens. This action would occur during early April, which is outside of pallid sturgeon migration and spawning, so no effects to adult pallid sturgeon are expected.

The LYP uses five small surface water pumps to supplement diversions in the Main Canal during peak demand times. Four pumps are located on the Yellowstone River downstream of Sidney and one is located on the Missouri River. Currently, these pumps have two–inch wide trash racks and operate occasionally during May, July, and August. The trash racks largely eliminate the chances of adult and juvenile pallid sturgeon from becoming entrained. There would still be potential for free embryo and larval sturgeon in both the Missouri and Yellowstone rivers to be entrained in these pumps, but the likelihood is quite small as these pumps are only operated intermittently, divert a small portion of the Yellowstone and Missouri rivers, and do not occur on outside bends where free embryos and larvae are most likely to be concentrated. Further, free embryo and larval sturgeon would only likely be present in the river in July and these surface pumps are used less frequently in this month when flow diversions at the headworks are typically high.

The bypass channel alternative would likely substantially improve passage for pallid sturgeon and other aquatic species compared to No Action. The bypass channel is designed to meet the BRT criteria for optimal pallid sturgeon passage and would be accessible over a much wider range of flows than the existing side channel that has only been documented to pass pallid sturgeon when flows exceed 40,000 cfs (approaching a 2-year flood). It is anticipated that a majority of pallid sturgeon that swim up to the weir would encounter the bypass channel as its entrance would be located close to the weir, thus a likely majority of pallid sturgeon would find and could use the channel. Passage upstream would extend the available spawning habitat to pallid sturgeon, potentially up to the Cartersville Diversion Dam, adding over 165 miles of potential spawning habitat and the lower 20 plus miles of tributaries such as the Powder River. Currently, a small percentage of the pallid sturgeon in the Yellowstone River use the existing side channel to pass above the Intake Diversion Dam and the bypass channel would likely allow the majority of the pallid sturgeon to pass upstream. The fish passage benefits would likely provide a major benefit to pallid sturgeon. The existing side channel would be filled at the upstream end and would no longer be accessible for upstream passage, but the greater likelihood of passage in the bypass channel would outweigh the benefits of the existing side channel that a smaller percentage of fish used.

In order to maintain the bypass channel to BRT criteria a temporary blockage of the channel may be required for major maintenance activities such as sediment removal, channel realignment or riprap replacement. These activities would all occur during low summer flows and outside of the pallid sturgeon migration and spawning period and last only a couple of weeks. Juveniles could be present in the bypass channel, but as work would occur at low flows, it is likely that any juveniles would have moved upstream or downstream prior to the work. Any short-term blockage of the bypass channel would not affect adults, but may have a short-term discountable effects on juveniles. Further, any short-term turbidity generated from these activities is likely to be well within the naturally high turbidity levels of the Yellowstone River which pallid sturgeon are adapted to.

For those pallid sturgeon that fail to find or use the proposed bypass channel, the new concrete weir, existing diversion structure, and rock field would continue to be an upstream barrier in the main stem of the Yellowstone River. However, velocity and depth conditions with the proposed replacement weir and low-flow notch would be an improvement compared to existing conditions (Table 5-2). Also, the smooth surface of the replacement weir would not cause turbulent flows, although the continued presence of the rock field downstream of the weir would still create turbulent conditions. It is still unlikely that adult or juvenile pallid sturgeon would pass upstream over the existing weir, rock field and replacement weir, but other native fish species may have improved passage.

Table 5.2 Comparison of Depths and Velocities over Existing vs. Proposed Weir.

Structure	Depths and Velocities at 15,000 cfs	Depths and velocities at 30,000 cfs
Existing Intake Diversion Dam	2.1-2.9 feet, 8 ft/sec	4 feet, 10 ft/sec
Replacement Weir Notch	3.5 feet, 5 ft/se	5.4 feet, 6.8 ft/sec

Adult and juvenile pallid sturgeon have been documented to have passed successfully downstream of the existing weir without any observable injury (Jaeger et al. 2004, 2005; Rugg et al. 2016), and downstream passage past the replacement weir should be improved compared to existing conditions. The replacement weir would have a smooth concrete top and a low-flow notch located approximately 100 feet out from the left bank, near to the channel thalweg. Rock and cobble will be placed sloping up to the new weir from the upstream side and between the replacement weir and existing weir. This will smooth out flows and reduce turbulence at the weir.

It is anticipated that there would be limited potential for injury or mortality of free embryos/larvae passing downstream. The replacement weir would be similar to rapids that drifting embryos encounter naturally on the Yellowstone River. A preliminary laboratory evaluation of the potential effects of riprap on white sturgeon larvae indicated no differences in injury or mortality to fish drifting past riprap versus a control group (Kynard et al. 2014). Intuitively, considering that free embryos and larvae are neutrally buoyant and are present in the lower part of the water column where velocities are lower, it is less likely they would be adversely affected when drifting through the Project Area.

The Bypass Channel Alternative was evaluated using the FPCI (Chapter 2 and Appendix E). The resulting index value for an alternative is based on the probability of fish encountering the fish passageway, the potential for the species to use the passageway considering adult swimming performance and hydraulic conditions, and duration of time that the passageway is available during the migration period. The Bypass Channel Alternative merited an index score of 0.67 (out of a maximum score of 1.0) because there is a high likelihood of fish encountering a passageway that occurs immediately downstream of the dam and it would be accessible and meet BRT criteria for pallid sturgeon passage at all flows at or above 7,000 cfs in the river.

There are still uncertainties over whether a majority of pallid sturgeon would actually pass through the bypass channel as there are no other examples of similar natural-type channels designed for non-jumping benthic fish. However, because it would mimic the characteristics of the existing side channel and other natural side channels with much more attraction flow, it is reasonable to assume that a majority of fish would find and use the channel. To address these uncertainties Reclamation and the Corps would implement a Monitoring and Adaptive Management Plan (AMP; see Appendix E of the EIS). This AMP takes into account the physical and biological criteria that were provided by the Service's Biological Review Team (Service 2013, 2016) and potential adaptive management measures that could be implemented if a problem was identified. Reclamation would continue to conduct monitoring of entrainment at the headworks and the monitoring identified in the AMP would occur for at least 8 years. To date, there have been no known adverse effects to pallid sturgeon from the various monitoring studies and protocols to avoid and minimize harm to pallid sturgeon would continue to be implemented.

Species of Concern

Wildlife species of concern that are likely to be present in the Bypass Channel Alternative construction area include hoary bat, little brown myotis, bald eagle, black-billed cuckoo, chestnut collared longspur, great blue heron, loggerhead shrike, long-billed curlew, red-headed woodpecker, yellow-billed cuckoo, veery, plains spadefoot, snapping turtle, and spiny softshell. Most of these species are associated with riparian or shoreline habitats and could be present along the Yellowstone River or existing side channel or riparian areas on Joe's Island. In order to ensure protection of sensitive wildlife species, it is recommended that a pre-construction survey be conducted to identify if any of these species are present. If any are discovered that cannot easily fly or move away, they should be relocated downstream of the construction zone. This would ensure that there are only minor effects on sensitive wildlife species.

The Bypass Channel Alternative would be unlikely to have any operational effects on wildlife species of concern as the vast majority are not present in proximity to the weir, Joe's Island, the quarry, or irrigation system.

Fish species of concern known to be present include blue sucker, paddlefish, sauger, shortnose gar, sicklefin chub, and shovelnose sturgeon, sturgeon chub. These species could be moderately affected during construction as the use of cofferdams that increase water velocities may reduce passage at the dam during the 28 month construction period. Also, the existing side channel would not be available for passage around the dam, thus resulting in a moderate adverse effect on these species. Installation of the small cofferdams to isolate the bypass channel and existing side channel would be driven out-of-water and would have only a minor effect on fish in the river from either noise or turbidity.

The bypass channel would have deeper depths and substantially lower velocities than those at the existing weir that would allow for sensitive fish species to move upstream, particularly strong-swimming species such as blue sucker, paddlefish, and sauger, providing a major benefit to these species. The existing side channel would no longer be accessible for passage, although only small numbers of sensitive fish species have have been documented to use the side channel (Rugg et al. 2016). The new weir may also improve passage over the weir for species that currently sometimes pass over the weir. Operation and maintenance of the headworks and screens would continue and other ongoing maintenance activities of the irrigation system. These maintenance measures do not reflect a change in current conditions. Entrainment at the headworks has been much reduced as described above for pallid sturgeon and entrainment of other native fish species is likely to be substantially reduced.

None of the insect species of concern are likely to be present in the bypass channel construction work zone, thus no effects are expected to these species.

None of the plants classified as species of special concern in Montana have been observed in recent years in the study area and they are unlikely to be present. However, to ensure protection of rare plants, it is recommended that a survey be conducted prior to construction to identify any plant species of concern in the area. If any are present, they should be fenced off and protected during construction. Pre-construction surveys would ensure that effects on protected plant species would be negligible. If any of these species are discovered in the first survey, additional surveys may need to be conducted each spring as construction is reinitiated.

A number of measures can be employed to minimize effects to listed and sensitive fish and wildlife species, including:

- Conduct pre-construction surveys within the construction footprint for listed and sensitive wildlife and plant species and fence and protect any listed plant species observed.
- All surface-disturbing and construction activities will be prohibited from occurring within 0.25 mile of any existing and active least tern or piping plover nest within the dates of May 15 to August 15.
- If any whooping cranes are sighted during the project construction, the on-site manager will immediately notify Corps/Reclamation environmental staff to consult with the USFWS regarding appropriate actions.
- Construction activities within the wetted perimeter of the active channel will be observed and monitored by a qualified fisheries biologist during the first day of in-water work for each activity to determine if there is potential for direct harm or harassment of pallid sturgeon. This will include coordination with MFWP to make sure radio-tagged pallid

sturgeon and other monitored native fish continue to be monitored, especially during the construction season.

- All pumps used in the river during construction will use intakes screened with no greater than 0.25 inch mesh when dewatering coffer dam areas in the river channel. Pumping will continue until water levels within the contained areas are suitable for salvage of any juvenile or adult fish occupying these areas. All fish will be removed by methods approved by the USFWS and MFWP prior to final dewatering.
- Care will be taken to prevent any petroleum products, chemicals, or other harmful materials from entering the water.
- All work in the waterway will be performed in such a manner to minimize increases in suspended solids and turbidity that could degrade water quality and damage aquatic life outside the immediate area of operation.
- All areas along the bank disturbed or newly created by the construction activity will be seeded with vegetation native to the area for protection against subsequent erosion and the establishment of noxious weeds.
- Clearing vegetation will be limited to that which is absolutely necessary for construction of the project.
- Any in-stream construction activity will be conducted during periods least likely to impact the pallid sturgeon or other sensitive fish species.
- Sheetpiles will be installed using vibratory equipment to the maximum extent practicable to minimize noise levels and potential effects to fish.
- At the start of pile driving each day, conduct a low-energy ramp up with reduced noise levels to allow fish the opportunity to move from the area.
- A monitoring and adaptive management plan will be implemented for the preferred alternative to document fish passage, entrainment, and success of the project in meeting physical and biological objectives (see Appendix E).

5.2 AQUATIC FOOD WEB

5.2.1 Existing Conditions

The aquatic community includes fish, mussels, macroinvertebrates, and aquatic vegetation. The Yellowstone River still has relatively pristine character (Jaeger et al. 2006). However, several anthropogenic factors influence the aquatic ecosystem, including alterations to the hydrograph, geomorphology, riparian vegetation and wetlands, river and tributary connectivity, and water quality, as well as introduction of non-native species and pressure from recreational fishing (Corps 2015b).

5.2.2 Potential Impacts

5.2.2.1 No Action Alternative

No changes to the existing aquatic food web would occur under the No Action Alternative.

5.2.2.2 Proposed Bypass Channel Alternative

During construction, the placement of fill in the existing side channel could bury mussels that utilize side channel habitat. Giant Floaters (*Pyganodon grandis*) are a species that utilizes backwater habitat, but has not been found in the Yellowstone River. Giant Floaters have only been found in three Yellowstone River Tributaries (O'Fallon, Little Porcupine, and Tongue Rivers). Since the existing side channel is not known to provide habitat for native mussels, impacts would be minor.

In the main channel, construction in the river could result in the loss of mussels. Surveys found Fatmucket densities in the Missouri River and Marias River averaging between 7-8 mussels per hour. The Yellowstone River has a much lower mussel density overall, with survey rates for Fatmuckets averaging around one mussel per hour (Stagliano 2010). The estimated number of mussels between the boat ramp and the Intake Diversion Dam was 24 individuals which is an insignificant numberfor the population as a whole.

Maintenance of the new weir would only occur occasionally so impacts to mussels would be minimal. Operation and maintenance of the bypass cannel would include occasional rock replacement at the bends and along the banks. This could bury mussels that have started to utilize side channel habitat (Giant Floaters, *Pyganodon grandis*, in particular), thus burying affected individuals. The number of affected individuals is likely to be low, so impacts would be minor.

Construction and fill in the river and in the existing side channel could result in the direct burial and mortality of macroinvertebrates. This is anticipated to be a minor, temporary effect and the new substrate in the river and the bypass channel would be rapidly colonized by macroinvertebrates once construction is complete. Installation and removal of coffer dams and construction of the new weir could disturb sediments and increase turbidity around the Intake Diversion Dam area. Increased turbidity and suspended sediment could negatively affect macroinvertebrates. Some macroinvertebrates tolerate sediment suspension such as flies *(Diptera),* midges *(Chironomidae)* and earthworms *(Oligochaeta*). However, the mayflies *(Ephemeroptera)* stoneflies *(Plecoptera*), and caddisflies *(Trichoptera)* are not tolerant of sediment suspension. Even with actions to minimize effects, there may be short-term effects near construction activities. These impacts are expected to be minor and temporary, and macroinvertebrate populations should recover quickly.

Rock placement for maintenance along the bends and banks of the bypass channel could disturb sediment and affect macroinvertebrates that are not tolerant of high turbidity. This impact would be localized and temporary and have minor effect.

The new bypass channel would be armored with a layer of large gravel and cobble. This substrate would provide more long-term habitat for macroinvertebrates as the amount of interstitial spaces resulting from the armor layer would likely provide substantial short term improvement for macroinvertebrates. Over time, the interstices could fill in and more likely be similar to substrate conditions in the existing side channel.

Measures to minimize effects to the aquatic food web would include:

- All work in the river will be performed in a manner to minimize increased suspended solids and turbidity including the use of coffer dams to isolate in-water work zones and taking appropriate erosion control measures.
- All areas along the bank disturbed by construction will be seeded with native vegetation to minimize erosion.
- All contractors will be required to inspect, clean and dry all machinery, equipment, materials and supplies to prevent spread of Aquatic Nuisance Species.
- Construction activities will be conducted in accordance with permit conditions, including water quality monitoring, if required. All pumps will have intakes screened with no greater than 0.25-inch mesh when dewatering coffer dam areas in the river channel. Pumping will continue until water levels within the contained areas are suitable for salvage of juvenile or adult fish occupying these areas. Fish will be removed by methods approved by the Service and MFWP prior to final dewatering.
- Reclamation will implement a monitoring and adaptive management plan that will include measures to take if project objectives are not met (see Appendix E).

5.3 WILDLIFE

5.3.1 Existing Conditions

Five general habitat types in the study area provide productive ecological support for native terrestrial wildlife: wetland, woody riparian, barren land, shrubland, and grassland. These habitats are utilized by frogs, toads, snakes, lizards, bats, large and small mammals, songbirds, waterfowl, wading birds, shorebirds, and insects.

5.3.2 Potential Impacts

5.3.2.1 No Action Alternative

No impacts to wildlife would occur from the No Action Alternative.

5.3.2.2 Proposed Bypass Channel Alternative

Loss of a diversity of high-quality habitat patches would occur and potentially affect wildlife under the Bypass Channel Alternative, while disturbance from construction activities, which would last approximately 28 months, would also result in moderate temporary impacts.

Joe's Island would be fundamentally altered by the Bypass Channel Alternative. Joe's Island and the adjacent mainland include all wildlife habitats found in the greater study area. Because they are relatively high in quality, and would experience both short-term and long-term impacts from this action, the resulting effects on wildlife may be locally widespread and substantial, but scaled-down when considering their regional impact.

All anticipated impacts to wildlife from the Bypass Channel Alternative would be concentrated in Dawson County, Montana, and likely cause the degradation of County-regulated and protected wildlife resources, including big game winter range, waterfowl nesting areas, habitat for rare or endangered species, and wetlands (Dawson County, Unknown year; MFWP 2012). Big game winter range for mule deer, white-tailed deer, and pronghorn all occur in the project area and would be degraded by the Bypass Channel Alternative, and are also protected by the State of Montana (MFWP 2012). Impacts would generally be disturbance and elevated noise levels during construction, clearing of riparian trees and shrubs, and conversion of primarily grassland habitats to the new channel.

Wildlife disturbed by the construction activities is anticipated to be displaced from the area unharmed. The wide diversity of habitats that would be disturbed and locally large geographic footprint of the construction area, suggest a wide range of wildlife would be displaced by this alternative. The majority of these effects would occur on Joe's Island, which has a diversity of relatively high quality habitat patches. Because all habitat types identified in the study area would be subjected to construction disturbance, all associated wildlife species have the potential to be effected and displaced by this alternative. Sage grouse, if present, are well known to be sensitive to disturbance by large equipment use and construction activities such as those related to roadwork and rock quarries (summarized in Service 2015). This species, however, is likely not present in the study area (MSGWG 2005) and would not be affected by this alternative.

The presence of the new bypass channel and associated constructed features are the primary source of long-term impacts to wildlife under the Bypass Channel Alternative. Excavation would mostly occur within upland habitats, fundamentally altering their structure and capacity to host wildlife. Because the bypass channel would convey greater flows than the existing side channel, and would be perennial instead of seasonal, the portion of the Island located between it and the main channel would become somewhat isolated from terrestrial wildlife such as big game species, reducing its utility to support those taxa. In contrast, aerial species such as waterfowl and other birds, as well as bats, may benefit from this same isolation by the creation of refuge areas.

The filling of the upper section of the existing side channel would result in the loss of the existing riverine habitat in that area, including woody riparian and wetland, as well as adjacent terrestrial habitats reliant on existing hydrology. The lower section of the existing side channel would become a backwater. This would likely cause changes to vegetation, and the conversion and degradation of existing habitat in and adjacent to the channel. For example, barren land is a prominent feature adjacent to the right streambank of the existing side channel, making it likely to be degraded in quality due to the proposed stream channel alterations. The additional disposal of excavated material in the spoil area would cover and largely eliminate patches of several types of existing upland habitat. Native vegetation would be restored or allowed to reestablish on these disposal sites.

Several existing access roads would be improved under this action, and one that would be constructed along the north side of the river to allow access for heavy equipment during construction would be retained for long-term maintenance. Assuming all road improvements would be permanent, road use and public access under this alternative would likely result in long-term impacts from enhancing the fragmentation of habitats that they cross, because the roads would result in interruptions in otherwise contiguous habitat patches, and would be expected to facilitate vehicle use, increasing likelihood for disturbance and vehicle strikes.

Operation and maintenance activities would be spread through a relatively large and diverse area (specific acreages of loss are provided in Section 4.10), potentially affecting a wide array of wildlife. Maintenance and associated disturbance is likely to occur in all construction areas, where inspections would survey the constructed features for damage from ice and/or the spring freshet, and repairs could occur. Disturbance would extend into the existing rock quarry and access roads used to make needed repairs. Maintenance would also include the periodic removal of sediment deposited in the constructed bypass channel. Maintenance scheduling outside of that for the headworks would be largely as needed, but is anticipated to peak in summer following ice melt and reduction in flows, thus reducing the potential for disturbance during the breeding season. The operation and maintenance of the new headworks would continue to occur unchanged under this alternative, and result in the same negligible impacts on wildlife as those discussed under the No Action Alternative.

Although the bypass channel would be built to specifications established to support native fish species, there are several components that would prevent the final design from providing habitat that would support wildlife after construction, resulting in long-term impacts. These components are explicitly part of the design and collectively intended to ensure the stability of the constructed features. They include the placement of bank armoring riprap at 4 river bends and grade control structures consisting of buried riprap covered by gravel/cobble at the downstream and upstream ends of the bypass channel as well as at two intermediate locations. The fill material placed in the existing side channel would be suitable for the establishment of native upland vegetation. Taken together with the deposition of spoil materials in the spoil area under this alternative, approximately 30 acres of relatively high-quality wildlife habitat on Joe's Island would be degraded and/or eliminated by the excavation and deposition of substrate, resulting in a moderate long-term impact on wildlife.

The new weir would itself have little effect on wildlife. Maintenance of the new weir would be reduced relative to that of the existing structure. This would benefit wildlife by reducing the ongoing disturbance that occurs annually to repair damage caused by ice and/or high flows. This potential reduction in disturbance relative to existing conditions would also extend into the rock quarry that supplies the materials used for these repairs, which need to be accessed less often compared to existing conditions. This would likely also reduce the potential for harm to wildlife from vehicle strikes during maintenance periods.

Actions to minimize effects would include:

- Conduct pre-construction survey for wildlife prior to the start of each year's work. If wildlife are observed, identify the type and timing of use, and important biological information important to minimize impacts.
- If appropriate, establish construction buffers around sensitive wildlife, such as an active bird nests.
- At the start of construction, a wildlife biologist would provide awareness training to the construction crew to educate them on sensitive wildlife resources they may encounter during construction, and provide a protocol and contacts to call if any listed species or other sensitive wildlife are observed on site during construction.

- Areas potentially hazardous to wildlife will be adequately protected (e.g., fenced, netted) to prevent access that could lead to their harm.
- To protect wildlife and their habitats, project-related travel will be restricted to existing roads and easements. No off-road travel would occur, except with prior approval. Speed limits will be followed at all times and drivers should be cognizant of safely avoiding vehicle strikes. Species at particular risk to vehicle strikes include ungulates during crepuscular hours, various bird species, snakes, and small and mid-sized mammals. Driver safety remains paramount, and would be maximized by following this guidance for minimizing vehicle strikes of wildlife.
- Removal and/or degradation of specific habitat features identified as important to wildlife would minimized to the extent possible. Examples include large snags, patches of mature riparian forest, and native grassland and shrubland habitat.
- Wildlife-proof fencing will be used on reclaimed areas, if it is determined that wildlife species and/or livestock are impeding successful vegetation establishment.
- All riverbank disturbance areas will be inventoried for potential turtle nesting habitat. If turtle nesting habitat or evidence of turtle nesting is found in construction areas, construction in these areas will be restricted during June and July, or approved mitigation measures will be implemented.
- Effort would be made to reestablish native vegetation and habitat comparable to that disturbed and/or destroyed by construction activities. This would include minimizing the establishment of invasive plant species, which greatly degrade the quality of native habitats.

6.0 Potential Impacts on Special Aquatic Sites (Subpart E)

6.1 SANCTUARIES AND REFUGES

6.1.1 Existing Conditions

There are no sanctuaries or refuges in the study area.

6.2 WETLANDS

6.2.1 Existing Conditions

A diversity of wetland types are found within the study area, and are classified according to Cowardin et al. (1979). Floodplain and depressional wetlands have formed primarily from alluvial processes. Willow shrublands are found in floodplains, around beaver ponds and lakes, and non-willow shrublands are found in springs and seeps along streams (Jean and Crispin 2001).

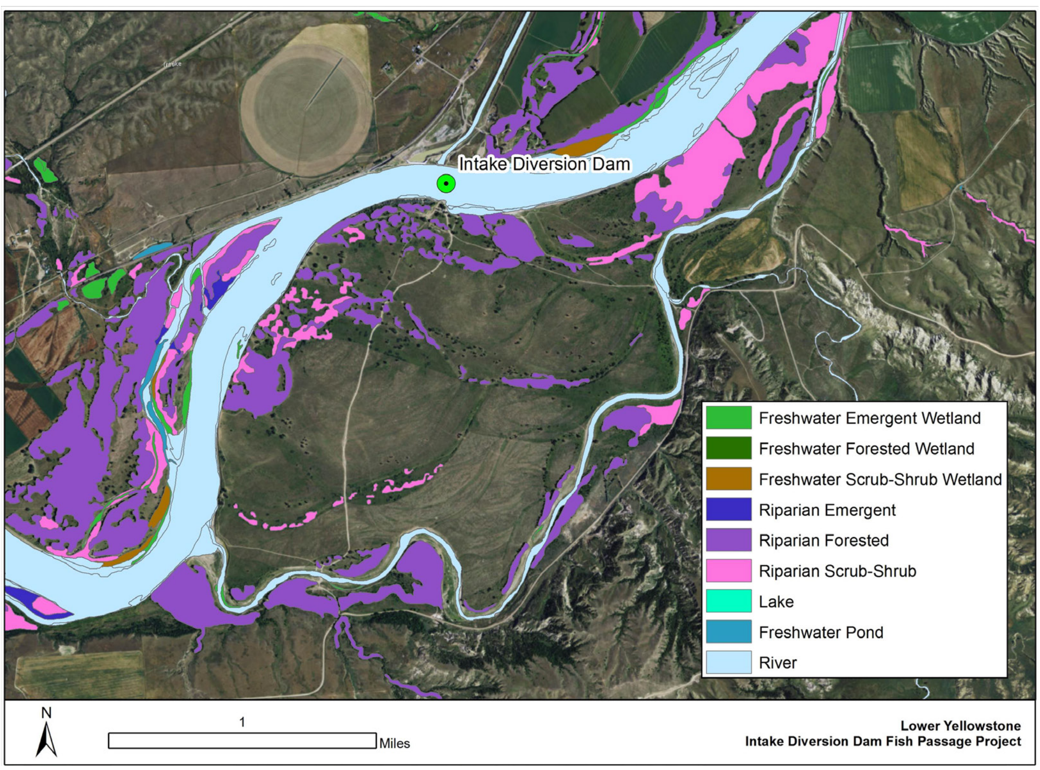

Figure 6.1 Riparian Areas and Wetlands in the Study Area

Palustrine emergent wetlands are the most common type of wetlands in the study area and typically contain persistent erect, rooted herbaceous vegetation. Depressional wetland can be either open or closed, depending on whether the water source is connected to groundwater or surface draining systems or completely isolated from drainage systems (McIntyre et al. 2010).

Dominant graminoids found in these types of wetlands include foxtail barley (*Hordeum jubatum*) and western wheatgrass (*Pascopyrum smithii*) on drier sites; and bulrush (*Schoenoplectus* spp.), sedges (*Carex* spp.), cattails (*Typha* spp.), and bluejoint reedgrass (*Calamagrostis canadensis*) on wetter sites (Corps and YRCDC 2015). Halophytic species such as saltgrass (*Distichlis spicata*) and Nuttall's alkaligrass (*Puccinellia nuttalliana*) occur on sites with saline soils.

Palustrine scrub-shrub wetlands are associated with streams and rivers within the study area. These types of wetlands are dominated by woody vegetation less than 20 feet tall. Native species in scrub/shrub wetlands are red-osier dogwood (*Cornus sericea*), chokecherry (*Prunus virginiana*), western snowberry (*Symphoricarpos occidentalis*), silver buffaloberry (*Shepherdia argentea*), silverberry (*Elaeagnus commutata*), sandbar willow (*Salix exigua*), peach-leaf willow (*Salix amygdaloides*), several cottonwood species (*Populus* spp.), and Rocky Mountain juniper (*Juniperus scopulorum*) (Corps and YRCDC 2015). In many cases, this wetland type represents transitional plant communities of younger age classes of forest communities.

Palustrine forested wetlands are dominated by trees taller than 20 feet and are typically classified as seasonally flooded. Cottonwood species are the tallest and most visible native woody species, Great Plains cottonwood (*Populus deltoides*) being the dominant species. Other native woody species such as peach-leaf willow, sandbar willow, yellow willow (*Salix lutea*) and green ash (*Fraxinus pennsylvanica*) are present throughout (Corps and YRCDC 2015).

Riverine wetlands include lower perennial unconsolidated bottom wetlands which are low gradient and have a slow water velocity. Substrates in this system are predominantly sand and mud and floodplains are usually well developed. Also present are lower perennial unconsolidated shore wetlands which are the shorelines to low gradient rivers that have less than 75% areal cover of stones, cobbles, boulders or bedrock and less than 30% vegetative cover. These shorelines are also irregularly exposed due to flooding and drying.

Mountain alder (*Alnus incana*), water birch (*Betula occidentalis*), and Western snowberry (*Symphoricarpos occidentalis*), silver sagebrush (*Artemisia cana*), chokecherry, and red-osier dogwood are common along riverine floodplains (Corps and YRCDC 2015).

The Corps conducted a wetland delineation in the study area in 2012 (Corps 2015c). This field investigation confirmed the presence of a seep spring, wetlands, and intermittent waterway near the western boundary of the waste pile site in a drainage way that connects to a side channel of the Yellowstone River. The side channel of the Yellowstone River that flows around Joe's Island had a gravel/cobble bed that was intermittently exposed and contained patchy emergent wetlands. Flow was not apparent during the investigation.

6.2.2 Potential Impacts

6.2.2.1 No Action Alternative

There would be no effects on wetlands resulting from the No Action Alternative.

6.2.2.2 Proposed Bypass Channel Alternative

Impacts to wetlands or waterbodies adjacent to the Yellowstone River would include the construction of the new weir upstream of the existing weir, excavation of the bypass channel, bank modifications near the downstream entrance to the bypass channel, and filling of upstream portions of the existing side channel.

Weir construction would result in disturbance of approximately 3 acres of the river with riprap and cobble fill being placed in the river to stabilize the existing and new weirs. This impact on the riverine habitat will be minimal, as there is already large rock present in the low quality riverine habitat at the existing weir area, which would be converted to a shallower smaller rock substrate. There will be temporary effects on velocities and depths as the river is diverted from one side to the other with coffer dams.

Bank modifications on both the right and left banks of the downstream portion of the bypass channel would result in approximately 2 acres of fill being placed in the Yellowstone River at the scour hole and where the current eddy forms on the south bank of the river – this fill is to send the flow from the bypass channel towards the main channel and reduce the eddy in the river. The placement of the excavated material from the bypass channel as fill in the existing high flow channel would eliminate approximately 66 acres of existing seasonal riverine side channel and backwater habitat. These acres will be offset by the creation of approximately 64 acres of year-round riverine habitat that will be created by the excavation of the new channel. The bypass channel habitat will be more functional for fish, mussels, and macroinvertebrates as there will be year-round flow.

Approximately 1 acre of palustrine emergent wetlands would be permanently filled by the placement of fill in the existing side channel. This acre of palustrine emergent wetlands will be offset by the development of up to 30 acres of backwater emergent wetland habitat along the downstream portion of the existing side channel.

For operation and maintenance actions on the new weir and bypass channel, temporary access would occur on existing access routes, thus effects on wetlands would be negligible. The impacts would be minor to riverine habitat associated with temporary disturbance by occasionally placing rock at the new weir. The need for rock replenishment would be substantially reduced from the existing condition resulting in much less frequent maintenance activities.

Periodic replacement of riprap along the banks and bottom of the bypass channel could have temporary impacts on riverine habitat and adjacent wetlands by placement of riprap. The area of impact would be minimal and infrequent as the rock is designed to withstand expected velocities. Bypass channel maintenance may require a temporary coffer dam for removal of accumulated sediment. Temporary coffer dams could temporarily impact riverine habitat and wetlands, but the impact would be minor.

Actions taken to minimize effects would include:

- The disposal of waste material, topsoil, debris, excavated material or other construction related materials within any wetland, drainage way, stream or aquatic system would be minimized to the extent possible.
- Discharges of fill material associated with unavoidable crossings of wetlands or intermittent streams will be minimized to the maximum extent practicable.
- Low pressure equipment or pressure-spreading mats will be used as feasible to minimize compaction of wetland soils during construction.
- Rock quarry materials will come from approved upland sites.

6.3 MUDFLATS

There are no mudflats within the study area as defined in 40 CFR §230.42 as "broad flat areas along the sea coast and in coastal rivers to the head of tidal influence and in inland lakes, ponds, and riverine systems."

6.4 VEGETATED SHALLOWS

Vegetated shallows are defined in 40 CFR §230.43 as "permanently inundated areas that under normal circumstances support communities of rooted aquatic vegetation, such as turtle grass and eelgrass in estuarine or marine systems as well as a number freshwater species in rivers and lakes." All existing vegetation in the study area would be considered emergent rather than rooted aquatic vegetation.

6.5 CORAL REEFS

There are no coral reefs in the study area.

6.6 RIFFLE AND POOL COMPLEXES

6.6.1 Existing Conditions

The Yellowstone River has naturally wide, shallow flows over sand and gravel substrate. Pools and riffles are formed by the natural hydrograph of high velocity spring flows interacting with the channel bed and shoreline. The presence of the Intake Diversion Dam alters that natural pool and riffle formation process, creating one large backwater pool behind the weir and one long riffle extending 300 feet downstream and spanning the 700 foot width of the river.

6.6.2 Potential Impacts

6.6.2.1 No Action Alternative

Under the No Action Alternative, the existing Intake Dam would continue to create a backwater pool behind the weir. The annual placement of rock along the weir crest would ensure continued presence of the rock/rubble field riffle.

6.6.2.2 Proposed Bypass Channel Alternative

Replacement of the existing weir with a concrete weir would not change the configuration of pools and riffles in the main channel.

Placement of fill in the existing side channel would eliminate side channel habitat and therefore any riffle and pool complexes present in this channel. However, this channel only conveys flows occasionally (at or above 20,000 cfs in the river), so if any riffle and pool complexes are present, they are likely to be of low quality due to sediment deposition and only occasional inundation. Construction of the new bypass channel would generally be similar to substrate and channel configurations present in natural side channels in the Yellowstone River.

7.0 Potential Effects on Human Use Characteristics (Subpart F)

7.1 MUNICIPAL AND PRIVATE WATER SUPPLIES

7.1.1 Existing Conditions

7.1.1.1 Lower Yellowstone Irrigation Project (LYP)

These districts and Reclamation jointly hold the following unadjudicated irrigation water rights in the state of Montana totaling 1,374 cubic feet of water per second (cfs):

- 1,000 cfs (Water Right No. 42M 40806-00)
- 300 cfs (Water Right No. 42M 40807-00)
- 18 cfs (Water Right No. 42M 40808-00)
- 42 cfs (Water Right No. 42M 40809-00)
- 14 cfs Provisional Permit (Savage Irrigation District only; Permit No. 97792-42M)

The period of use on the LYP water right is April 15 - Oct. 15, and Savage Irrigation District from April 1 - Oct. 31 (MDNRC, 2016). The oldest of these claims has a Priority Date of 1905 and a flow rate of 1,000 cfs. In addition to the 1,374 cfs claimed, LYP claims an additional 62.49 cfs for other water rights at Intake that include Stock watering and Domestic and Industrial Use.

The Intake Diversion Dam is maintained and operated by the Board of Control of the LYP. The LYP provides irrigation to about 58,000 acres of farmland along the Lower Yellowstone River. Acreage irrigated by the LYP is generally located between the main canal and the river in the Montana counties of Dawson and Richland, we well as in McKenzie County, North Dakota. The majority of the water is diverted between April 15 and October 15 each year.

The LYP facilities are owned by the Bureau of Reclamation but are operated and maintained by the water users via irrigation districts and the Board of Control of the LYP. The members of the Board of Control include Intake Project (Intake Irrigation District), Savage Unit of the Pick-Sloan Missouri Basin Program (Savage Irrigation District), and the Lower Yellowstone Irrigation Project Divisions One and Two (Lower Yellowstone Irrigation Districts One and Two). All of the irrigation districts obtain water from the LYP's main canal.

Most of the land that can by irrigated by the LYP is between the canal and the river. Since the early 1950s, both the agricultural economy and lands served by the LYP have remained relatively stable. In contrast to a dry-land farming trend towards larger, consolidated farms, the number of farm units on the LYP has dropped only slightly. Until recently, the primary irrigated crop was sugar beets with some small grains, alfalfa, and corn. Recently commodity prices have caused a shift to more corn and small grain production, with a corresponding decline in sugar beet acreage, though sugar beets are still the highest value crop, accounting for over half the total crop revenue in 2014 (Lower Yellowstone Project Board of Control 2009).

7.1.1.2 Tribal Water Rights

The United States government has recognized through the Winters Doctrine that tribes in the western United States (west of the Mississippi) may hold rights to water in streams running through or alongside the boundaries of their reservations (U. S. Supreme Court decision *Winters v. United States,* 1908). The Winters Doctrine will apply to any Indian water rights in Montana or along the Missouri River. When a reservation is established with expressed or implicit purposes beyond agriculture, such as to preserve fishing, then water may also be reserved in quantities to sustain use (U.S. Supreme Court *Arizona v. California* 1963). The Court held that tribes need not confine the actual use of water to agricultural pursuits, regardless of the wording in the document establishing the reservation. However, the amount of water quantified was still determined by the amount of water necessary to irrigate the "practicably irrigable acreage" on a reservation. The Court also held that the water allocated should be sufficient to meet both present and future needs of the reservation to assure the viability of the reservation as a homeland. Case law also supports the premise that Indian reserved water rights are not lost through non-use.

7.1.2 Potential Impacts

Under either the No Action or Bypass Channel Alternatives, Tribal water rights and irrigation needs would be protected as required.

7.2 RECREATIONAL AND COMMERCIAL FISHERIES

7.2.1 Existing Conditions

Recreation in the vicinity of Intake Diversion Dam and downstream to the Missouri River includes hunting, fishing, boating, camping, picnicking, walking/hiking, and scenic and wildlife viewing within recreation areas located along the river. Recreation facilities range from open space with no amenities to established camping areas water and vault toilets.

Game fish in the Lower Yellowstone River include paddlefish, shovelnose sturgeon, walleye, sauger, catfish, bass, and trout. The protected pallid sturgeon must be released if caught. Fishing is a popular activity on the river along the whole length between Intake and the state line. The City of Sidney has two annual catfish tournaments, and two additional tournaments were proposed in 2015, one at Miles City, and one at Savage (Corps and YRCDC 2015).

The most popular game fish is the paddlefish, with nearly half of the annual visitation to the site occurring during the paddlefish season, which occurs during May and June. Visitors enjoy paddlefish snagging as a family tradition, and visitors come from all over, including other states, to participate in paddlefish snagging.

Paddlefish anglers come from all over the state to participate in the sport at Intake. Paddlefish congregate on the downstream side of the Intake Diversion Dam, presenting a very accessible location for paddlefish snagging. Fishing by boat is prohibited within a quarter-mile downstream of the weir during paddlefish season.

The MFWP monitors the number of paddlefish caught and closes the season when the quota is met. In 2015, the total quota was 1,000 paddlefish caught in the Missouri River downstream of

Fort Peck Dam and the Yellowstone River. Intake FAS has its own annual limit of 800 fish. In 2015, the harvest season lasted from May 15 through June 3, with catch-and-release closing on June 13 (Stuart 2015). The 2015 season was atypically long at Intake. In some years, the quota is met in a week (Reclamation and Corps 2015).

Montana law prohibits commercialization of fish and wildlife; however, special state legislation authorizes a MFWP-designated Montana non-profit corporation to accept paddlefish roe donations and process and market the roe as caviar. The MFWP issues a yearly memorandum of understanding to one non-profit corporation for this opportunity, which has been the Glendive Chamber of Commerce and Agriculture since the inception of the program in 1990.

7.2.2 Potential Impacts

7.2.2.1 No Action Alternative

Future recreational fishing activities will remain the same without the proposed project.

7.2.2.2 Proposed Bypass Channel Alternative

The Bypass Channel alternative would have a variety of adverse effects on recreation resources in the study area during construction, most of which are concentrated at Intake FAS and Joe's Island. Temporary effects on the quantity and quality of recreation from the presence of construction activities are judged to minor to moderate, and less than significant. To the extent possible, construction activities will be minimized within, or occur outside of, the Intake FAS area during the paddlefish season.

From the perspective of effects on recreation, the operation of the Bypass Channel would result in mostly beneficial effects. Beneficial effects on recreation from the Bypass Channel include the creation of additional channel area that would be open for recreation use, including boating. A navigable bypass channel would also provide boaters easier access to the upstream side of the Intake Diversion Dam from the Intake FAS boat ramp. Visitation to Joe's Island may also increase in the short term as visitors explore the new channel.

The bypass channel could also improve fishing opportunities upstream of the Intake Diversion Dam. Paddlefish would still be expected to stack up downstream of the Intake Diversion Dam, but would also have the opportunity to move further upstream. Paddlefish could potentially travel as far upstream as the Cartersville irrigation dam, at Forsythe (RM 238.6). Upstream spawning by paddlefish could result in an increase in paddlefishing opportunities upstream of Intake over the long term, which would in turn increase visitation and use of upstream fishing access sites. In the short term, beneficial effects may be minor to moderate as anglers monitor and adapt to changes in the recreational fishery.

With changes in the location of fishing opportunities, and a potential reduction in the availability of fish at the downstream end of the Intake Diversion Dam, use of the Intake FAS may be reduced. Overall, the adverse operational effects of the selected alternative on recreation would be minor and less than significant, while there would be moderate beneficial effects.

Additional actions to minimize effects identified for the Bypass Channel alternative include:

- Reclamation and MFWP would meet to evaluate and coordinate closures at the FAS and Joe's Island to recreational use, including closure of construction zones to swimming, fishing, boating, hiking, camping, hunting, etc. on one or both sides of the river.

7.3 WATER RELATED RECREATION

7.3.1 Existing Conditions

Boating is allowed on the lower Yellowstone River, and access is provided via boat ramps at the various fishing access sites on the river. The Intake FAS provides a concrete boat ramp below the weir. The nearest upstream access is at the Black Bridge FAS, in Glendive, which has a concrete boat ramp. Downstream of Intake, the Elk Island FAS provides a gravel boat ramp at the downstream end of the site, and an older concrete ramp at the upstream end of the site that may not be usable except during high flows.

Boaters occasionally pass downstream over Intake Diversion Dam. Most boaters launching from the Intake FAS are heading downstream for fishing, hunting, boat touring, or pulling persons on inner tubes or other flotation devices. Waterskiing is not a popular recreational activity at Intake FAS. Intake FAS may also be used by boaters to access Joe's Island.

Activities other than fishing and boating that visitors may engage in at the study area include swimming, wildlife viewing, ice fishing, picnicking, and other general day uses, such as nature appreciation, that are dependent or enhanced by the river's presence. Swimming may be dangerous near Intake due to rough water and submerged obstacles, and is discouraged by posted signs. Picnicking and day use facilities are open to the public at no cost, and may be used throughout the year. While most fishing visitation occurs during the spring, summer, and fall, anglers do engage in ice fishing during the winter. Because of the weir, the river does typically freeze over at Intake FAS, and anglers typically fish upstream or downstream of the weir.

7.3.2 Potential Impacts

7.3.2.1 No Action Alternative

No changes to boating opportunities will result from the No Action Alternative.

7.3.2.2 Proposed Bypass Channel Alternative

During construction, the Intake FAS will remain open to boaters. Following construction, there will be no change in the availability of boat access from the Intake FAS. Navigation above the Intake Diversion Dam will remain available as it is now and safety may be slightly improved with the concrete weir. Boating would also be possible through the bypass channel. During construction, Joe's Island will be closed to visitors, but will reopen after the project is completed.

7.4 AESTHETICS

7.4.1 Existing Conditions

From points on and near the Intake Diversion Dam, views would include the wide, turbid stretch of the Yellowstone River, industrial headworks at the entrance of the main canal and the canal itself, a network of unpaved roadways, lands with exposed dirt, rock and sand shoreline along the river, agricultural lands and sparse cottonwood gallery and other vegetation communities. In winter, snow and ice may cover the area, creating a white expanse dotted by defoliated trees. In summer, the study area has a dichotomy of aesthetics, with areas around the canal and headworks having a barren and industrial appearance in contrast to the river and green cottonwood galleries providing a more natural look. On the south shore of the river, sandy shorelines, grasslands, shrublands, and cottonwood gallery comprise the visual environment. Distant views from higher points within the site are of the low elevation bluffs that are part of the Great Plains Badlands. Joe's Island is directly south of the Intake Diversion Dam and is an approximately 1,400 acre island formed by a side channel to the Yellowstone River. The island topography is shaped by overbank flooding and formation of side channels. Cottonwoods and other riparian trees and vegetation occupy the depressions where these old side channels once flowed, while a combination of native and non-native prairie and shrub steppe occupy the remaining areas. There are no homes, but a modest network of dirt roads provides access to most of the island, including the right bank cableway tower. Distant views of low badlands bluffs can be seen to the south. Visitors to this area would primarily and most often include recreationists.

7.4.2 Potential Impacts

7.4.2.1 No Action Alternative

There would be no changes to the study area under the No Action Alternative, and therefore, no changes to visual resources.

7.4.2.2 Proposed Bypass Channel Alternative

Construction of the new weir for the Bypass Channel Alternative would result in changes to visual conditions during and after construction. These include the temporary presence of mobile and fixed construction equipment onsite at Intake FAS and Joe's Island, for an estimated three years, which would vary with season and would be experienced by a variety of viewer groups. Once construction is complete, most areas disturbed for weir construction would be returned to pre-construction conditions via reseeding and equipment removal. Overall, construction of the Bypass Channel Alternative is expected to have a moderate and less than significant effect on visual conditions.

New permanent features would include the bypass channel with armoring, infill of the existing side channel, placement of spoils, and access roads. The new bypass channel would receive a portion of the Yellowstone River flow on a year round basis. The existing side channel only conveys water during higher flows. In general, the overall visual condition would not change, since one high flow channel is replaced with another, with the new one operating similarly to the old one. Over time, revegetation would obscure traces of channel construction, eventually approaching a more natural appearance.

Measures taken to minimize effects at the project site would include:

- Minimize footprints of construction as much as possible to limit areas of effect.
- Restrict construction or staging from using areas that are subject to erosion.
- Minimize haul and access road use and improve those roads that would become permanent.
- Strategize construction schedule to minimize truck, equipment, and personnel presence.
- Minimize footprint of clearing and grubbing to protect as much existing vegetation as possible.
- Minimize stream crossings and restore shoreline or instream habitat that are damaged.
- Mulch and reseed areas that are cleared after construction is complete to facilitate return to vegetated conditions.
- Limit operation and maintenance to annual or emergency basis to reduce onsite equipment and personnel.

7.5 PARKS, NATURAL AND HISTORIC MONUMENTS, NATIONAL SEASHORES, WILDERNESS AREAS, RESEARCH SITES, AND SIMILAR PRESERVES

7.5.1 Existing Conditions

There are no parks, natural or historic monuments, national seashores, wilderness areas, research sites or other similar preserves within the study area or vicinity.

7.6 OTHER FACTORS IN THE PUBLIC INTEREST

7.6.1 Cultural Resources

7.6.1.1 Existing Conditions

A total of 27 sites have been previously recorded within the study area (Table 7-1), three of which are within the APE of the Proposed Project: 24DW287, 24DW443, and 24DW447. (24DW287 and 24RL204 are both portions of the Lower Yellowstone Irrigation Project main canal in Dawson and Richland counties; however sections in different counties are given different identifying site trinomials.) All three resources are NRHP-eligible and considered historic properties for this analysis. It is unclear at this time if any of the resources recorded within the study area are within the alternatives.

- 24DW287 is the main canal of the Lower Yellowstone Irrigation Project, described above. The site is a contributing element to the Lower Yellowstone Irrigation Project Historic District and is considered an NRHP-eligible historic property.

- 24DW443 is the Lower Yellowstone Irrigation Project Diversion Dam, described above. The site is a contributing element to the Lower Yellowstone Irrigation Project Historic District and is considered an NRHP-eligible historic property.
- 24DW447 is the site of the Lower Yellowstone Irrigation Project Headworks Camp/Gate Tender Residence, described above. The site is a contributing element to the Lower Yellowstone Irrigation Project Historic District and is considered an NRHP-eligible historic property.

Table 7.1 Previously conducted surveys in study area

SHPO Document Number	Author	Date	Title
DW 6 2401	Herbort, Dale P.	1980	Cultural Resource Evaluation Belle Prairie and Box Elder Reservoir
DW 4 2348	Huppe, Katherine M.	1981	Cultural Resource Reconnaissance of a Portion of Montana Department of Highways Project FR20-1(1)19, Glendive-Sidney, and associated Materials Sources
DW 6 2406	Pearson, Jay, et al.	1981	A Class III Intensive Inventory for all Cultural Resources along the Proposed Route of the Montana -Dakota Utilities Cabin Creek to Williston Pipeline From the Sacomorgan Creek Line to the Richland-Dawson County Line
DW 6 2411	Aaberg, Stephen A.	1984	Intake State Recreation Area
RL 6 20052	Davis, Leslie B.	1984	1983 Effort, Nollmeyer (Letter Report to Dr. Ann Johnson, NPS)
RL 4 8931	Wood, Garvey C.	1985	Hilde Construction – Molly Eidness Pit (Pit 136-3)
DW 4 2352	Rossillon, Mitzi	1987	A Cultural Resources Inventory at the Bridge Over the Diversion Canal at Intake
RL 4 30084	Vinson, Edrie L.	1988	Lower Yellowstone Project Main Canal Bridge U.S. Reclamation Service 1907-1908
RL 6 13050	Coutant, Brad A.	1991	Fifteen Assorted Structures on the Lower Yellowstone Irrigation District, Richland County, Montana
DW 6 15872	Tingwall, Douglas, et al.	1994	Intake Fishing Access Site Class III Cultural Resource Survey Results
RL 4 15917	Platt, Steve	1994	District 4 MCS Sites
DW 6 23072a	Kordecki, Cynthia, et al.	2000	Lower Yellowstone Irrigation Project, 1996 and 1997 Cultural Resources Inventory, Dawson and Richland Counties, Montana and McKenzie County, North Dakota
RL 6 23550	Brumley, John H.	2000	A Cultural Inventory of 14 Bridge Projects Areas within Richland County, Montana
ZZ 6 23753a	Kordecki, Cynthia, et al.	2001b	Lower Yellowstone Irrigation Project, 1996 and 1997 Cultural Resources Inventory, Dawson and Richland Counties, Montana and McKenzie County in North Dakota
DW 4 24430	Aaberg, Stephen A. and Chris Crofutt	2002	30 KM Northeast of Glendive Northeast Class III Cultural Resource Survey Results In Dawson County and Richland County Montana
RL 6 24567	Vincent, William B.	2002	Notification of Undertaking – Proposed Replacement of a Deteriorated Chute at the Savage Spillway Structure and Associated Bridge in Richland County Montana
RL 6 30349	Boughton, John, et al.	2008	Williston Basin Interstate Pipeline Company: A Cultural Resource Inventory Along the Cabin Creek-Williston Pipeline, in Richland County, Montana

SHPO Document Number	Author	Date	Title
DW 6 34023a	Vincent, William B.	2009	Test Drilling Near the Lower Yellowstone Diversion Dam and Canal, Dawson County, Montana
DW 6 34030a	Vincent, William B.	2009	Intake Diversion Dam Modification, Lower Yellowstone Project
DW 6 34186a	Toom, Dennis, et al.	2011	Headworks Camp (24DW0447) Historic Site archaeological Excavations, Dawson County, Montana
RL 2 35413	Brooks, Brittany A.	2013	Weber 24-30-1H, 2H, 3H & 4H Well Pad and Access Road: A Class III Cultural Resource Inventory in Richland County, Montana
RL 6 34235	O'Dell, Kevin C.	2013	A Class III Cultural Resource Survey for Mercury Towers' Mt46467 Savage Communications Tower in Richland County, Montana
RL 6 36650	Person, Amanda C. and Wade K. Burns	2013	Lower Yellowstone Irrigation Canal/Drain Crossings: A Class III Intensive Cultural Resource Inventory in Richland County, Montana
RL 6 36909	Littlestrand, Eric and Wade K. Burns	2013	Balducki, Yellowstone Farms, and Oberfall Borehole Locations: A Class III Intensive Cultural Resource Inventory in Richland County, Montana
RL 6 37204	Livers, Michael C.	2013	Lower Yellowstone Irrigation Project PW # 1442 DR 1996: A Cultural Resource Survey for the Lateral HH Replacement Project, Richland County, Montana
ZZ 5 34260	Rennie, Patrick	2013	Cultural and Paleontologic Resources Inventory of Six Parcels of State Land in Custer, Garfield and Richland Counties
RL 2 37039	Brooks, Brittany A.	2014	Asbeck 12-31-1H, Asbeck Federal 13-31-2H, 13-31-3H, and 13-31-4H Well Pad and Access Road: A Class III Intensive Cultural Resource Inventory in Richland County, Montana

a. Survey conducted within APE of Proposed Project.
b. Survey ZZ 6 23753 is listed in SHPO's database with a date of 2001. However, the report title page indicates a date of 2000. Therefore, the report is referenced in this document as Kordecki, et al. (2000).

Kordecki, et al. (2000; Survey Report ZZ 6 23753) documents a survey of the Lower Yellowstone Irrigation Project completed in 1996 and 1997 as part of compliance efforts ahead of the 2010 EA. Kordecki, et al. (2000; Survey Report DW 6 23072), Vincent (Test Drilling Near the Lower Yellowstone Diversion Dam and Canal, Dawson County, Montana 2009), and Vincent (Intake Diversion Dam Modification, Lower Yellowstone Project 2009) are Section 106 consultations that were based on the work of Kordecki, et al. (2000; Survey Report ZZ 6 23753).

The systematic pedestrian survey of Kordecki, et al. (2000; Survey Report DW 6 23072) covered all linear features (i.e. canals and laterals) of the irrigation system as well as all Reclamation-owned and administered lands along the system that had not been previously surveyed. Survey of the system's linear features totaled 288 miles: 71.6 miles of main canal and 202 miles of laterals. The Reclamation-owned and administered lands were surveyed in 12 blocks totaling 3,082 acres. The survey identified a total 12 historic engineering and architectural sites directly related to the Lower Yellowstone Irrigation Project (in addition to several bridges associated with the initial construction of the system) and 25 prehistoric archaeological sites (20 newly recorded and five previously recorded sites that were updated by the survey). The historic sites include the Lower Yellowstone Diversion Dam (24DW443), the Lower Yellowstone Main Canal and Lateral System (24DW287/24RL204/32MZ1174), the Savage Sluiceway (24RL142), the Intake Pumping Plant (24DW446), the Thomas Point Pumping Plant (24RL231), the Savage Irrigation Unit (24RL275), the Headworks Camp/Gate Tender Residence (24DW447), the Crane Canal Rider Residence (24RL277), the Savage Headquarters Camp (24RL209), the Ridgelawn Camp

(24RL80), the Fairview Canal Rider Residence (24RL208), and the Lateral LL Reclamation Building (24RL283). These sites represent a NRHP-eligible historic district, although the pumping plant component of the Savage Irrigation Unit and the Crane Canal Rider Residence are not considered contributing elements to the district.

Toom, et al. (2011; Survey Report DW 6 34186) documents a large-scale data recovery archaeological excavation at the Headworks Camp (24DW447). The excavations were conducted as mitigation for impacts related to the Project as proposed in the 2010 EA and 2015 Supplemental EA and as required by the 2010 memorandum of agreement discussed above. The excavation sought to examine the relationships between structural features, status-diagnostic artifacts, and social stratification within the camp, as reflected in the archaeological record. Although many period artifacts of interest were recovered, very few structural features of original camp buildings, such as foundations, were found, making it impossible for the researchers to achieve their primary goal of answering questions of social stratification.

7.6.1.2 Potential Impacts

No Action Alternative

No changes would result to cultural resources under the No Action Alternative.

Proposed Bypass Channel Alternative

Direct, major impacts are anticipated during construction under this alternative as a result of the excavation of the bypass channel and use of the stockpile area and haul roads. The alignment of the bypass channel would require relocation of the historic south rocking tower and boiler building on Joe's Island, both of which are features of 24DW0443. Although the structure and building would not be destroyed, their removal from their historic location and setting would be considered adverse effects under Section 106 of the NHPA. This impact was considered under the previous Final and Supplemental EAs in 2010 and 2013. Mitigation for the impact was agreed upon in the June 2010 Memorandum of Agreement, which resulted in documentation of the buildings and structures. The parties to the Memorandum were to consult and determine if any additional or different mitigation was warranted. Until the Memorandum is re-initiated and the additional consultations completed, the potential for direct, major impacts remains.

The proposed locations of the coffer dams at the upstream entrance and downstream exit of the bypass channel as well as the around the new weir is unclear at this time. Although impacts at the upstream entrance are not anticipated due to a lack of recorded cultural resources there, impacts at the downstream exit may occur if the coffer dam is placed over and into the existing weir. One of the haul/access roads to be improved passes through the northern boundary of 24DW0296. Although the road is existing, widening of it within the site boundaries may result in adverse effects under Section 106 of the NHPA. Sites 24DW0430, 24DW0431, and 24DW0442 are within the footprint of the stockpile area. Site 24DW0431 is also partially within the staging area, however impacts to this NRHP-ineligible resource would not be considered adverse under Section 106. While capping of sites 24DW0430 and 24DW0442 could be considered beneficial and protective impacts, it also makes access to the resources difficult for future study or traditional use. Further, if construction equipment were to drive across the sites while depositing materials or otherwise disturb the sites, it would be considered an adverse effect under Section

106 of the NHPA. The above described adverse effects would also be considered direct, major impacts under NEPA.

Excavation of the channel would be extensive. Although the entirety of the construction footprint has been surveyed for cultural resources (outside of active river channels), there is potential for intact subsurface archaeological resources to exist within this alluvial island. Disturbance of these potential historic properties would be considered an adverse effect under Section 106 of the NHPA and a direct, major impact under NEPA.

Measures taken to minimize effects to cultural resources would include:

- MM-CR-01: Impacts on Intake Diversion Dam (24DW0443) may be mitigated to minor or moderate through detailed recording of the structure. Engineering drawings and photographs of the dam would be filed with the SHPO and National Archives. If engineering drawings and photographs are unavailable, the dam would be recorded in accordance with the Historic American Buildings Survey and the Historic American Engineering Record.
- MM-CR-02: Impacts on the Old Cameron and Brailey Sub Camp (24DW0298) may be mitigated to no effect through avoidance. If avoidance is infeasible, impacts may be mitigated to moderate through data recovery of the archaeological site under an approved research design.
- MM-CR-03: Potential impacts on unidentified cultural resources in unsurveyed portions of the APE may be reduced to no effect through avoidance of unsurveyed areas. If avoidance is infeasible, impacts may be mitigated to minor or moderate by surveying such areas within the APE. Additional mitigation measures may be necessary to avoid impacts on newly identified resources/potential historic properties as a result of the survey.

7.6.2 Activities Affecting Coastal Zones

There are no coastal zones within the study area.

7.6.3 Navigation

7.6.3.1 Existing Conditions

Recreational boating is allowed on the Yellowstone River. There is no commercial use of the river.

7.6.3.2 Potential Impacts

No Action Alternative

No changes to boating opportunities will result from the No Action Alternative.

Proposed Bypass Channel Alternative

During construction, the Intake FAS will remain open to boaters. Following construction, there will be no change in the availability of boat access from the Intake FAS. Navigation above the Intake Diversion Dam will remain available as it is now and safety is likely to be improved with the new concrete weir. The bypass channel would also be available for boating. Actions taken to minimize effects would be the same as those for Section 7.2 Recreational and Commercial Fisheries.

8.0 Evaluation and Testing of Discharge or Fill Material (Subpart G)

The evaluation procedures and testing sequences outlined in Subpart G are intended to support the determinations concerning the suitability of the material proposed for discharge into waters of the United States.

8.1 GENERAL EVALUATION OF DREDGED OR FILL MATERIAL

All materials discharged as fill would be obtained from on-site or a source that meets the standards for suitability of material. This would generally mean that any materials imported to the project area would have low or non-detectable levels of contaminants that are not expected to have significant adverse impacts on water quality or biota in the short or long term.

9.0 Actions to Minimize Adverse Effects to the Aquatic Environment (Subpart H)

9.1 GENERAL

The overall outcome of the proposed Bypass Channel Alternative is beneficial to the endangered pallid sturgeon, as well as other fish species that would benefit from providing upstream passage above the Intake Diversion Dam. However, there may be adverse effects resulting to aquatic resources as a result of construction or operation. General conservation recommendations include a variety of measures intended to minimize the adverse effects to each of the aquatic environment. Specific measures to avoid or reduce the effects of construction have been included above for each applicable resource area, as described in Sections 4, 5, 6, and 7. General or additional details are provided below.

a. Work Window. To minimize effects to pallid sturgeon or other sensitive fish species, construction shall primarily occur during summer low flows or other low flow periods outside of the migration period (April 15 to July 1).
b. Notice to Contractors. Before beginning work, all contractors working on site shall be provided with a complete list of permit conditions, reasonable and prudent measures, and terms and conditions intended to minimize the amount and extent of take resulting from in-water work.
c. Minimize Impact Area. The applicant will confine construction impacts to the minimum area necessary to complete the project.
d. Fish Capture and Removal. Whenever work isolation is required and ESA-listed fish are likely to be present, the applicant must attempt to capture and remove the fish as follows:
   i. A fishery biologist experienced with work area isolation and competent to ensure the safe capture, handling and release of all fish will supervise this part of the action.
   ii. Any fish trapped within the isolated work area must be captured and released using methods prudent to minimize the risk of injury, then released at a safe release site.
e. Pile Driving. Pile driving will only occur outside of the pallid sturgeon migration season (April 15-July 1) and vibratory pile driving shall be used to the maximum extent practicable.
f. Pollution Control Plan. The applicant will implement a pollution control plan (PCP) to prevent pollution caused by construction activities from entering the river. The PCP must have the following components:
   i. The name and address of the party responsible for accomplishment of the PCP.
   ii. Practices to prevent contaminant releases associated with equipment and material storage sites and fueling staging areas.

iii. A description of any regulated or hazardous products or materials that will be used for the project, including procedures for inventory, storage, handling, and monitoring.
iv. A spill containment and control plan with notification procedures, specific cleanup and disposal instructions for different products, quick response containment and cleanup measures that will be available on the site, proposed methods for disposal of spilled materials, and employee training for spill containment.
v. Practices to prevent debris from dropping into any stream or waterbody, and to remove any material that does drop with a minimum disturbance to the streambed and water quality.
vi. During construction activities, monitoring will be done as often as necessary to ensure the controls discussed above are working properly. If monitoring or inspection shows that the controls are ineffective, work crews will be mobilized immediately to make repairs, install replacements, or install additional controls as necessary.

g. The applicant will maintain an absorptive boom during all in-water activities to capture contaminants that may be floating on the water surface as a consequence of construction activities.

9.2 MONITORING, ADAPTIVE MANAGEMENT, AND MAINTENANCE

In order to ensure the effectiveness of the proposed bypass channel, Reclamation will implement a long-term monitoring and adaptive management plan. A plan was developed in 2015 (Reclamation 2015) and is being implemented to determine the effectiveness of the headworks and screens that were designed to reduce entrainment into the main irrigation canal. The plan developed in 2015 was designed to evaluate key project uncertainties related to the design, performance, and biological response of pallid sturgeon and other fish species. The Service has developed further biological criteria that would indicate success of the proposed bypass channel (Service 2016) based upon the overall goal of unimpeded movement by pallid sturgeon through the free-flowing Lower Yellowstone River. Thus, a revised monitoring and adaptive management plan (see Appendix E of the EIS) has been prepared to address both the physical and the biological criteria that would indicate success of the project and are summarized below.

Objective 1: Construct and maintain appropriate physical criteria parameters that allow pallid sturgeon passage.. The physical criteria are:

Objective 1a - Depth

1) Minimum depths in fish passageway measured at the lower discharge range of 7,000 cfs to 14,999 cfs at any sampled cross-section must be greater than or equal to 4.0 feet across 30 contiguous feet of the measured channel cross section profile.

2) Minimum depths in the fish passageway measured at the discharge range of 15,000 cfs to 63,000 cfs at any sampled cross-section must be greater than or equal to 6.0 feet across 30 contiguous feet of the measured channel cross sectional profile.

Objective 1b - Velocities
1) Mean cross-sectional velocities must be equal or greater than 2.0 feet/second, but less than or equal to 6.0 feet/second over the discharge range of 7,000 cfs to 14,999 cfs (equal to or less than 4.0 feet/second for a rock ramp).

2) Mean cross-sectional velocities must be equal or greater than 2.4 feet/second, but less than or equal to 6.0 feet/second over the discharge range of 15,000 cfs to 63,000 cfs (equal to or less than 4.0 feet/second for a rock ramp).

Objective 2: Upstream and downstream passage of pallid sturgeon

Objective 2a - Upstream Adult Passage

1) Greater than or equal to 85% of motivated adult pallid sturgeon (fish that move up to the weir) annually pass upstream of the weir location during the spawning migration period (April 1 to June 15) within a reasonable amount of time without substantial delay (≥0.19 miles/hour).

Objective 2b - Upstream Juvenile Passage

1) No Criteria Set - Develop decision criteria to trigger adaptive management options to improve passage for juveniles if the lack of juvenile passage is demonstrated to result in negative population level effects.

Objective 2c - Downstream Passage

1) Mortality of adult pallid sturgeon that migrate downstream of the weir location cannot exceed 1% annually during first 10 years. Document any injury or evidence of adverse stress.

Objective 2d – Pallid Sturgeon Free Embryo and Larval Downstream Passage

1) Assess impingement and entrainment of free-embryo, larval, and young-of-year sturgeon at headworks/screens, irrigation canal and downstream of the weir location.

Objective 3: Upstream and Downstream Passage of Native Fish

- Determine if native fish can migrate upstream and downstream of the weir location.

Objective 3a – Native Species Upstream Passage

1) Determine if native fish are migrating upstream of the weir location at a level greater than or equal to existing conditions.

Objective 3b – Native Species Downstream Passage

1) Determine if native fish are migrating downstream of the weir location at a level greater than or equal to existing conditions.

Objective 4: Reliable Delivery of Water for Irrigation (Pumping Alternatives Only)*

1) Determine if 1,374 cfs of water can be reliably diverted (Multiple Pump Alternative).

2) Determine if 608 cfs of water can be reliably diverted (Multiple Pumps with Conservation Measures).

*Objective 4 could be assessed under all alternatives however, past experience has shown that a diversion weir at elevation 1991.0 feet, as proposed under the rock ramp, bypass channel and modified side channel alternatives, generally meets current crop demands and enables 1,374 cfs to be diverted from the Yellowstone River. As discussed below there are questions whether the current design of the pumping alternatives would meet current crop demand or have the ability to divert the water needed by the Lower Yellowstone Project.

10.0 Analysis of Practicable Alternatives

The Lower Yellowstone Intake Diversion Dam Fish Passage Project Environmental Impact Statement provides an analysis of alternatives considered. The purpose of the project is to improve passage for pallid sturgeon, contribute to ecosystem restoration and maintain the viable and effective operation of the Lower Yellowstone Project. The Intake Diversion Dam hinders upstream passage of endangered pallid sturgeon and other native fish species. Sections 10.1 through 10.6 summarize the findings per the CWA Section 404(b)(1) alternatives analysis criteria.

10.1 WATER DEPENDENCE

Intake Diversion Dam and the associated Lower Yellowstone Project are necessarily water dependent as the entire purpose is to divert the water right of 1,374 cfs from the Yellowstone River for the purposes of irrigation to approximately 58,000 acres of farmland. Infrastructure to divert this quantity of water must be within or immediately adjacent to the river to accomplish this diversion. Fish passage is also necessarily water dependent. Any of the alternatives are thus, water dependent.

10.2 SITE AVAILABILITY

Pursuant to the CWA Section 404(b)(1) regulations, an alternative is practicable if it is available to meet and capable of meeting the project purpose, among other considerations. The regulations at 40 CFR 230.1(a)(2) state "an area not presently owned by the applicant, which could be reasonably obtained, utilized, expanded, or managed in order to fulfill the basic purpose of the proposed activity may be considered." The project area includes the Intake Diversion Dam and the lower Yellowstone River and could not be accomplished at a location distant from the river. All of the alternatives evaluated in detail in the EIS are located within or adjacent to the river.

The Rock Ramp and Bypass Channel alternatives can be constructed entirely on Reclamation owned lands or within the river.

The Modified Side Channel Alternative would require the acquisition of one parcel of land at the downstream end of the side channel (22 acres).

The Multiple Pump Alternative would require purchasing lands at each of the pump station locations and rights-of-way for pipes to deliver the water to the Main Canal (44.3 acres).

The Multiple Pumps with Conservation Measures Alternative would require acquisition of multiple parcels of land to site and install pumps, pipes, access roads, and electrical delivery infrastructure (280 acres). While the acquisition of lands does not render any of the alternatives impracticable, it adds to the time, difficulty, and risk of each of the alternatives that requires land acquisition.

10.3 COST EFFECTIVENESS

Pursuant to the CWA Section 404(b)(1) regulations, a determination of practicability must consider if fill or disposal can be accomplished at a reasonable cost (§230.10(a)(2)). All alternatives evaluated in the feasibility study require excavation, fill, and grading work in and adjacent to the Yellowstone River. To determine cost effectiveness, a cost effectiveness and incremental cost analysis (CE/ICA) was conducted to compare the costs and habitat benefits for each alternative. The proposed Bypass Channel Alternative is the most cost effective alternative to achieve all of the project objectives in a manner that is designed to avoid unacceptable adverse impacts to the aquatic ecosystem and other elements of the environment, and to balance human considerations.

The No Action Alternative does not meet the project purpose and need and continues the impediment to pallid sturgeon passage and does not provide an opportunity for potential spawning and recruitment.

The Rock Ramp Alternative is not cost effective and there are concerns about its effectiveness for fish passage as it does not meet the BRT criteria for depths and velocities that are likely to pass pallid sturgeon during all flows, particularly at flows above 30,000 cfs when pallid sturgeon are typically migrating upstream. Additionally, it is unclear whether turbulence can effectively be reduced to the point that pallid sturgeon would use it.

The Modified Side Channel Alternative was considered cost effective, but not a best buy plan because the bypass channel would provide more fish passage benefit for the cost. There are substantial concerns about its effectiveness for fish passage as the downstream entrance is located nearly 2 miles downstream of the weir and is located behind sand/gravel bars on the opposite bank of the river from the main channel where pallid sturgeon typically migrate.

The Multiple Pump Alternative is a best buy, but is substantially more costly than the next best buy option. While removal of the weir and rock in the river should be effective in providing pallid sturgeon passage, substantial costs and risks with pumps may not maintain a viable Lower Yellowstone Project and could cause substantial economic harm to some farms by doubling the per acre operation and maintenance cost assessment.

The Multiple Pumps with Conservation Measures Alternative was not cost effective or a best buy as the Multiple Pump Alternative would provide the same benefits at a lower cost. There are substantial costs and risks with Ranney Wells and implementation of the conservation measures that would not meet water supply demands. And, reducing the water diversion to 608 cfs would require farmers to shift crops and/or fallow some irrigated lands. In addition, the approximate 60% increase in per acre operation and maintenance cost assessment could cause substantial economic harm to some farms.

10.4 FEASIBILITY

The preferred alternative was determined to be the most practicable alternative considering cost, existing technology, and construction feasibility in light of the overall project purpose and need.

10.4.1 Technical Feasibility

The preferred alternative is constructible using common, existing technology and equipment. The construction contract was advertised and several bids were received in 2015. A construction contract had been let by the Corps for project construction in 2015, which is currently on hold.

The Rock Ramp Alternative has serious practicability concerns regarding the ability to construct and maintain a 1,200 foot long ramp within the river that will be sufficiently stable and durable to resist ice and high flow damages while maintaining the fish passage design features (low-flow channel and reduced turbulence) to allow fish passage.

The Modified Side Channel Alternative is constructible using common, existing technology and equipment.

The Multiple Pump Alternative has multiple practicability concerns, which are reflected in the high risk-based contingency assigned to the costs (35.4%). The existing irrigation canal was designed to be operated on gravity flow from the upstream end and operation with both gravity flows and pumps will be complicated and highly variable from year to year. For example, transferring from gravity inflows to pumped inflows would require highly precise timing on the startup and shutdown of each pump and monitoring the water level change at multiple points in the canal as it progresses downstream to avoid flooding or dewatering the system. Also, rapid drawdowns in the main canal can cause bank failures, so substantial monitoring will be required to prevent bank failures. This is technically feasible with an automated monitoring sensor system, but would result in greater costs and complexity for the irrigation districts and require rapid response to address problems. A recent study of pumping stations on the Yellowstone River (Performance Engineering 2016) indicated that the existing pumping stations have substantial annual damages and problems resulting from channel migration, significant ice flow damages, sediment erosion and deposition and pump wear from high suspended sediment loads. In most cases, water rationing or shutdowns are required during low flows as well. All of these factors require very costly repairs and maintenance on an annual basis. Bank failures, flooding, and other problems occurred recently on the Intake Main Canal that can dewater landowners pumps and shut-down irrigation for days and weeks at a time. There are further practicability concerns with the screens and pumped fish return system at the pumping stations and the frequency of cleaning/maintenance required and whether they can be removed seasonally to prevent ice damage. Due to the known problems already incurred by existing pumping stations and further risks from fish screening, the practicability of this alternative is highly questionable and the costs required for O&M could even be higher than estimated.

The Multiple Pumps with Conservation Measures Alternative has substantial practicability concerns, which are partly reflected in the high risk-based contingency assigned to the costs (50%). The biggest concern is whether there are sufficient locations with coarse alluvial soil that would support pumping up to a total of 608 cfs. A preliminary investigation of geologic and soils conditions indicates that soils may not be sufficiently coarse to provide sufficient connectivity with the river and sufficient water supply (Appendix A2, Attachment 2). Data from other locations has also indicated that Ranney Well performance declines over time due to clogging with fine sediments, which could require flushing or rebuilding the wells. Secondly, the amount of water conservation that can actually be achieved is also of low confidence at this time as it has not been field measured. It is known with certainty that 608 cfs would not supply the current crop demand, so would require a change in crops and likely fallowing some lands, which could substantially change farm profitability.

10.4.2 Administrative Feasibility

Administrative feasibility refers to the requirements associated with coordinating with other offices and agencies, including statutory limits, waivers, and requirements for off-site actions. Overall, the administrative logistics increase as the project area and potential construction duration increases. The agencies believe that the Bypass Channel Alternative is the most administratively feasible alternative to achieve the project purpose in a manner that also minimizes unacceptable adverse impacts to the aquatic ecosystem and other elements of the environment. All elements of the bypass channel are fully within the authority of the agencies.

The No Action Alternative would not meet Reclamation needs for ESA compliance at Intake Diversion Dam, other actions would likely be required. Reclamation would be required to reinitiate consultation.

The Rock Ramp Alternative would be within the authority of the agencies to implement.

The Modified Side Channel Alternative would be within the authority of the agencies to implement, although due to the need to acquire additional lands, it would increase the logistics and duration necessary for implementation.

The Multiple Pump Alternative would be within the authority of the agencies to implement, although due to the need to acquire additional lands and upgrade the power grid, it would increase the logistics and duration necessary for implementation.

The Multiple Pumps with Conservation Measures Alternative would be within the authority of the agencies to implement, although due to the need to acquire significant areas of additional lands, it would substantially increase the logistics and duration necessary for implementation. The installation of conservation measures would also be logistically difficult. Lining of the main canal would either require shutting down of irrigation for the season or require winter construction.

Congressional action could authorize an agency (such as the Corps or Reclamation) to establish a trust fund for OM&R costs. Congressional authority would need to include specific instructions for the establishment, management, and use. Additionally, if the intent is for Federal dollars to be used for the initial investment, authorization for appropriations would also be necessary. The establishment of a trust for the payment of OM&R costs above those of the No Action Alternative could have implications within existing project authorizations. Consistent with the existing authorization for the Lower Yellowstone Project (LYP), project costs, including OM&R, are the responsibility of the LYIP. Thus without specific language establishing appropriated trust funds as non-reimbursable, OM&R costs would remain the responsibility of the LYIP and repayment of the initial trust investment would be anticipated. The purpose of a trust fund for the Lower Yellowstone Intake Diversion Dam Fish Passage Project would be to provide a permanent source of funding to the LYIP for the increased OM&R costs associated with Multiple Pumps and Multiple Pumps with Conservation Measures alternatives which substantially exceed the costs for the No Action Alternative.

10.5 AQUATIC IMPACTS FROM DISPOSAL

Potential aquatic impacts are discussed in more detail in Section 4 of this analysis. The No Action Alternative would continue to prevent pallid sturgeon passage upstream of the Intake Diversion Dam. The No Action alternative would require the annual placement of approximately 1,500 CY of rock fill into the river at the weir, which translates to approximately 75,000 CY of rock over the 50-year planning horizon. It would likely expand the rock rubble field another 2 acres in the river.

The proposed bypass channel would require excavation of 869,000 CY to create 64 acres of new perennial side channel (i.e. the new bypass channel) from uplands. This material would be placed as fill in the existing side channel (both seasonally inundated and backwater areas) and would fill approximately 66 acres (convert to uplands) of seasonal riverine side channel and backwater habitat and place fill in 2 acres of the Yellowstone River at the downstream end of the new bypass channel. Non wetland habitats disturbed during construction (i.e. riparian areas) would be restored and enhanced with native plantings.

The initial fill in the river for the Rock Ramp Alternative is 350,000 CY over 34 acres, plus approximately three acres would be filled associated with the new weir. It is likely that the ramp would require annual maintenance to fix portions of the ramp, thus requiring the placement of additional rock in the river as fill, potentially a similar volume of rock as for the No Action Alternative (up to 75,000 CY over the 50-year planning horizon). Non wetland habitats disturbed during construction (i.e. riparian areas) would be restored and enhanced with native plantings.

The Modified Side Channel Alternative would require excavation of 1,144,000 CY within the existing side channel and uplands (47 acres of upland converted to new perennial side channel), and 365,000 CY of fill placed in bend cutoffs in the existing channel (52 acres filled and converted to upland). Approximately 130,000 CY of cobbles and boulders would be placed in the side channel for substrate and bank protection (remains as perennial side channel with coarser substrate). Eight acres of existing side channel would be converted to palustrine emergent wetland in the bend cutoffs. Non wetland habitats disturbed during construction (i.e. riparian areas) would be restored and enhanced with native plantings.

The Multiple Pump Alternative would convert approximately one acre of wetlands to perennial backwater canals and fill one acre of riverine habitat with riprap for bank protection. Weir and rock removal would permanently remove wood, steel, and rock from six acres of the river.

The Multiple Pumps with Conservation Measures would fill approximately one acre of wetlands for access roads and pump stations. An unknown, but anticipated 10 acres of wetlands fringing along the Main Canal and laterals would be filled associated with canal linings. An unknown, but potentially 100 or more acres of wetlands supported by return flows and seepage would be eliminated by eliminating their hydrology. Non wetland habitats disturbed during construction (i.e. riparian areas) would be restored and enhanced with native plantings.

10.6 CONSERVATION AND RECOVERY

Section 9 of this document provides a detailed set of potential avoidance and minimization measures as well as conservation measures that will reduce effects to ESA-listed species and their critical habitat. Section 9 also includes a description of proposed monitoring actions that would be implemented post-construction.

There is insufficient information at this time to quantify the potential contribution that the proposed project or any of the alternatives would make to recruitment of pallid sturgeon or recovery. However, improving passage of pallid sturgeon

10.7 LIMIT NUMBER OF SITES

The project area comprises the minimum area required to feasibly build a technically sound bypass channel for upstream passage of pallid sturgeon around the Intake Diversion Dam, and all activities are confined to the immediate Intake Diversion Dam and Joe's Island vicinity. The sites selected for placement of fill material included in the proposed plan were determined based on the need to prevent flows into the existing side channel below 63,000 cfs in the river in order to ensure that the 13-15% flow volume into the bypass channel to meet the BRT criteria. Further, if the upper end of the existing side channel is not filled, the risk of main channel avulsion into one of the channels is substantially increased as a substantial portion of the river flow volume could flow into the channels during high flows.

The Rock Ramp and Modified Side Channel alternatives similarly are confined to activities in the immediate Intake Diversion Dam and Joe's Island vicinity. The Multiple Pump and Multiple Pumps with Conservation Measures alternatives would require construction and operation and maintenance at multiple sites along the lower 70 miles of the Yellowstone River.

11.0 Factual Determination

This section provides a summary of the determinations made for each component of the aquatic ecosystem evaluated in previous sections.

11.1 PHYSICAL SUBSTRATE DETERMINATIONS

The physical and chemical substrate conditions are described in Section 2 and Section 4. Potential impacts to the physical and chemical properties of the substrate are discussed in Section 4.1.2. The proposed project would result in temporary impacts to the existing substrate during construction. Measures to reduce effects would be implemented during construction to minimize disturbance to substrate as described in Section 9.

11.2 SUSPENDED PARTICULATES AND TURBIDITY DETERMINATIONS

Suspended particulates and turbidity existing conditions and potential impacts are described in Section 4.2. The proposed project would result in minor temporary and localized increases in suspended particulates in the project area. Measures to reduce effects would be implemented during construction to minimize suspended particulate materials and turbidity, as described in Section 9.

11.3 WATER QUALITY DETERMINATIONS

Water quality existing conditions are described in Sections 2 and 4. Potential impacts to water quality are described in Section 4.3.2. The proposed project would result in minor increases in turbidity and the potential for spills/leaks from construction equipment. Long-term beneficial effects include improvements to beneficial uses for Aquatic Life, specifically through providing upstream fish passage. There are no long-term adverse impacts identified. Measures to reduce effects would be implemented during construction to minimize potential water quality impacts as described in Section 9.

11.4 CURRENT PATTERNS, WATER CIRCULATION, AND FLUCTUATION DETERMINATIONS

Current patterns, water circulation, and fluctuation existing conditions and potential impacts are described in Section 4.4. The proposed project would have minor short-term effects on current patterns or water circulation in the project area due to coffer damming during concrete weir construction. The effects of these actions are anticipated to be negligible because they would be insignificant localized and temporary impacts. The project will result in much improved passage of endangered pallid sturgeon upstream of the Intake Diversion Dam.

11.5 SALINITY DETERMINATIONS

Salinity considerations are not applicable to the Yellowstone River.

11.6 AQUATIC ECOSYSTEM AND ORGANISM DETERMINATIONS

The aquatic ecosystem and organism existing conditions within the project area are described in Section 5. The proposed construction activities associated with the proposed restoration plan may have short-term impacts on primary and secondary productivity, benthic and epibenthic organisms, from short-term increases in turbidity, excavation and disturbance, foraging disruption, and fish handling and removal. Short-term upland impacts on terrestrial mammals and birds may result from potential increased noise and grading, which may result in disruption of foraging. Long-term effects include the opening of 165 miles of spawning habitat for endangered pallid sturgeon and other Yellowstone River fish. Impacts would be temporary and less than significant and upstream passage above the Intake Diversion Dam would represent a long-term benefit. Measures to reduce effects would be implemented during construction to minimize impacts to the aquatic ecosystem and organisms as described in Section 9.

11.7 RECREATIONAL, AESTHETIC, AND ECONOMIC VALUES DETERMINATIONS

Recreational, aesthetic, and economic existing conditions and potential impacts are described in Section 7. Potential effects of the proposed project on human use characteristics would occur during construction and would be temporary. Impacts to historic and cultural resources are not likely. Recreation in the project area would be temporarily affected during construction on Joe's Island, but the Intake FAS would not be closed. Construction would be minimized or avoided, as possible, during paddlefish season. Impacts would be temporary and localized during construction. The completed project would not interfere with future recreation or navigation within the project area. Therefore, these impacts would be less than significant. Measures to reduce effects would be implemented during construction to minimize construction-related impacts as described in Section 9.

11.8 DETERMINATION OF CUMULATIVE IMPACTS ON THE AQUATIC ECOSYSTEM

Cumulative impacts are impacts on the environment that result from the incremental impact of actions when added to other past, present, and reasonably foreseeable future actions. The implementation of the proposed project would incrementally reverse the cumulative adverse impacts that have occurred to pallid sturgeon and the Lower Yellowstone River by allowing fish passage around the weir that has been a fish passage barrier for 100 years. Impacts from construction are short-term and minor and would not contribute substantially to cumulative effects.

11.9 DETERMINATION OF SECONDARY IMPACTS ON THE AQUATIC ECOSYSTEM

Secondary effects are "associated with a discharge of dredged or fill materials, but do not result from the actual placement of the dredged or fill material" (40 CFR 230.11(h)(1)). Under CWA, secondary impacts are generally interpreted as indirect impacts. Therefore, secondary effects are limited to effects in the aquatic environment that are indirectly related to implementation of the action, such as minor erosion or downstream sedimentation.

12.0 Review of Conditions for Compliance

According to the guidance, “no discharge of dredged or fill material shall be permitted if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as the alternative does not have other significant adverse environmental consequences” (40 CFR 230.10 [a]). The potential for significant adverse impacts on the aquatic ecosystems resulting from implementation of the preferred alternative would be mitigated to the extent possible through the application of avoidance and minimization measures described in Section 9. The following subsections contain a review of conditions for compliance for the practicable alternatives assessed under the Yellowstone Intake Diversion Dam Fish Passage Project EIS.

12.1 AVAILABILITY OF PRACTICABLE ALTERNATIVES

Section 230.10 of Subpart B of the Section 404(b)(1) Guidelines further specifies four general conditions that must be met for compliance. These include consideration of practicability, compliance with the ESA, protections for water quality and human uses, and compliance with the avoidance, minimization, and compensatory mitigation requirements. The results of the analyses are summarized below.

12.1.1 Practicability (40 CFR Section 230.10(a))

A practicable alternative according to 40 CFR 230.10 is one that has a reasonable expectation of success in achieving the overall purpose and need, and is feasible to implement in consideration of cost, existing technology, and logistics. The alternatives are evaluated for compliance with the definition of practicability in the EIS and while each were found to be potentially practicable there are substantial concerns with the alternatives that remove the existing weir. The proposed alternative is the most cost effective, constructible, practicable, and sustainable with a high likelihood of success.

12.1.2 Compliance with Water Quality Standards, ESA, and Protection of Habitat (40 CFR Section 2301.10(b))

Based on the evaluation of impacts in Sections 4, 5, and 6 of this document, the alternatives have been assessed for any cause of, or contribution to significant degradation to, waters of the U.S. Under 40 CFR 230.10(c), special emphasis on the persistence and permanence of the effects is considered in making the significant degradation determination. The potential impacts to the chemical and biological characteristics from the proposed restoration plan are generally low. The potential to release pollutants arises from the use of construction equipment (i.e. fuels and oils). Evaluation of the alternatives has indicated that implementation of the proposed project would not result in substantial water quality exceedances, and therefore would not result in significant degradation. The long-term result of the project would be improved fish passage, thus, improving a current 303(d) listing.

Consultation with the Service under Section 7 of the ESA is in process to ensure that this project does not cause jeopardy to any listed species or result in the destruction or adverse modification of critical habitat.

12.1.3 Protections for Water Quality, Special Aquatic Sites, and Human Uses (40 CFR Section 130.10(c))

This criteria involves prevention of significant degradation or significant adverse effects resulting from the discharge of pollutants on water supplies, fish and wildlife, aquatic organisms, and special aquatic sites; significant adverse effects on ecosystem diversity, productivity, or stability through the transfer of pollutants outside of the disposal site; and/or significant adverse effects on human use values (40 CFR 230.10 (c)(1) – (4)).

Based on this analysis, the proposed restoration plan would meet all applicable state water quality standards within appropriate compliance distances and durations and are not expected to violate any toxic effluent standard or prohibition under CWA Section 307.

12.2 COMPLIANCE WITH PERTINENT LEGISLATION

All of the practicable alternatives are expected to comply with pertinent legislation and treaty rights as described below.

- ESA: Formal consultation in process under Section 7 of the ESA.
- Section 106 of the National Historic Preservation Act: Section 106 consultations with the Montana State Historic Preservation Officer is in process.
- Section 401 of the CWA: A water quality certification would be obtained from the State of Montana

12.2.1 Treaty Rights

The proposed work would not affect treaty fishing rights or Indian Trust Assets and may have beneficial effects on overall fish populations.

12.3 POTENTIAL FOR SIGNIFICANT DEGRADATION OF WATERS OF THE UNITED STATES AS A RESULT OF THE DISCHARGE OF POLLUTED MATERIALS

As described in Section 8, any materials imported to the project area would have low or non-detectable levels of contaminants that are not expected to have significant adverse impacts on water quality or biota in the short or long term.

12.4 STEPS TO MINIMIZE POTENTIAL ADVERSE IMPACTS ON THE AQUATIC ECOSYSTEM

Finally, no discharge of fill shall be allowed unless all appropriate and practicable measures have been taken to minimize and avoid and then compensate for potential adverse impacts. Section 9 details the avoidance, minimization and conservation measures that would be applied to the proposed project.

13.0 Findings

This section describes findings of compliance or non-compliance with the restrictions on discharge per 40 CFR Section 230.12. These findings are supported by the factual determinations and conditions for compliance included in Sections 11 and 12.

13.1 ALTERNATIVES TEST

Based on the discussion above, are there available, practicable alternatives having less adverse impact on the aquatic ecosystem?

Yes ☐ No ☒ Not Applicable ☐

Based on the discussion above, if the project is in a special aquatic site and is not water-dependent, has the applicant demonstrated there are no practicable alternative sites available?

Yes ☐ No ☐ Not Applicable ☒

13.2 SPECIAL RESTRICTIONS

Would the project:

Violate state water quality standards?

Yes ☐ No ☒ Not Applicable ☐

Violate toxic effluent standards (under Section 307 of the CWA)?

Yes ☐ No ☒ Not Applicable ☐

Jeopardize endangered or threatened species or their critical habitat?

Yes ☐ No ☒ Not Applicable ☐

Violate standards set by the Department of Commerce to protect marine sanctuaries?

Yes ☐ No ☐ Not Applicable ☒

Evaluation of the information above indicates that the proposed discharge material meets testing exclusions criteria for the following reason(s):

☐ based on the above information, the material is not a carrier of contaminants

☒ the levels of contamination are substantially similar at the extraction and disposal sites and the discharge is not likely to result in degradation of the disposal site and pollutants would not be transported to less contaminated areas

☒ acceptable constraints are available and would be implemented to reduce contamination to acceptable levels within the disposal site and prevent contaminants from being transported beyond the boundaries of the disposal site

13.3 OTHER RESTRICTIONS

Would the discharge contribute to significant degradation of waters of the U.S. through adverse impacts to:

Human health or welfare, pollution of municipal water supplies, fish, shellfish, wildlife, and special aquatic sites?

Yes ☐ No ☒ Not Applicable ☐

Life stages of aquatic life and other wildlife?

Yes ☐ No ☒ Not Applicable ☐

Diversity, productivity, and stability of the aquatic ecosystem, such as the loss of fish or wildlife habitat, or loss of the capacity to assimilate nutrients, purify water or reduce wave energy?

Yes ☐ No ☒ Not Applicable ☐

Recreational, aesthetic, and economic values?

Yes ☐ No ☒ Not Applicable ☐

13.4 ACTIONS TO MINIMIZE POTENTIAL ADVERSE IMPACTS (MITIGATION)

Would all appropriate and practicable steps (40 CFR 23.70-77) be taken to minimize the potential adverse impacts of the discharge on the aquatic ecosystem?

Yes ☒ No ☐ Not Applicable ☐

Based upon this Section 404(b)(1) analysis, I have determined that the proposed action is in compliance with the Section 404(b)(1) guidelines and would not have a significant adverse effect on waters of the U.S.

Date: ______________________

John W. Henderson
Colonel, Corps of Engineers
District Commander

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Lower Yellowstone Intake Diversion Dam Fish Passage Project, Montana

FINAL - APPENDIX D

Lower Yellowstone Intake Fish Passage EIS

Fish Passage Connectivity Index and Cost Effectiveness and Incremental Cost Analysis

OCTOBER 2016

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1.0 Fish Passage Connectivity Index

1.1 Introduction

Intake Diversion Dam has likely impeded upstream fish passage for pallid sturgeon and other fish species in the Yellowstone River since it was completed in approximately 1909. The best available science suggests that the diversion dam is a partial barrier to some fish species including shovelnose sturgeon (Bramblett, et al. 2015; Helfrich et al. 1999; Jaeger et al. 2004; Backes et al. 1994; Stewart 1986, 1988, 1990, 1991; Rugg et al. 2016). It is essentially a total barrier to other fish species, such as pallid sturgeon, due to a high level of turbulence associated with the rocks at the dam crest and in the downstream boulder field and high velocities at the dam crest (Jaeger et al. 2005; Fuller et al. 2007; Helfrich et al. 1999; White and Mefford 2002; Bramblett and White 2001). Pallid sturgeon were tracked passing upstream of the dam via the existing high-flow side channel in 2014 and 2015 (Rugg 2014, 2015; Rugg et al. 2016) during flows greater than 30,000 cfs. It is not known if passage has occurred before 2014 because this was the first year that fish were tracked swimming upstream of the dam.

Improving fish passage at Intake Diversion Dam accomplishes several things from a pallid sturgeon recovery perspective:

- It would provide access to approximately 165 miles of Yellowstone River habitat upstream of Intake Diversion Dam and additional miles on tributaries such as the Powder River that are currently inaccessible to the pallid sturgeon;
- The area to which access would be provided appears to include substantial areas of suitable spawning habitat for pallid sturgeon including bluff pools and other areas of swift water over gravel and cobble substrates (Jaeger, et al. 2005, Rugg 2014, 2015; Bramblett, et al. 2015);
- If 165 more river miles were accessible for spawning, it would provide longer drift distances and a larger area available for larvae to stop dispersal and seek rearing habitat before reaching Lake Sakakawea, which is currently thought to be unsuitable larval settling habitat due to the fine substrates and low dissolved oxygen levels (Braaten et. al. 2008, 2011; Guy et al. 2015; Bramblett & Scholl 2016)

While the primary purpose of a fish passage project at Intake Dam is to improve pallid sturgeon passage, other migratory species of fish are also likely to benefit from the project. This includes fish that are important from a management perspective by the State of Montana, such as shovelnose sturgeon, paddlefish, sauger, and blue sucker, as well as a variety of native fish species that reside in the Yellowstone River and undertake shorter seasonal movements.

Federal agencies are required to evaluate the economic and environmental costs and benefits of water resources projects that it undertakes (CEQ 2013). For a project with environmental benefits, such as this fish passage project, benefits are not reasonably monetized. However, if benefits can be quantified in some dimension, cost effectiveness and incremental cost analysis can be used to assist in selecting a preferred plan. Cost effectiveness analysis evaluates which alternatives are the least-costly way of attaining the project objectives. Incremental analysis is then used to evaluate the change in cost from each measure or alternative to the next to determine their incremental costs and incremental benefits. This type of analysis helps identify which measures or alternatives provide more benefits for lower cost and can be used as one element to inform the selection of a preferred plan.

1.2 Fish Passage Connectivity Index

The Fish Passage Connectivity Index (FPCI) was developed to evaluate ecosystem outputs (i.e. benefits) of alternative measures for fish passage improvements on the Upper Mississippi River and Illinois Waterway System for cost effectiveness and incremental analysis (Corps 2011). The model was developed for use in the plan formulation process for the Navigation and Ecosystem Sustainability Program for the Upper Mississippi River System fish passage improvement ecosystem restoration projects. The model is semi-quantitative in that relative scores are assigned to variables using best professional judgment informed by available literature on fish behavior and swimming abilities. The model is currently in review by the Ecosystem Restoration Center of Expertise as required for use in the U.S. Army Corps of Engineers (Corps) planning context for this project (Corps 2016). This model was used in an assessment of fish passage alternatives at Intake Diversion Dam in 2015 (Corps 2015).

The FPCI is a simple arithmetic index that is calculated as:

$$\epsilon = \frac{\Sigma\, i \ldots n\ [(E_i \times U_i \times D_i)/25]}{n}$$

Where,

ϵ = Fish Passage Connectivity Index.

i = a migratory fish species that occurs in Pool or reach below the dam.

n = number of fish species included in the index.

Ei = Probability of encountering the fishway entrance is a calculated value ranging from 1 to 5, where 5 = highly likely; 3 = moderate probability; 1 = unlikely.

Ui = Potential for species i to use the fish passage pathway or fishway (5 = Good, 3 = Moderate, 1 = Poor, 0 = None) considering adult fish swimming performance and hydraulic conditions within the fishway or fish travel pathway.

Di = Duration of availability, the fraction of the upriver migration period for fish species i that the passage pathway is available. Di incorporates a risk component (i.e., the potential failure of an alternative to perform or be available during a critical fish movement period.)

Although the model was developed to measure benefits of fish passage in the Upper Mississippi River, the model is applicable (with slight adjustments) to fish passage projects on other large river systems, especially those with very similar fish communities. This model, with minor adjustment, was used as a planning tool for comparing benefits of alternative measures for provide fish passage at Intake Dam. It should be recognized that this model is a planning tool that relies on the best professional judgment of users (informed by the published literature on the species) and does not represent a statistical probability of fish passage but a relative comparison of effectiveness. This memo describes the input data used and minor adjustments made to the model to demonstrate ecological benefits of the Yellowstone River Intake Diversion Dam fish passage alternatives.

1.3 Data Required for the Model

1.3.1 Identify fish to be included for analysis, and their associated habitat preferences, swimming behaviors, and swimming abilities.

1.3.1.1 The FPCI model was created with a list of 40 fish species that could be considered for use in the model (Corps 2011). This list does not include pallid sturgeon. Swimming performance data, swimming behavior, and critical current velocities (Ucrit) for prolonged swimming by adult fish used in the creation of the model were sourced from two primary studies on the Upper Mississippi River (Wilcox et al. 2004; Pitlo et al. 1995). More recent data were used to calculate an estimated Ucrit for adult pallid sturgeon (Braaten et al. 2015) and to make one other change to anticipated swimming speeds of other species; walleye Ucrit was reduced to 3.0 feet/second (Peake et al. 2000). The 14 species used in this model are shown in Table 1-1.

1.3.1.2 For ensuring a good comparison of benefits across fish passage alternatives, the fish species selected for use in this FPCI modeling effort, the thirteen (13) species used by the Corps in 2014 with the addition of pallid sturgeon, for a total of 14 species. The inclusion of pallid sturgeon does not change the ranking of alternatives. Because this project is focused on improving fish passage for pallid sturgeon, the project team felt that including it specifically (instead of using shovelnose sturgeon as a surrogate) gives added importance to pallid sturgeon capabilities and provides a better differentiation between similar alternatives. As explained in the Corps (2015) modeling, the other 13 species were selected because they represent the native migratory species typically found in the Yellowstone River at Intake Diversion Dam and the species provide good representation of the various guilds of fish based on their various migration behaviors (benthic (8), pelagic (2), and littoral (3) and swimming abilities (strong (6), medium (5), weak (2)).

1.3.1.3 Habitat preferences/use for each species was considered acceptable as presented in the FPCI with one slight adjustment as noted by the Corps (2015); white sucker, blue sucker and river carpsucker were shown only to be associated with main channel border habitats in the original FPCI. However, for purposes of this study, these species were also assumed to utilize main channel habitats. The “main channel” habitat type in the Upper Mississippi River was defined as a navigation channel, which is very different than main channel habitats in the Yellowstone River, and may be the reason those species were not associated with that habitat type. These three species are known to utilize main channel habitats available in the Yellowstone and Upper Missouri River systems, and as such, were associated with it for purposes of this study. In addition, pallid sturgeon was included and shown with a habitat preference for main channel and main channel border habitats similar to the habitat preferences provided for shovelnose sturgeon.

1.3.1.4 Fish species of concern are well represented. Species of special concern that are included in this analysis include the shovelnose and pallid sturgeon, paddlefish, sauger, and blue sucker. Habitat loss and fish passage barriers have contributed to the decline of these species (Montana AFS 2016). It is important to ensure fish passage alternatives do not reduce passage for these species.

Table 1.1. Species Used in the FPCI Model for Intake Diversion Dam with Swimming Speed and Habitat Preference.

Common Name	Scientific Name	Swimming Behavior	Swimming Performance	Swimming Speed (Ucrit)[1,2,3] (ft/sec)	Habitat Preference
Shovelnose sturgeon	*Scaphirhynchus platorhynchus*	Benthic	Medium	2.7	B,C
Paddlefish	*Polyodon spathula*	Pelagic	Strong	4.2	B,C
Goldeye	*Hiodon tergisus*	Pelagic	Medium	2	A,B,D,E
Smallmouth buffalo	*Ictiobus bubalus*	Benthic	Medium	2.1	B,C,D,E
Blue sucker	*Cycleptus elongatus*	Benthic	Strong	2.6	B,C
White sucker	*Catosomus commersoni*	Benthic	Weak	2.1	B,C
River carpsucker	*Carpiodes carpio*	Benthic	Weak	1.5	B,D,E
Shorthead redhorse	*Moxostoma macrolepidotum*	Benthic	Medium	2	B,C
Channel catfish	*Ictalurus punctate*	Benthic	Strong	2.7	A,B,C,D,E
Smallmouth bass	*Micropterus salmoides*	Littoral	Medium	2.1	A,B,D,E
Walleye	*Sander vitreus*	Littoral	Strong	3[4]	B,C,D
Sauger	*Sander canadensis*	Littoral	Strong	2.6	B,C,D
Freshwater drum	*Aplodinotus grunniens*	Benthic	Strong	2.7	A,B,C,D,E
Pallid sturgeon	*Scaphirhynchus albus*	Benthic	Medium	3.3	B,C

A = Contiguous floodplain lake; B = Main channel border; C = Main channel; D = Secondary channel; E = Tertiary channel; F = Tributary

[1] Pitlo, J., Jr., Van Vooren, A., and Rasmussen, J. (1995). “Distribution and relative abundance of Upper Mississippi River fishes,” Upper Mississippi River Conservation Committee Fish Technical Section, Rock Island, IL.

[2] Wilcox, D.B. et al (2004) "Improving fish passage through navigation dams on the Upper Mississippi River system", ENV Report 54, U.S. Army Corps of Engineers, Rock Island, St. Louis, and St. Paul Districts

[3] Braaten, P.J., C.M. Elliott, J.C. Rhoten, D.B. Fuller, & D.J. McElroy. 2015. Migrations and swimming capabilities of endangered pallid sturgeon (*Scaphirhynchus albus*) to guide passage designs in the fragmented Yellowstone River. Restoration Ecology 23(2): 186-195.

[4] Peake, S., R.S. McKinley, & D.A. Scruton. 2000. Swimming performance of walleye (*Stizostedion vitreum*). Canadian Journal of Zoology 78: 1686-1690.

1.3.2 Identify habitat acres made available by passage.

1.3.2.1 Habitat Units are calculated in the model by multiplying the fish passage index by the total acres of available preferred habitat upstream of Intake Diversion Dam for each species. For this analysis, the habitat acres mapped between Intake and Cartersville on low-level aerial photography for the *Yellowstone River Cumulative Effects Analysis* (Corps & YRCDC 2015; Corps 2015; Yellowstone River Corridor Clearinghouse 2016) were used.

1.3.2.2 Habitat types from the Cumulative Effects Analysis (CEA) include the following primary categories:

Scour – (SC) Scour pool occurring in otherwise unconstrained river channel.

Bluff – (BL) Scour pool located at the base of a bedrock bluff. Indicates a relatively permanent pool location bounded by a geologic constraint.

Terrace – (T) Scour pool located at the base of a terrace (Quarternary Alluvium).

Riprap Bottom – (RRB) Scour pool occurring in riprap constrained channel where riprap is located in the middle of the active channel area.

Riprap Margin – (RRM) Scour pool occurring in riprap constrained channel where riprap is located at the edge of the active channel area.

Channel Crossover – (CC) A transitional unit where the river is translating from one bendway or pool to the next.

Bedrock – (BED) Channel is controlled by bedrock bed.

Secondary Channel – (2C) Undifferentiated low flow channel. No additional habitat typing is defined, though the channel likely contains areas of pool and riffle.

Secondary Channel Seasonal – (2CS) Secondary channel High flow channel.

Point Bar – (PB) Areas in the bank full lines that show aggradation associated with the insides of a bendway. Can include exposed gravel, or areas with vegetation, as long as they lie within the bank full area.

Side Bar – (SB) Areas in the bank full lines that show aggradation along the sides of a channel. These bar areas create channel sinuosity at low flows but are inundated at higher or bank full flows. Can include exposed gravel, or areas with vegetation, as long as they lie within the bank full area.

Mid-Channel Bar – (MCB) Areas in the bank full lines that show aggradation, creating islands within the low flow area. Can include exposed gravel or areas with emergent vegetation, as long as they lie within the bank full area.

Dry Channel – (DC) This is a general category for areas within the bank full boundaries that do not fit into Point Bar, Side Bar, Mid-channel Bar, or Island categories. They are generally associated with split flows around islands where there is exposed channel bed at low flow, but does not appear to be strictly depositional in nature, though they could still have some depositional characteristics. Can include exposed gravel or areas with vegetation, as long as they lie within the bank full area.

Dam – Habitat unit is influenced by a dam in the main channel.

1.3.2.3 As depicted in Table 1-2, the CEA habitat categories were cross-walked to the habitat categories as defined for the Upper Mississippi River in the FPCI, allowing Yellowstone River habitat acreages to be compatible with the existing layout as presented in the FPCI model. The habitats for the Upper Mississippi River were defined as:

- Contiguous Floodplain Lake
- Main Channel Border
- Main Navigation Channel
- Secondary Channel
- Tertiary Channel
- Tributary Channel

1.3.3 Identify Windows of Opportunity for Upstream Fish Passage

A window of opportunity, or the timing of when fish passage is physically possible at a dam due to typical peak flows (and suitable depths and velocities), compared with the timeframe of when fish typically migrate, is used to estimate the duration of availability (Di) for the baseline condition and each alternative in the FPCI. The Corps (2015) modified the "percent probability of open river conditions" in the original model (which referred to when the dam gates were open on the Upper Mississippi River) and used available literature (Jaeger, et al. 2005; Helfrich et. al. 1999), anecdotal information, and best professional judgment, to assign probabilities that passage opportunities exist on a weekly basis as a function of flow, with highest probabilities being associated with the peak of the typical hydrograph, and very small (1%) probabilities being attributable to the timeframes outside of the peak river flow (September-April). These same probabilities were used in this analysis for the existing conditions. Table 1-3 shows the windows of opportunity for fish passage, as entered into the FPCI model to represent the no action alternative (existing condition).

For the rock ramp alternative, the depths and velocities are suitable at most times, but for some species at some flows, depths may be too shallow or velocities too high to have suitable passage. Thus, the 2D model results for the rock ramp were used to indicate the duration of passage availability for the median flows in each month of interest. Table 1-4 shows the opportunity for passage as used in the FPCI model for the rock ramp alternative.

For the other alternatives, an assumption was made both by the Corps in 2015 and for this application that the duration available for fish passage would be 100% during the pre-spawn and spawning migration season for the bypass channel, modified side channel, and dam removal alternatives because suitable depths and velocities would be provided across all typical flows. Table 1-5 shows the opportunity for passage as used in the FPCI model for these remaining alternatives.

1.3.3.1 Seasonality of Fish Migration

Basic information on fish migratory behaviors and timing from the original FPCI model was modified by Corps (2015) because the actual time of year when migration takes place on the Yellowstone River is different than on the Mississippi River. Movement and spawning periods were pushed back 3-4 weeks later in the year as migrations tend to take place later in the year for cooler, more northern latitudes. Other information considered in establishing the migratory timeframes for the Yellowstone River at Intake Diversion Dam included data found in Elser, et al. (1977), anecdotal data from George Jordan (Mike Backes, Montana Fish Wildlife and Parks survey data) and best professional judgment. Migratory timeframes as utilized in the FPCI modeling for the Intake Dam project are shown in Table 1-6.

In addition, for this analysis, the migratory timing was adjusted for four fish species: shovelnose sturgeon, paddlefish, blue sucker, and sauger based on literature available for these species from recent tracking on the Yellowstone River (Rugg 2014, 2015; Rugg et al. 2016; Bramblett et al. 2014). Pallid sturgeon timing was also adjusted based on recent tracking data for the Yellowstone River (Delonay et al. 2015; Rugg 2014, 2015; Rugg et al. 2016).

Table 1.2. Habitat crosswalk for area between Intake and Cartersville (Yellowstone River Corridor Clearinghouse 2016).

Low Flow Fisheries Habitat	Acres	Habitats as Defined in UMRC FPCI Model					
		Contiguous Floodplain Lake	Main Channel Border	Main Nav Channel	Secondary Channel	Tertiary Channel	Trib Channel
2C - Secondary low flow channel	1,251				1,251		
2CS - Secondary high flow channel	1,930				1,930		
CC - Channel crossover	3,152			3,152			
DC - Dry Channel not meeting PB, SB, MCB or I categories	1,348					1,348	
I - Islands - vegetated	6,589						
MCB - Mid Channel Bar aggradation area within bankfull lines	772		772				
PB - Point Bar area in bankfull line showing aggradation	1,062		1,062				
SB - Side Bar area in channel showing aggradation at high flow lines at bank	0						
RRB - Scour at riprap - mid active channel	722			723			
RRM - Scour at riprap - margin of active channel	723		723				
SC - Scour in unconstrained river	3,099			3,099			
T - Scour at base of terrace	1,762		1,762				
BL - Scour at base of bedrock bluff	1,293		1,293				
Trib - Large tributary confluences	10						10
Dam	51			51			
TOTAL		0	5,612	7,025	3,181	1,348	10

Table 1.3. Opportunity for Fish Passage at Intake Diversion Dam for the No Action (existing conditions; associated primarily with peak runoff).

Month	Jan-Apr			May			June			July			Aug-Dec		
Week	1-17	18	19	20	21	22	23	24	25	26	27	28	29	30	31-52
% Opportunity for Passage	1	1	1	25	50	100	100	100	100	100	50	25	1	1	1

Table 1.4. Opportunity for Fish Passage for Rock Ramp Alternative

Month	Jan-Mar	Apr	May	June	July	Aug	Sept	Oct-Dec
Week	1-13	14-17	18-21	22-25	26-30	30-34	35-38	39-52
% Opportunity for Passage	1	95	97	100	97	95	95	1

Table 1.5. Opportunity for Fish Passage for the Bypass Channel, Modified Side Channel, and Multiple Pump Alternatives

Month	Jan-Mar	Apr	May	June	July	Aug	Sept	Oct-Dec
Week	1-13	14-17	18-21	22-25	26-30	30-34	35-38	39-52
% Opportunity for Passage	1	100	100	100	100	100	100	1

Table 1.6. Migratory Timing for Species Used in FPCI.

▨ **Pre-spawning movement period** ▩ **Spawning period**

	Month of Year	February				March				April					May				June				July					August				September			
	Week of Year	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	**Shovelnose sturgeon**														▨	▨	▩	▩																	
2	**Paddlefish**												▨	▨	▨	▨	▩	▩	▩	▩	▩	▩	▩												
3	**Goldeye**												▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩												
4	**Smallmouth buffalo**																	▨	▨	▩	▩	▩	▩	▩											
5	**Blue sucker**													▨	▨	▨	▩	▩	▩	▩	▩	▩													
6	**White sucker**									▨	▨	▩	▩	▩	▩																				
7	**River carpsucker**												▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩	▩	▩	▩									
8	**Shorthead redhorse**												▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩												
9	**Channel catfish**																		▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩	▩					
10	**Smallmouth bass**													▨	▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩										
11	**Walleye**						▨	▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩																	
12	**Sauger**						▨	▨	▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩	▩															
13	**Freshwater drum**														▨	▨	▨	▩	▩	▩	▩														
14	**Pallid Sturgeon**											▨	▨	▨	▩	▩	▩	▩	▩	▩	▩	▩													

1.3.4 Identity Potential Fish Passage Connectivity

1.3.4.1 Probability that Fish Encounters Fish Passage Alternative **(Ei)**

E_i simulates the relationship between fishway size (F_s) and ability of a fish to encounter the fishway entrance location (F_l) within the FPCI. (E_i) is expressed as a value ranging from 1 to 5, with 5 being highly likely, and 1 being unlikely. The relationship is represented by the following equation: $E_i = (F_s+F_l)/2$

1.3.4.2 Determine Potential for Fish to Encounter Passage Alternative **(Fl)**

Fl is used to assess the suitability of the fishway entrance location for each fish guild based on swimming performance and behavior. As described in the FPCI, swimming performance and migration behavior are important because they indicate the route as well as vertical and horizontal position within the flow field that a fish would generally select. Guilds of fish species, as defined by swimming performance and behavior. Table 4 in the Corps (2011) model documentation assigned values for the potential for fish species to encounter a fish passageway located in main channel, main channel border (near channel), main channel border (near shore) and lock locations (Table 4 attached). Species that primarily use main channel habitats are highly likely to encounter a main channel passageway (received a score of 5, indicating that the fish passageway entrance would be encountered by a significant portion of the population of that species). Species that primarily use channel border, side channel, or other habitats would be unlikely to encounter a main channel fish passageway (received a score of 1 indicating that it was unlikely the fish passageway entrance would be encountered). Scores ranging from 1 to 5 were assigned based on the location of the fish passageway in comparison to the primary habitat used by the species.

To assign an Fl value to each guild, the Corps (2015) used the same likelihood that was used in the Upper Mississippi system based on monitoring data and the professional judgment of an interagency group of large river fisheries biologists. For this analysis, as additional alternatives were included and additional detailed design had been completed for the proposed bypass channel to maximize the orientation and flows from the bypass channel for main channel fish to locate the channel entrance, the scores were re-evaluated and adjusted. The no action and rock ramp scores were not modified from the scores used by the Corps in 2015 (Table 1-8). For the bypass channel, main channel species including pallid sturgeon, shovelnose sturgeon, paddlefish, and blue sucker were assigned a score of 4 as the bypass channel entrance has been further modeled and designed for its attraction flows to be directed towards the main channel thalweg where these main channel species would be present. Additionally, walleye and sauger were assigned a score of 5 as the bypass channel entrance would be located and directed towards the near channel areas used by these species.

1.3.4.3 Determining the Size of Fish Passage Alternative (Fs)

- This parameter is the size of the fishway relative to the discharge of the river under low flow conditions. For the Yellowstone River, Corps (2014) used the recommendation by the BRT that fish passage alternatives should be capable of conveying up to 30% of river flow. Therefore the following range of inputs for Fs were established by Corps (2015) for the

Intake project; 5 was assigned to fishway designs that pass 30 percent or more of the low flow discharge, 4 = 25 percent, 3 = 20 percent, 2 = 15 percent, and 1 = equal to or less than 10%.

- More recent tracking of pallid sturgeon passing upstream of Intake Diversion Dam by pallid sturgeon in 2014 and 2015 (Rugg 2014, 2015) indicates that passage is possible when flow in the existing side channel is only 2-6% of the river flow (based on HEC-RAS modeling for this study of flow splits into the side channel at river flows from 30,000 to 63,000 cfs, which was the rage of river flows when passage occurred).

The size of fishway for each alternative is listed in Table 1-9. The No Action, Rock Ramp, and dam removal alternatives all pass full flows of the river and received inputs of 5, whereas the bypass channel and modified side channel alternatives pass 15% of the flow and received inputs of 2.

Table 1.7. Swimming Performance and Behavior Guilds.

Performance	Behavior		
	Benthic	**Littoral**	**Pelagic**
Strong	Pallid sturgeon	Walleye	Paddlefish
	Shovelnose sturgeon	Sauger	
	Blue sucker		
Medium	Channel catfish	Smallmouth bass	Goldeye
	Freshwater drum		
	Shorthead redhorse		
	Smallmouth buffalo		
Weak	River carpsucker		
	White sucker		

Table 1.8. Estimate of Likelihood of Encountering the Fishway Entrance for Each Fish Guild. (Values: 5 – significant portion of population would encounter, 1 –unlikely that fish would encounter)

Estimated Probability of Encountering Fishway Locations (Fl) for Each Fish Guild				
	Fishway Location			
Guild	**Main Channel – Rock Ramp**	**Main Channel Border –Near Channel Thalweg(Bypass Channel)**	**Main Channel Border – Near Shore or Side Channel (Modified Side Channel)**	**No Dam**
Benthic – Strong -Pallid Sturgeon -Shovelnose Sturgeon -Blue sucker	5	4	2	5
Littoral – Strong -Walleye -Sauger	5	5	5	5
Pelagic – Strong -Paddlefish	5	4	2	5
Benthic – Medium -Channel Catfish -Freshwater Drum -Shorthead Redhorse -Smallmouth Buffalo	3	5	5	5
Littoral – Medium -Smallmouth Bass	1	5	5	5
Pelagic – Medium -Goldeye	1	5	5	5
Benthic – Weak -River Carpsucker -White Sucker	1	5	5	5
Littoral – Weak	1	5	5	5
Pelagic – Weak	1	5	5	5

Table 1.9. FPCI input data for Size of the fishway relative to flow (Fs). (Range of inputs for Fs are as follows: 5 = >30% of low flow discharge of river, 4 = 25% to >20% percent, 3 = 20% to >15% percent, 2 = 15% to >10%, and 1 = < 10%)

Size of Fishway (F_s)					
Measure A: No Action	**Measure B: Rock Ramp**	**Measure C: Bypass Channel 15% Flow**	**Measure D: Modified Side Channel 15% Flow**	**Measure E: Multiple Pumps**	**Measures F: Multiple Pumps with Conservation Measures**
F_s - Size of Fishway: 5	F_s - Size of Fishway: 5	F_s - Size of Fishway: 2	F_s - Size of Fishway: 2	F_s - Size of Fishway: 5	F_s - Size of Fishway: 5

1.3.4.4 Determine the Potential (U_i) for Fish to Use Alternative Fish Passage Measures, and the Duration of Availability (D_i) of the Alternative Measures.

The potential for a fish to pass upriver past an obstacle is dependent on its swimming performance, the hydraulic conditions that are encountered, and the likely pathway a fish would use (i.e. main channel vs. bank zone). Critical current velocities (U_{crit}), or the speed at which a fish can maintain prolonged swimming by adult fish used in this analysis are found in Table 1-1. The average current velocity at specific locations within each alternative (at 30,000 or 40,000 cfs) was compared to the U_{crit} speed for each migratory fish species. Scores can be selected over a range from 1 to 5. If velocities did not exceed the U_{crit} speed, the U_i was scored a 5. If velocities exceed U_{crit} speed, but was not likely to exceed burst speed it was scored a 3, and if velocity was likely to exceed burst speeds in a key location (i.e. inlet or outlet), or was widespread without potential for resting, it was scored a 1.

Scores for Ui can be found in Table 1-10. Explanation of the selection of scores are provided below.

a. Flow velocities over the existing dam are over 10 ft/sec, with turbulent flow. As such, it scores 1 for the U_i variable for most fish, with the exception of shovelnose sturgeon, paddlefish, blue sucker, walleye and sauger that have been documented to pass over the dam occasionally (Rugg et al. 2016; Bramblett, et al. 2015), thus each getting a score of 2.
b. The rock ramp has slightly reduced velocities as compared to the existing condition, but exceeds the U_{crit} of all species over a majority of the ramp (i.e. 8 ft/sec) and would likely have turbulent flow. The only fish likely to be able to pass consistently is paddlefish that have high U_{crit}, thus meriting a 5. Walleye is a strong swimmer that may be able to pass high velocities, but based on data from Peake et al. (2000) indicating walleye do not like to transition from slower to faster water readily, thus meriting a slightly reduced score of 4. Fish that are more littoral or pelagic in behavior that may use the margins of the rock ramp received a 3, and strong benthic swimmers other than paddlefish also received a 3, since passage is likely to be somewhat improved and these species have occasionally shown an ability to pass over the dam. Pallid sturgeon are still unlikely to be able to swim through turbulent flows and uneven rocks over such a long distance, although improved from the existing condition, thus receiving a 2 and river carpsucker are weak swimmers, thus receiving a 1.
c. The bypass channel and modified side channel velocity modeling indicates velocities not greater than the U_{crit} for all species along the sides of the channel, thus allowing passage for all species.
d. While not a consideration in the modeling, both the bypass and modified side channel alternatives would also have much less turbulence associated with them, as they would both provide channels that are very much like existing side channels of the Yellowstone River in terms of width, gradient and substrate.
e. The multiple pump alternatives would return the channel to near natural conditions, thus allowing passage for all species.

1.3.4.5 Duration of Availability (Di) of the fish passage structure is the proportion of time when both the fish passage structure is physically available for passage, and migration is actually occurring for a particular species of fish.

Table 1-11 identifies when fish passage alternatives are available to fish for each alternative.

Di for the existing condition is calculated as the fraction of time that upriver movement may generally occur when the physical conditions at the dam allow for passage, typically during runoff. Thus, the Di is highly variable between each species of fish, depending on their migration timing in relation to the runoff period.

The Di for the rock ramp would be more passable with a low-flow channel through the replacement weir and ramp, but does not necessarily provide suitable depths and velocities at all times for all species and would not necessarily be the location where all species would seek passage. Thus, D_i was calculated from the opportunity for passage and migration timing of the species in relation to the runoff period.

The Di for all the other alternatives is available 100% of the time (ranked a 1) when passage is occurring. This is because the channels are all designed to have 13-15% flows at all flows above 7,000 cfs and also still convey flow down to 3,000 cfs, or lower, in the river.

Scores can be selected on a scale of 1 to 5: If velocities do not exceed the U_{crit} speed for the alternative, the U_i was scored a 5; If velocities exceed U_{crit} speed but did not exceed burst speed it was scored a 3; and if velocities exceed burst speeds at all times it was scored a 1. Scores of 2 or 4 were selected for instances of known, but infrequent passage or limited flows when velocities do not exceed burst speed; or if velocities occasionally exceed U_{crit}, respectively.

Table 1.10. Potential (Ui) for Fish to Use Alternative Fish Passage Measures.

Potential for Species to Use Fishway Type						
	Measure A: No Action	**Measure B: Rock Ramp**	**Measure C: Bypass Channel 15% Flow**	**Measure D: Modified Side Channel**	**Measure E: Multiple Pumps**	**Measure F: Multiple Pumps with Conservation Measures**
Fish Species	Ui	Ui	Ui	Ui	Ui	Ui
Shovelnose sturgeon	1	3	5	5	5	5
Pallid sturgeon	1	2	5	5	5	5
Paddlefish	2	5	5	5	5	5
Goldeye	1	3	5	5	5	5
Smallmouth buffalo	1	3	5	5	5	5
Blue sucker	2	3	5	5	5	5
White sucker	1	3	5	5	5	5
River carpsucker	1	1	5	5	5	5
Shorthead redhorse	1	3	5	5	5	5
Channel catfish	1	3	5	5	5	5
Smallmouth bass	1	3	5	5	5	5
Walleye	2	4	5	5	5	5
Sauger	1	3	5	5	5	5
Freshwater drum	1	3	5	5	5	5

Table 1.11. Duration Of Availability (Di) Of The Fish Passage Structure Is The Proportion Of Time When Both The Fish Passage Structure Is Physically Available For Passage, And Migration Is Likely Occurring For A Particular Species Of Fish.

Potential of Availability of Fishway Alternatives						
	Measure A: No Action	**Measure B: Rock Ramp**	**Measure C: Bypass Channel 15% Flow**	**Measure D: Modified Side Channel**	**Measure E: Pumping**	**Measure F: Ranney Wells**
Fish Species	Di	Di	Di	Di	Di	Di
Shovelnose sturgeon	0.19	0.97	1	1	1	1
Pallid sturgeon	0.44	0.98	1	1	1	1
Paddlefish	0.53	0.98	1	1	1	1
Goldeye	0.53	0.98	1	1	1	1
Smallmouth buffalo	0.86	0.99	1	1	1	1
Blue sucker	0.53	0.98	1	1	1	1
White sucker	0.01	0.95	1	1	1	1
River carpsucker	0.47	0.98	1	1	1	1
Shorthead redhorse	0.53	0.98	1	1	1	1
Channel catfish	0.48	0.98	1	1	1	1
Smallmouth bass	0.54	0.98	1	1	1	1
Walleye	0.07	0.72	1	1	1	1
Sauger	0.20	0.76	1	1	1	1
Freshwater drum	0.54	0.98	1	1	1	1

Table 1.12. Connectivity Index and Habitat Units

Migratory Fish Species		Measure A: No Action		Measure B: Rock Ramp		Measure C: Bypass Channel, 15% Flow		Measure D1: Modified Side Channel		Measure E: Multiple Pump		Measure F: Multiple Pumps w/ Conservati	
Common Name	Total Available Preferred Habitat (acres)	Є = Fish Passage Connectivity	Habitat Units (Є X acres)	Є = Fish Passage Connectivity	Habitat Units (Є X acres)	Є = Fish Passage Connectivity	Habitat Units (Є X acres)	Є = Fish Passage Connectivity	Habitat Units (Є X acres)	Є = Fish Passage Connectivity	Habitat Units (Є X acres)	Є = Fish Passage Connectivity	Habitat Units (Є X acres)
Shovelnose sturgeon	12637	0.08	973.0	0.58	7,354.7	0.60	7,582.2	0.40	5,054.8	1.00	12,637.0	1.00	12,637.0
Paddlefish	12637	0.21	2,660.7	0.98	12,349.8	0.60	7,582.2	0.40	5,054.8	1.00	12,637.0	1.00	12,637.0
Goldeye	10141	0.06	640.5	0.35	3,567.8	0.70	7,098.7	0.70	7,098.7	1.00	10,141.0	1.00	10,141.0
Smallmouth buffalo	17166	0.10	1,765.6	0.36	6,100.3	0.70	12,016.2	0.70	12,016.2	1.00	17,166.0	1.00	17,166.0
Blue sucker	5612	0.21	1,192.2	0.59	3,303.6	0.60	3,367.2	0.40	2,244.8	1.00	5,612.0	1.00	5,612.0
White sucker	5612	0.00	6.7	0.34	1,926.0	0.70	3,928.4	0.70	3,928.4	1.00	5,612.0	1.00	5,612.0
River carpsucker	10141	0.06	569.3	0.12	1,187.4	0.70	7,098.7	0.70	7,098.7	1.00	10,141.0	1.00	10,141.0
Shorthead redhorse	5612	0.06	354.5	0.35	1,974.4	0.70	3,928.4	0.70	3,928.4	1.00	5,612.0	1.00	5,612.0
Channel catfish	17166	0.06	995.6	0.35	6,025.3	0.70	12,016.2	0.70	12,016.2	1.00	17,166.0	1.00	17,166.0
Smallmouth bass	15818	0.07	1,032.9	0.35	5,571.1	0.70	11,072.6	0.70	11,072.6	1.00	15,818.0	1.00	15,818.0
Walleye	15818	0.03	448.2	0.58	9,132.3	0.70	11,072.6	0.70	11,072.6	1.00	15,818.0	1.00	15,818.0
Sauger	15818	0.08	1,288.0	0.46	7,226.6	0.70	11,072.6	0.70	11,072.6	1.00	15,818.0	1.00	15,818.0
Freshwater drum	17166	0.06	1,109.4	0.35	6,073.8	0.70	12,016.2	0.70	12,016.2	1.00	17,166.0	1.00	17,166.0
Pallid sturgeon	12637	0.04	551.4	0.20	2,465.4	0.60	7,582.2	0.40	5,054.8	1.00	12,637.0	1.00	12,637.0
		Avg.	971	Avg.	5,304	Avg.	8,388	Avg.	7,766	Avg.	12,427	Avg.	12,427

Table 1-13 shows the resulting fish passage connectivity index and habitat units for each alternative.

Table 1.13. Fish Passage Connectivity Index Scores and Habitat Units.

Alternative	W/ Pallid, 14 Species		
	Є = Fish Passage Connectivity (Avg.)	Avg. Habitat Units	Δ HUs
A: No Action	0.08	971	**0**
B: Rock Ramp	0.43	5,304	**4,333**
C: Bypass Channel	0.67	8,388	**7,417**
D: Modified Side Channel	0.61	7,766	**6,795**
E: Multiple Pump Alternative	1	12,427	**11,456**
F: Multiple Pumps with Conservation Measures	1	12,427	**11,456**

2.0 Cost Effectiveness and Incremental Cost Analysis

The plan evaluation process utilized in this study is based upon methods described in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (U.S. Water Resources Council 1983) referred to as the P&G and the associated Corps implementation guidance found in Engineer Regulation (ER) 1105-2-100 Planning Guidance Notebook (U.S. Army Corps of Engineers 2000). The specific plan evaluation and comparison methods applied are from the *Evaluation of Environmental Investments Procedures Manual, Interim: Cost Effectiveness and Incremental Cost Analysis* document (U.S. Army Corps of Engineers 1995). This methodology consists of a series of steps that provide an orderly and systematic approach to comparing the costs and benefits of a range of alternative plans to inform the selection of a recommended plan. Plan formulation and evaluation is a dynamic process, whereby the steps may be iterated one or more times as new information or new alternatives are developed, or as planning objectives are reevaluated.

When planning for the restoration of environmental resources, cost effectiveness (CE) and incremental cost analyses (ICA) may be used as tools for the comparison of alternative plans (CE/ICA). CE/ICA are comparisons of the effects of alternative plans; more specifically, they involve comparisons between the outputs and costs of different solutions. Information about alternative plans and their effects must be developed in order to conduct the CE/ICA comparisons.

Traditional benefit-cost analyses are not applicable to environmental planning when costs and benefits are expressed in different units; however, CE/ICA offers plan evaluation approaches that are consistent with the P&G evaluation framework. The Institute for Water Resources (IWR) Planning Suite software was used to assist in performing the CE/ICA. Alternative plans were evaluated and compared in terms of cost (e.g. construction, operation, and maintenance) and environmental outputs over a 50-year period of analysis. IWR Planning Suite helps determine and present the relative efficiency and effectiveness of alternative plans at generating environmental outputs. The most efficient plans are referred to as "best buys." The Corps' policies for cost effectiveness and incremental cost analysis, ER 1105-2-100, paragraph E.36, states:

> *Cost effectiveness and incremental cost analysis are two distinct analyses that must be conducted to evaluate the effects of alternative plans. First, it must be shown through cost effectiveness analysis that an alternative restoration plan's output cannot be produced more cost effectively by another alternative. "Cost effective" means that, for a given level of nonmonetary output, no other plan costs less and no other plan yields more output for less money. Subsequently, through incremental cost analysis, a variety of implementable alternatives and various-sized alternatives are evaluated to arrive at a "best" level of output within the limits of both the sponsor's and the Corps capabilities. The subset of cost effective plans are examined sequentially (by increasing scale and increment of output) to ascertain which plans are most efficient in the production of environmental benefits. The most efficient plans are called "Best Buys." They provide the greatest increase in output for the least increases in cost. They have the lowest incremental costs per unit of output.*

2.1 Methodology

The CE/ICA analysis utilized the Corps IWR Planning Suite model. The Corps-certified model provides a systematic method for testing all possible combinations of ecosystem restoration measures to identify combinations of measures (alternative plans) which are cost effective, and then ranks cost effective plans according to their efficiency to identify "best buy" plans. Because this analysis considered six complete alternatives which were mutually exclusive, no alternatives were combined in the model. Instead, the software identified which plans were cost effective, and then ranked the cost effective plans by efficiency to identify "best buy" plans. The CE/ICA model required the following inputs:

Average annual habitat units (AAHUs) for each alternative: Because habitat benefits are non-monetary, the outputs are referred to as "units" of output. In order to compare action alternatives to the No Action Alternative, AAHUs are typically converted to "net AAHUs," which is the change in habitat units versus No Action. Thus, the No Action Alternative is always entered as zero net AAHUs, and each action alternative is entered as the additional AAHUs that would be generated compared to this baseline. AAHUs were developed using the FPCI Model as detailed previously in this appendix.

Average annualized cost for each alternative: Costs used in the analysis included construction, PED/CM, real estate, monitoring and adaptive management, interest during construction, and operation, maintenance, and rehabilitation (OM&R). Annualized costs are presented at an FY16 price level, amortized over a 50-year period of analysis using the FY16 Federal interest rate for Corps of Engineers projects of 3.125% (U.S. Army Corps of Engineers 2015). For each action alternative, net costs above the No Action Alternative are calculated for use in the analysis, consistent with the net habitat output calculation. Detailed cost tables are available in Cost Appendix B.

2.1.1 Annualized Costs and AAHU's

Table 2-1 summarizes AAHUs for each alternative, in total and on net. As defined above, AAHUs are average annual habitat outputs, and net AHHUs are the change in output versus the No Action Alternative.

Table 2.1. AAHU's By Alternative

Alternatives	Habitat Output	
	AAHUs	**Net AAHUs**
No Action	971	-
Rock Ramp	5,304	4,333
Bypass Channel	8,388	7,417
Modified Side Channel	7,766	6,795
Multiple Pump	12,427	11,456
Multiple Pumps with Conservation Measures	12,427	11,456

Table 2-2 summarizes the annualized cost for each alternative. Like the habitat output calculation, costs for each action alternative are calculated as the net costs above the No

Action Alternative. For each alternative, inputs to the model were the net AAHUs and the net annualized project cost. Because the only costs which would be incurred in the No Action Alternative would be OM&R and monitoring, the net cost for each action alternative is equivalent to construction-related costs plus the incremental operational costs above the No Action for each alternative, as noted by the row "Net OM&R and Monitoring" in the following table.

Table 2.2. Net Cost by Alternative ($1000s)

	No Action	Rock Ramp	Bypass Channel	Modified Side Channel	Multiple Pump Alternative	Multiple Pumping w/ Cons.
Construction First Cost (PV)	$0	$90,454	$57,044	$54,441	$132,028	$477,925
Interest During Construction (PV)	$0	$1,880	$2,002	$1,123	$6,556	$53,789
Adaptive Management (PV)	$0	$796	$538	$476	$1,153	$4,145
OM&R and Monitoring (PV)	$66,420	$71,370	$70,333	$73,046	$124,395	$114,768
Net OM&R and Monitoring (PV)	**$0**	**$4,950**	**$3,913**	**$6,626**	**$57,975**	**$48,348**
Subtotal - Net Alternative Costs (PV)	$0	$98,081	$63,497	$62,665	$197,712	$584,208
Total Annualized Net Cost (AC)	**$0**	**$3,903**	**$2,527**	**$2,494**	**$7,868**	**$23,247**

IDC – interest during construction
OM&R – operation, maintenance, and rehabilitation
PV – Present Value (FY2016)
AC – Annualized Cost (3.125%, 50 years)

2.2 Cost Effectiveness Analysis

Cost effectiveness analysis is a form of economic analysis designed to compare costs and outcomes (or effects) of two or more courses of action. This type of analysis is useful for environmental restoration projects where the benefits are not measured in monetary terms but in environmental output units such as the Habitat Units developed in this study. The purpose of the cost effectiveness analysis is to ensure that the least cost plan alternative is identified for each possible level of environmental output; and that for any level of investment, the maximum level of output is identified. In short, cost effectiveness means no other plan provides more habitat benefits for the same money. Per IWR 95-R-01, an alternative is ***not*** to be considered cost effective if any of the following rules are met:

1. The same output level could be produced by another plan at least cost;
2. A larger output level could be produced at the same cost; or
3. A larger output level could be produced at less cost.

Table 2-3 provides the results of the cost effectiveness analysis sorted by increasing output. As shown in the table, alternatives were identified as cost effective only when no other alternative provided the same output for less cost, and no other alternative provided larger output at the same or less cost. The No Action, Bypass Channel, Modified Side Channel and Multiple Pump alternatives were identified as cost effective. The Rock Ramp alternative is not cost effective because the Bypass Channel alternative provides greater output for less cost. The Multiple Pumps with Conservation Measures alternative is not cost effective because the Multiple Pump alternative provides the same level of output for less cost.

Table 2.3. Cost Effectiveness by Alternative

Alternative	Annual Cost ($)	Net AAHUs	Cost per AAHU ($)	Cost Effective?
No Action	$0	0	$0	Yes
Rock Ramp	$3,903,000	4,333	$901	No
Modified Side Channel	$2,494,000	6,795	$367	Yes
Bypass Channel	$2,527,000	7,417	$341	Yes
Multiple Pump	$7,868,000	11,456	$687	Yes
Multiple Pumps w/ Conservation Measures	$23,247,000	11,456	$2,029	No

Figure 2-1 provides a graph of the total output and annualized costs for each of the alternatives while differentiating the cost effective plans from the non-cost effective ones. Per IWR 95-R-01, any alternatives that are not found to be cost effective “should be dropped from further analysis” in the CE/ICA process. Therefore, the Rock Ramp and Multiple Pumps with Conservation Measures alternatives are not included in the ICA analysis that follows.

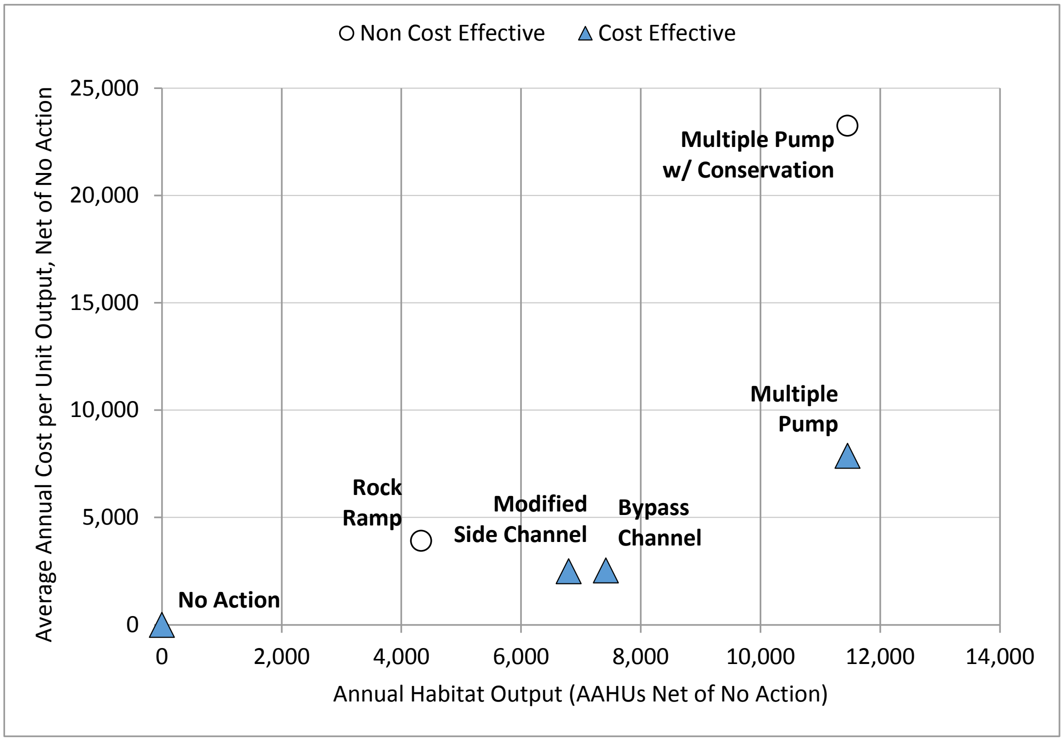


Figure 2.1. Cost Effectiveness Analysis Graph

2.3 Incremental Cost Analysis

The purpose of the ICA is to provide additional information about the cost effective plans previously identified. The ICA reveals changes in costs as output levels are increased, which provides information about how much each successive levels of total environmental output would cost. The term "incremental cost" refers to the additional cost that would be incurred to achieve successive levels of environmental output. Consider the following hypothetical example with two cost-effective action alternatives:

Plan A costs $100 and yields 100 units of output, or $1 per unit output. Plan B costs $200 and yields 150 units of output, or $1.33 per unit. Thus Plan B provides an additional 50 units of output over Plan A, but also costs $100 more. Therefore, the incremental cost of Plan B over Plan A is $100, the incremental output is 50, and the incremental cost per unit output is $2. In summary, the ICA shows that while Plan B outputs are only $0.33 more per unit on average, the true cost of Plans B's extra 50 units of output is $2 per unit. As shown in the example, the ICA provides useful information about the extra cost that would be incurred per unit output for larger and larger cost effective plans.

As previously noted, the cost-effective plans for this study are the No Action, Modified Side Channel, Bypass Channel, and Multiple Pump alternatives. During the ICA, the cost-effective plans are examined sequentially by increasing environmental output (net AAHUs). The horizon of cost effective plans which minimize incremental cost for successive levels of environmental output are called "best buy" plans in the ICA framework. Not all cost effective plans are best buy plans, and the No Action is always considered a best buy.

The first step in identifying best buy plans, other than the No Action, is to identify the plan with the lowest incremental cost per unit output compared to the No Action. Per IWR 95-R-01, this means to "smooth out fluctuations in incremental costs per unit as project scale increases such that incremental cost per habitat unit are continuously increasing." This is first completed by calculating the incremental cost per unit for each plan over the "baseline condition," which is the No Action plan. Once the incremental costs per unit are calculated and sorted by increasing output, the alternative with the lowest incremental cost per unit will be selected as the first "best buy" alternative. Table 2-4 shows the calculation of the incremental costs per unit with the No Action alternative set as the baseline for the cost effective alternatives. As shown in the table, the Bypass Channel alternative has the lowest incremental cost per unit output versus the No Action, and is therefore the first best buy plan among the action alternatives.

Table 2.4. Identification of the First Best Buy Plan

Alternative	Annual Cost ($)	Net AAHUs	Incremental Output vs No Action	Incremental Cost vs No Action	Incremental Cost per Unit Output vs No Action
No Action	$0	0	0	$0	$0
Modified Side Channel	$2,494,000	6,795	6,795	$2,494,000	$367
Bypass Channel	$2,527,000	7,417	7,417	$2,527,000	**$341**
Multiple Pump	$7,868,000	11,456	11,456	$7,868,000	$687

At this step of the ICA the incremental cost per unit is equal to the average annual cost per unit values calculated in Table 2-3 because complete alternatives are being compared, not combinations of measures.

Note that because the Modified Side Channel produced less total output than the Bypass Channel, and the Bypass Channel has already been identified as a best buy plan, the Modified Side Channel cannot be a best buy plan. It is only a cost effective plan. This is consistent with IWR 95-R-01, which states that after each iterations of the incremental calculation, all action alternatives which produce fewer net AAHU's (see last column in Table 2-1) are removed from further iterations of the incremental cost analysis.

Note that because the Modified Side Channel produced less total output than the Bypass Channel, and the Bypass Channel has already been identified as a best buy plan, the Modified Side Channel cannot be a best buy plan. It is only a cost effective plan.

Having identified the three best buy plans (No Action, Bypass Channel, and Multiple Pump), the final step in the ICA process is to analyze the incremental cost per incremental unit of output between these three plans. Like the hypothetical example above, this step illustrates the additional cost that would be incurred per unit output relative to each other. Table 2-5 shows the incremental cost per unit output between the three best buy alternatives.

Table 2.5. Incremental Cost Analysis Summary

Best Buy Alternative	Annual Cost ($)	Net AAHUs	Incremental Cost	Incremental Output	Incremental Cost per Unit Output
No Action	$0	0	$0	0	$0
Bypass Channel	$2,527,000	7,417	$2,527,000	7,417	$341
Multiple Pump	$7,868,000	11,456	$5,341,000	4,039	$1,322

This table shows that the most efficient plan above No Action is the Bypass Channel alternative that provides 7,417 additional habitat units at a cost of $341 each. If more output is desired, the next most efficient plan available is the Multiple Pump alternative that provides an additional 4,039 habitat units, at a cost of $1,322 dollars for each additional unit. Figure 2-2 provides a visual representation of this increase in incremental cost. The figure graphically illustrates the incremental cost and output differences between the two best buy action alternatives. The width of each box in the chart represents the incremental output of that plan, and the height of each box shows the incremental cost per unit of that output. The relatively wide box for the Bypass Channel alternative shows that it provides about 65% of the total output possible at a cost of approximately $341 per unit. The box for the Multiple Pump alternative shows that to achieve the remaining 35% of total possible output would be more expensive per unit than the first 65%. Such breakpoints in incremental cost per unit typically require a higher level of justification if the study team is to recommend the larger output plan.

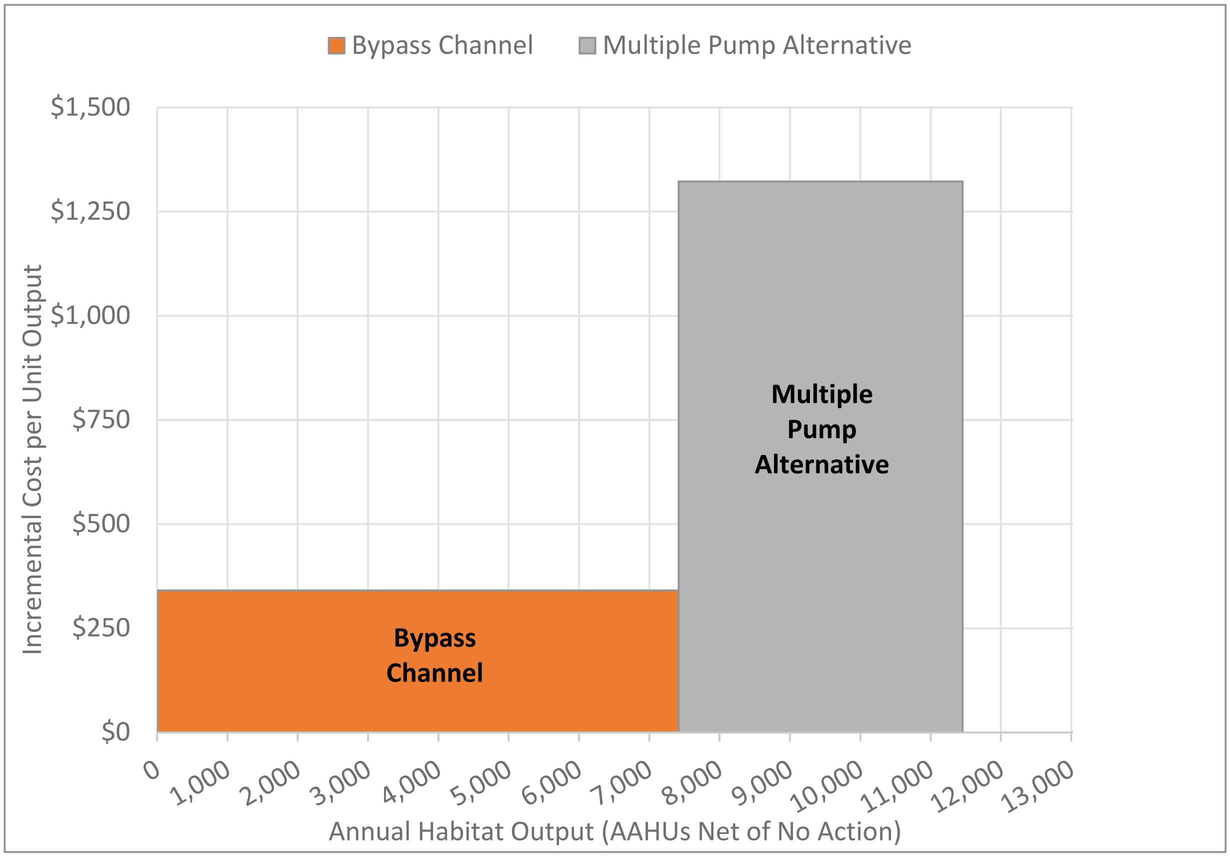


Figure 2.2. Incremental Cost Analysis Chart

2.4 Summary of Conclusions

The results of the CE/ICA do not provide a discrete decision for selecting the preferred plan, but rather they offer organized data on the effectiveness and efficiency of the range of alternatives under consideration to help inform a decision. For Corps ecosystem restoration projects, the selected plan should be the alternative having the maximum excess of non-monetary benefits (habitat output) over costs. This plan occurs where the incremental beneficial effects just equal the incremental costs, or alternatively stated, the recommended plan is selected by identifying the largest plan for which the extra habitat output is still worth the extra costs. Definition of the level of output that is "worth it" is a concern for the study team that will consider specific project factors and information.

Thus, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, can be identified as the selected plan. The selected plan should also be cost effective and justified in achieving the desired level of output. In practice, the selected plan is chosen from the suite of cost effective plans identified in the CE/ICA. While the selected plan is not required to be a best buy plan, this is typically the case.

2.5 Sensitivity Analysis

In order to evaluate the sensitivity of the CE/ICA results to changes in the FPCI model outputs, two sensitivity scenarios were modeled. In the first scenario, the scores for fishway location were reduced for the bypass channel, which reduces that alternative's habitat outputs. In the second scenario, pallid sturgeon only, only the variable for pallid sturgeon was included, which changes the total habitat outputs for all alternatives. These two scenarios reasonably evaluate the possibility of reduced effectiveness for the bypass channel and a focus on pallid sturgeon-specific benefits. In Scenario 1, the score for the fishway location was modified was due to the concern that benefits were overstated for the bypass. The fishway location score was lowered to "3" for pallid sturgeon, shovelnose sturgeon, paddlefish, and blue sucker, which indicates that it is equally likely or unlikely that these fish species could find the fishway due to swimming location/behavior of using the main channel. Scenario 2 was used to evaluate whether using the diversity of native fish species skews the resulting index score, or washes out the importance of pallid sturgeon benefits.

Note that fishway location scores were not lowered to a "1" or "2" because it is not reasonable to suppose that no fish would find a bypass channel located in immediate proximity to the weir (12 to 50 percent of telemetered pallid sturgeon that approached Intake Diversion Dam found the existing side channel in 2014 and 2015 [Rugg 2014, 2015]). Also note that the Modified Side Channel alternative in all scenarios always has been given a lower score of "2" for fishway location as the location of the entrance for upstream migrating fish is approximately 2 miles downstream of Intake Diversion Dam and distant from the main channel so fish are less likely to find it as compared to the bypass channel.

Tables 2-6 and 2-7 summarizes the FPCI revisions for each scenario. Based on these revised habitat output values, and using the same costs, the CE/ICA model was re-run twice. Tables 2-8 and 2-9 provides the cost effectiveness tables for the two scenarios, and Tables 2-10 and 2-11 provide the best buy plans incremental cost tables. Finally, summary graphics are provided for both scenarios side-by-side.

As shown in the tables and figures, even when components of the FCPI scoring are revised, the order of alternatives in terms of average cost per unit output does not change.

- Scenario 1 – Revised Fishway Location Score: the reduced output of the Bypass Channel alternative makes its average cost per unit output more expensive, though it remains less expensive per unit than the Modified Side Channel, resulting in no changes to the identified cost effective and best buy plans.
- Scenario 2 – Pallid Sturgeon Only: by only considering pallid sturgeon in the FPCI, the relative cost effectiveness of the alternatives does not change. The Bypass Channel remains the first best buy plan. However, the total output possible for the Rock Ramp, Modified Side Channel, and Bypass Channel alternatives are all reduced. In this scenario, the Bypass Channel would provide for about 48% of possible habitat output, rather than 65% as in the main analysis which considered 14 species.

In both scenarios, the order of alternatives in terms of average cost per unit output did not change. Based on this analysis, it was determined that there is reasonable confidence that, as currently designed, the Bypass Channel alternative is less costly per unit than the Multiple Pump Alternative, and that the two best buy action alternatives are the Bypass Channel and the Multiple Pump Alternative.

Table 2.6. Scenario 1 – Revised Fishway Location Score, FPCI

Alternative	W/ Pallid, 14 Species		
	€ = Fish Passage Connectivity (Avg.)	Avg. Habitat Units	Δ HUs
No Action	0.08	971	0
Rock Ramp	0.43	5,304	4,333
Bypass Channel	0.64	8,077	7,106
Modified Side Channel	0.61	7,766	6,795
Multiple Pump Alternative	1	12,427	11,456
Multiple Pumping w/ Cons.	1	12,427	11,456

Table 2.7. Sensitivity Scenario 2 – Pallid Sturgeon Only, FPCI

Alternative	Pallid Sturgeon Only		
	€ = Fish Passage Connectivity (Avg.)	Avg. Habitat Units	Δ HUs
No Action	0.04	551	0
Rock Ramp	0.2	2,465	1,914
Bypass Channel	0.5	6,319	5,768
Modified Side Channel	0.4	5,055	4,504
Multiple Pump Alternative	1	12,637	12,086
Multiple Pumping w/ Cons.	1	12,637	12,086

Table 2.8. Scenario 1 – Revised Fishway Location Score, Cost Effectiveness

Alternative	Annual Cost ($)	Net AAHUs	Cost per AAHU ($)	Cost Effective?
No Action	$0	-	$0	Yes
Rock Ramp	$3,903,000	4,333	$901	No
Modified Side Channel	$2,494,000	6,795	$367	Yes
Bypass Channel	$2,527,000	7,106	$356	Yes
Multiple Pump	$7,868,000	11,456	$687	Yes
Multiple Pumps w/ Conservation Measures	$23,247,000	11,456	$2,029	No

Table 2.9. Sensitivity Scenario 2 – Pallid Sturgeon Only, Cost Effectiveness

Alternative	Annual Cost ($)	Net AAHUs	Cost per AAHU ($)	Cost Effective?
No Action	$0	-	$0	Yes
Rock Ramp	$3,903,000	1,914	$2,039	No
Modified Side Channel	$2,494,000	4,504	$554	Yes
Bypass Channel	$2,527,000	5,768	$438	Yes
Multiple Pump	$7,868,000	12,086	$651	Yes
Multiple Pumps w/ Conservation Measures	$23,247,000	12,086	$1,923	No

Table 2.10. Scenario 1 – Revised Fishway Location Score, Incremental Cost

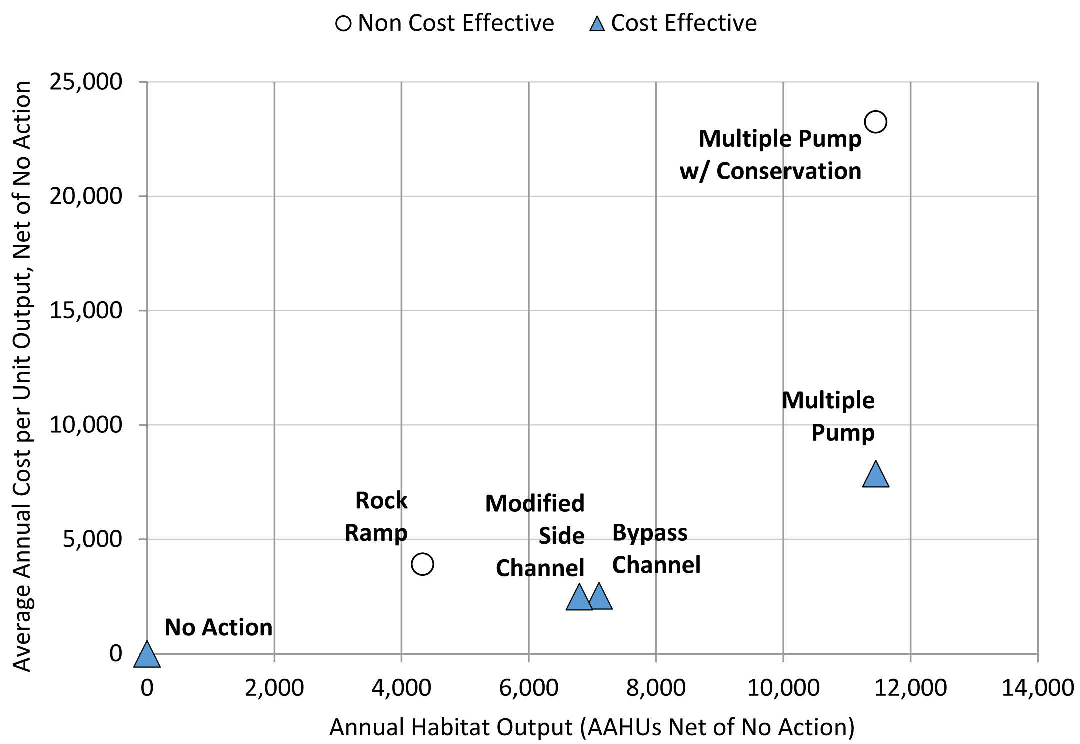
Best Buy Alternative	Annual Cost ($)	Net AAHUs	Incremental Cost	Incremental Output	Incremental Cost per Unit Output
No Action	$0	0	$0	0	$0
Bypass Channel	$2,527,000	7,106	$2,527,000	7,106	$356
Multiple Pump	$7,868,000	11,456	$5,341,000	4,350	$1,228

Table 2.11. Sensitivity Scenario 2 – Pallid Sturgeon Only, Incremental Cost

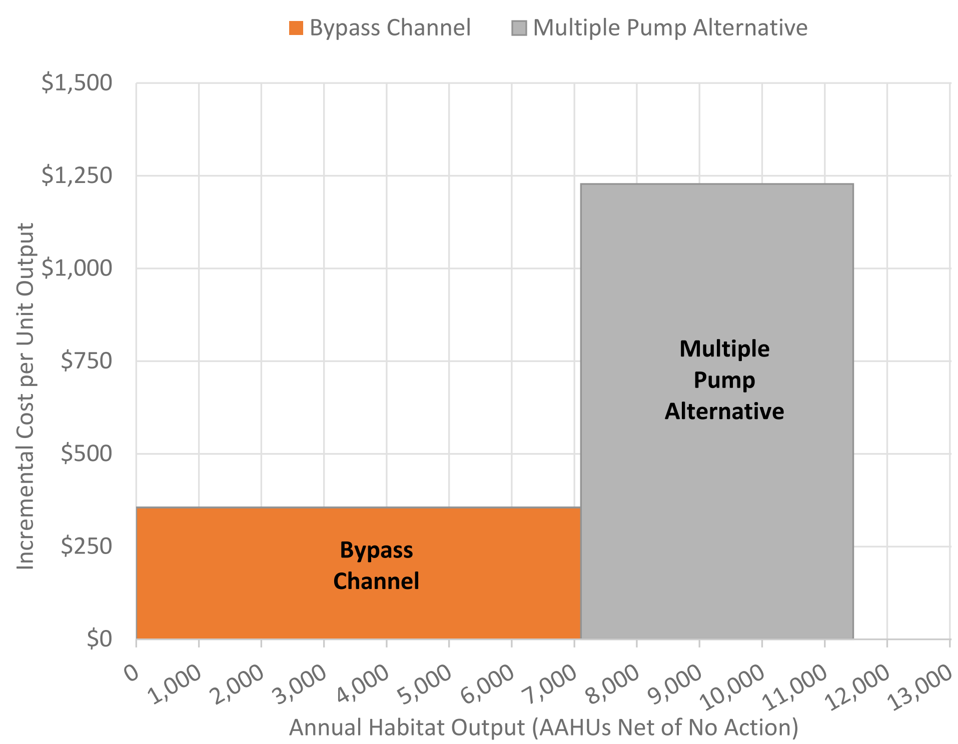
Best Buy Alternative	Annual Cost ($)	Net AAHUs	Incremental Cost	Incremental Output	Incremental Cost per Unit Output
No Action	$0	0	$0	0	$0
Bypass Channel	$2,527,000	5,768	$2,527,000	5,768	$438
Multiple Pump	$7,868,000	12,086	$5,341,00	6,318	$845

Scenario 1 – Revised Fishway Location Score

Cost Effectiveness

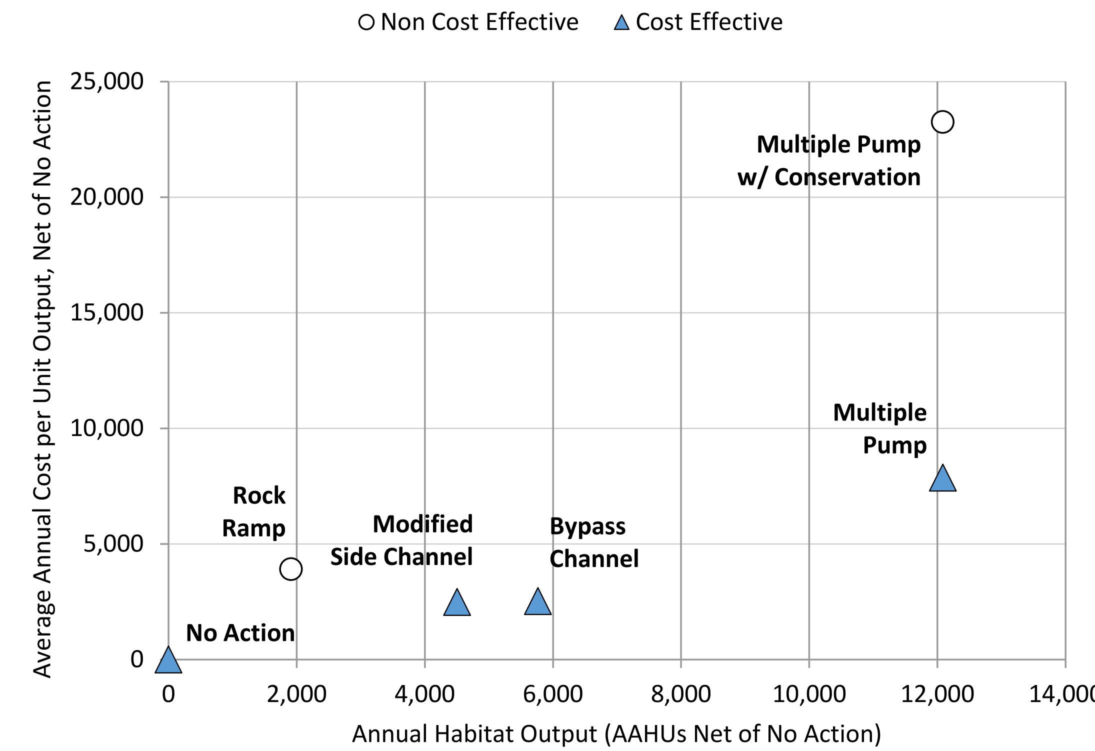


Best Buy Plans

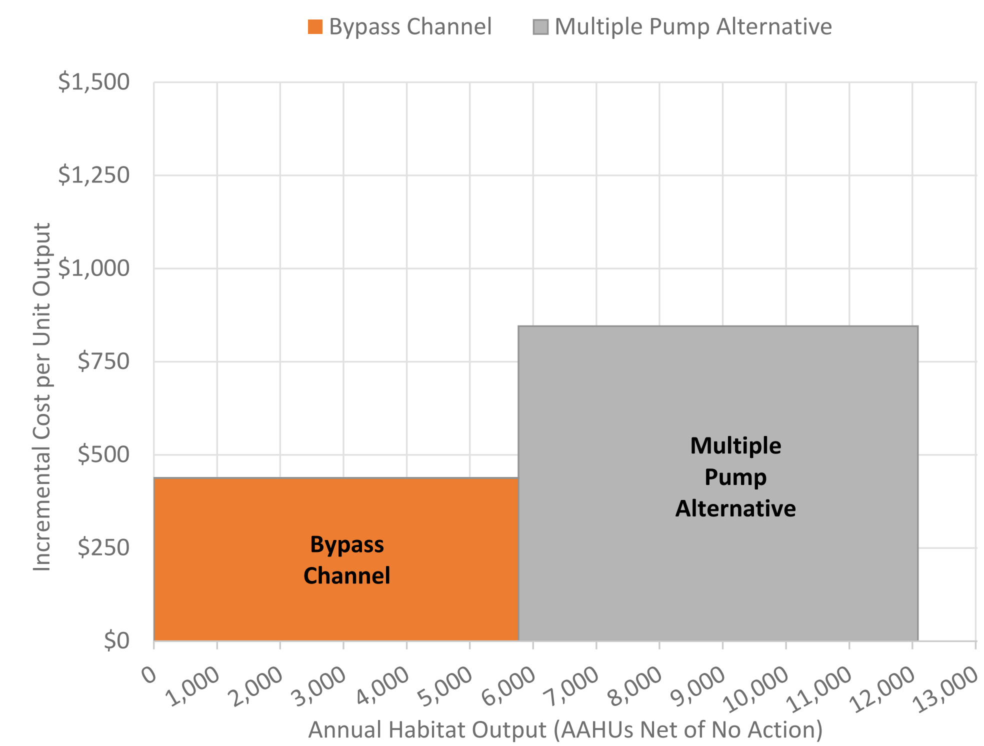


Scenario 2 – Pallid Sturgeon Only

Cost Effectiveness



Best Buy Plans



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Attachment 1

Table 4. Estimate Suitability of Fishway Locations (F_I) for Each Fish Guild Based Upon Swimming Performance and Behavior.

	Potential Fishway Location – Lock and Dam 22 example			
Guild	Main Channel	Main Channel Border – near channel	Main Channel Border– near shore; Side Channel; or Bypass Channel	Lock
Benthic – Strong	5	5	3	1
Littoral – Strong	5	5	3	1
Pelagic – Strong	5	5	3	1
Benthic – Medium	1	5	5	1
Littoral – Medium	1	3	5	1
Pelagic – Medium	1	5	5	1
Benthic – Weak	1	5	5	1
Littoral – Weak	1	3	5	1
Pelagic – Weak	1	1	5	1

5 = Entrance would be encountered by a significant portion of the population
3 = Entrance may be encountered
1 = Unlikely that entrance would be encountered

Table 4 is reproduced from Corps (2011) showing the scoring for various guilds of fish relative to general fishway locations.

Attachment 2

DEPARTMENT OF THE ARMY
MISSISSIPPI VALLEY DIVISION, CORPS OF ENGINEERS
P.O. BOX 80
VICKSBURG, MISSISSIPPI 39181-0080

REPLY TO
ATTENTION OF:

CEMVD-PD-L 15 September 2016

MEMORANDUM FOR CECW-NWD (Kramer)

SUBJECT: Recommendation for Single Use Approval of the Fish Passage Connectivity Index for the Lower Yellowstone Intake Diversion Dam Fish Passage Project

1. References:
   a. Engineer Circular 1105-2-412: Assuring Quality of Planning Models, dated 31 March 2011.

   b. Fish Passage Connectivity Index, Upper Mississippi River System Fish Passage Improvement Ecosystem Restoration Projects – Regional Certification Memo, dated 16 September 2011 (Encl 1).

   c. Model Documentation, Fish Passage Connectivity Index for the Lower Yellowstone Intake Diversion Dam Fish Passage Project, dated 08 September 2016 (Encl 2).

   d. Model Approval Plan, Fish Passage Connectivity Index for the Lower Yellowstone Intake Diversion Dam Fish Passage Project, dated 19 July 2016 (Encl 3).

   e. Model Review Comment Response Record, Fish Passage Connectivity Index for the Lower Yellowstone Intake Diversion Dam Fish Passage Project, dated 08 September 2016 (Encl 4).

   f. Model Spreadsheet Calculator, Fish Passage Connectivity Index for the Lower Yellowstone Intake Diversion Dam Fish Passage Project, dated 08 September 2016 (Encl 5).

2. The Fish Passage Connectivity Index (FPCI) model is certified for regional use in the Upper Mississippi River System with possible application on other river systems (Encl 1). The National Ecosystem Restoration Planning Center of Expertise (ECO-PCX) received a request from Omaha District (NWO) to use this model on the Yellowstone River for the purposes of evaluating the suitability of various fish passage alternatives for the Lower Yellowstone Intake Diversion Dam Fish Passage Project (Encl 2), and subsequently initiated review of this application following the model certification requirements (Reference 1.a.) and the model approval plan (Encl 3). Based on the review results (Encl 4), the ECO-PCX recommends Single Use Approval of the FPCI for the Lower Yellowstone Intake Diversion Dam Fish Passage Project. Please log in this recommendation with the Office of Water Project Review for the Model Certification Team to consider.

3. The FPCI model was developed by the Navigation and Ecosystem Sustainability Program, Lock and Dam 22 Fish Passage Ecosystem Restoration Project Delivery Team which included fisheries biologists and hydraulic engineers from USACE (MVS, MVR, MVP, ERDC), US Fish and Wildlife Service (USFWS) Ecological Services and Refuges, Illinois Department of Natural Resources, Illinois Natural History, Missouri Department of Conservation, and Iowa Department of Natural Resources. The model calculates Habitat Units (HU) for each migratory fish species and averages HU for all migratory fish species for each fish passage alternative. Model input includes movement periods for each migratory species, likelihood of species to encounter fishway entrance based on location, species potential to use passage route; and availability of suitable passage conditions during movement and spawning periods. The result is a 0-1 index that represents the suitability of the fish passage

alternative measure to a given species. The fish passage connectivity index is multiplied by the acres of connected, upstream habitat types that are suitable to the individual migratory species to get Habitat Units.

4. Prior review concluded the FPCI meets model criteria of technical and system quality and usability. The model addresses the key factors associated with fish passage and is easily modified for application at numerous locations. For a given area, users will input species data such as timing of migration, swimming abilities, swimming behavior, and input on habitat quality available to the migrating fish. Below is a summary of the input data used and minor adjustments made to the model to demonstrate ecological benefits of the Yellowstone River Intake Diversion Dam fish passage alternatives.

   - The certified FPCI model does not include pallid sturgeon, so it was added to the model.

   - Habitat preferences/use for each species was considered acceptable as presented in the FPCI with one slight adjustment as noted by the Corps (2015); white sucker, blue sucker and river carpsucker were shown only to be associated with main channel border habitats in the original FPCI. However, for purposes of this study, these species were also assumed to utilize main channel habitats. The "main channel" habitat type in the Upper Mississippi River was defined as a navigation channel, which is very different than main channel habitats in the Yellowstone River, and may be the reason those species were not associated with that habitat type.

   - The Di variable accounts for the timing of when fish passage is physically possible at a dam compared with the time of when fish typically migrate. NWO modified the "percent probability of open river conditions" in the original model (which referred to when dam gates were open on the Upper Mississippi River) and used available literature (Jaeger, et al. 2005; Helfrich et. al. 1999), anecdotal information, and best professional judgment, to assign probabilities that passage opportunities exist on a weekly basis as a function of flow, with highest probabilities being associated with the peak of the typical hydrograph, and very small (1%) probabilities being attributable to the timeframes outside of the peak river flow (September-April).

   - Information on fish migratory behaviors and timing from the original model was modified because the time of year when migration takes place on the Yellowstone River is different than on the Mississippi River. Movement and spawning periods were pushed back 3-4 weeks later in the year as migrations tend to take place later in the year for cooler, more northern latitudes.

5. Review of the input data and minor adjustments made to the model for this project was conducted by Joe Jordan (MVR) and Elliott Stefanik (MVP). Mr. Jordan is a MVD Biologist Regional Technical Specialist with specific expertise in large river fish passage and is familiar with the structure and use of the FPCI. Mr. Stefanik is the Environmental Planning Section Chief in MVP and is a subject matter expert in large river fish passage and has experience planning fish passage restoration projects. The ECO-PCX managed the review to assess the technical quality, system quality, and usability of the project specific input data. The review results are in Enclosure 4.

   There were three final comments (two moderate significance and one low significance). The first and second comments related to the application of the model for alternative evaluation. Specifically, the reviewers were concerned the inputs leading to the calculated value of the Ei variable within the FPCI may not be appropriate. Both comments were evaluated and closed by providing additional information on why the rock ramp would not be as suitable as a bypass channel for pallid sturgeon. This is also reinforced and documented through consultation and correspondence with the USFWS. The final comment was related to the usability of the model for this project. The reviewer was concerned about the selection of Ui (Potential for Species to Use Fishway) scores of 2 when the model documentation only lists possible scores of 5, 3, or 1. In this case, the PDT's deviation from the original model are relatively minor and are in fact justified with additional documentation and independent professional judgement from the various resource biologists. Documentation on the deviation from the model was included in the project report and model documentation for the project.

All comments were addressed and incorporated to the satisfaction of the ECO-PCX and reviewers.

6. The ECO-PCX finds the input data used and minor adjustments made to the FPCI for this project are technically appropriate, computational correct, and usable for the Lower Yellowstone Intake Diversion Dam Fish Passage Project. The use of the model outside of the certified geographic location is appropriate and the model continued to be used in a policy compliant manner. The ECO-PCX recommends Single Use Approval of the FPCI for the Lower Yellowstone Intake Diversion Dam Fish Passage Project. Please notify the ECO-PCX of the Model Certification Panel's findings.

Gregory Miller

Encls (5)

Gregory Miller
Operating Director
National Ecosystem Restoration
Planning Center of Expertise

CF (without enclosures)
CECW-PC (Paynes, Coleman, Matusiak, Trulick, Bee)
CECW-NWD (Durham-Aguilera, Dunn)
CENWD-PDD (Combs, Hudson, Fischer)
CENWO-PM (Thompson, Johnson, Laux, Vanosdall)
CEMVP-PD-F (Richards)
CEMVD-PD-L (Chewning, Lachney, Miller, Young)
CELRP-PM-EV (Fleeger)

Enclosure 1

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

CECW-P 16 September 2011

MEMORANDUM FOR Director, National Ecosystem Restoration Planning Center of Expertise (ECO-PCX)

SUBJECT: Fish Passage Connectivity Index (FPCI), Upper Mississippi River (UMR) System Fish Passage Improvement Ecosystem Restoration Projects – Regional Certification

The FPCI, which evaluates ecosystem outputs of alternative measures for fish passage improvements for cost effectiveness and incremental analysis, is certified for regional use. Adequate technical reviews have been accomplished and the model meets the certification criteria contained in EC 1105-2-412. The FPCI is an arithmetic index that incorporates characteristics of migratory fishes present at Lock and Dam 22 on the UMR and characteristics of fish passage alternative measures. While originally intended for use for the Lock and Dam 22 project, it is applicable to fish passage projects at other dams on the UMR and has the potential for application to fish passage projects on other river systems. Subject to a demonstration by the ECO-PCX that use of the model is applicable to other river systems, the regional certification will be expanded. This regional certification is based on the decision of the HQUSACE Model Certification Panel which considered the ECO-PCX assessment of the model.

APPLICABILITY: This regional certification is limited to fish passage projects at other dams on the UMR with possible application on other river systems.

EXPIRES: 30 September 2018

HARRY E. KITCH, P.E.
Deputy Chief, Planning and Policy Division
Director of Civil Works

Enclosure 2

Lower Yellowstone Intake Diversion Dam Fish Passage Project, Montana

FINAL - APPENDIX D

Lower Yellowstone Intake Fish Passage EIS

Fish Passage Connectivity Index and Cost Effectiveness and Incremental Cost Analysis

SEPTEMBER 2016

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1.0 Fish Passage Connectivity Index

1.1 Introduction

Intake Diversion Dam has likely impeded upstream fish passage for pallid sturgeon and other fish species in the Yellowstone River since it was completed in approximately 1909. The best available science suggests that the diversion dam is a partial barrier to some fish species including shovelnose sturgeon (Bramblett, et al. 2015; Helfrich et al. 1999; Jaeger et al. 2004; Backes et al. 1994; Stewart 1986, 1988, 1990, 1991; Rugg 2016). It is essentially a total barrier to other fish species, such as pallid sturgeon, due to a high level of turbulence associated with the rocks at the dam crest and in the downstream boulder field and high velocities at the dam crest (Jaeger et al. 2005; Fuller et al. 2007; Helfrich et al. 1999; White and Mefford 2002; Bramblett and White 2001). Pallid sturgeon were tracked passing upstream of the dam via the existing high-flow side channel in 2014 and 2015 (Rugg 2014, 2015, 2016) during flows greater than 30,000 cfs. It is not known if passage has occurred before 2014 because this was the first year that fish were tracked swimming upstream of the dam.

Improving fish passage at Intake Diversion Dam accomplishes several things from a pallid sturgeon recovery perspective:

- It would provide access to approximately 165 miles of Yellowstone River habitat upstream of Intake Diversion Dam and additional miles on tributaries such as the Powder River that are currently inaccessible to the pallid sturgeon;
- The area to which access would be provided appears to include substantial areas of suitable spawning habitat for pallid sturgeon including bluff pools and other areas of swift water over gravel and cobble substrates (Jaeger, et al. 2005, Rugg 2014, 2015; Bramblett, et al. 2015);
- If 165 more river miles were accessible for spawning, it would provide longer drift distances and a larger area available for larvae to stop dispersal and seek rearing habitat before reaching Lake Sakakawea, which is currently thought to be unsuitable larval settling habitat due to the fine substrates and low dissolved oxygen levels (Braaten et. al. 2008, 2011; Guy et al. 2015; Bramblett & Scholl 2016)

While the primary purpose of a fish passage project at Intake Dam is to improve pallid sturgeon passage, other migratory species of fish are also likely to also benefit from the project. This includes fish that are important from a management perspective by the State of Montana, such as shovelnose sturgeon, paddlefish, sauger, and blue sucker, as well as a variety of native fish species that reside in the Yellowstone River and undertake shorter seasonal movements.

Federal agencies are required to evaluate the economic and environmental costs and benefits of water resources projects that it undertakes (CEQ 2013). For a project with environmental benefits, such as this fish passage project, benefits are not reasonably monetized. However, if benefits can be quantified in some dimension, cost effectiveness and incremental cost analysis can be used to assist in selecting a preferred plan. Cost effectiveness analysis evaluates which alternatives are the least-costly way of attaining the project objectives. Incremental analysis is then used to evaluate the change in cost from each measure or alternative to the next to determine their incremental costs and incremental benefits. This type of analysis helps identify which measures or alternatives provide more benefits for lower cost and can be used as one element to inform the selection of a preferred plan.

1.2 Fish Passage Connectivity Index

The Fish Passage Connectivity Index (FPCI) was developed to evaluate ecosystem outputs (i.e. benefits) of alternative measures for fish passage improvements on the Upper Mississippi River and Illinois Waterway System for cost effectiveness and incremental analysis (Corps 2011). The model was developed for use in the plan formulation process for the Navigation and Ecosystem Sustainability Program for the Upper Mississippi River System fish passage improvement ecosystem restoration projects. The model is currently in review by the Ecosystem Restoration Center of Expertise as required for use in the U.S. Army Corps of Engineers (Corps) planning context for this project (Corps 2016). This model was used in an assessment of fish passage alternatives at Intake Diversion Dam in 2015 (Corps 2015).

The FPCI is a simple arithmetic index that is calculated as:

$$Є = \frac{\Sigma\, i \ldots n\ [(E_i \text{ x } U_i \text{ x } D_i)/25]}{n}$$

Where,

Є = Fish Passage Connectivity Index.

i = a migratory fish species that occurs in Pool or reach below the dam.

n = number of fish species included in the index.

Ei = Probability of encountering the fishway entrance is a calculated value ranging from 1 to 5, where 5 = highly likely; 3 = moderate probability; 1 = unlikely.

Ui = Potential for species i to use the fish passage pathway or fishway (5 = Good, 3 = Moderate, 1 = Poor, 0 = None) considering adult fish swimming performance and hydraulic conditions within the fishway or fish travel pathway.

Di = Duration of availability, the fraction of the upriver migration period for fish species i that the passage pathway is available. Di incorporates a risk component (i.e., the potential failure of an alternative to perform or be available during a critical fish movement period.)

Although the model was developed to measure benefits of fish passage in the Upper Mississippi River, the model is applicable (with slight adjustments) to fish passage projects on other large river systems, especially those with very similar fish communities. This model, with minor adjustment, was used as a planning tool for comparing benefits of alternative measures for provide fish passage at Intake Dam. It should be recognized that this model is a planning tool that relies on the best professional judgment of users (informed by the published literature on the species) and does not represent a statistical probability of fish passage but a relative comparison of effectiveness. This memo describes the input data used and minor adjustments made to the model to demonstrate ecological benefits of the Yellowstone River Intake Diversion Dam fish passage alternatives.

1.3 Data Required for the Model

1.3.1 Identify fish to be included for analysis, and their associated habitat preferences, swimming behaviors, and swimming abilities.

1.3.1.1 The FPCI model was created with a list of 40 fish species that could be considered for use in the model (Corps 2011). This list does not include pallid sturgeon. Swimming performance data, swimming behavior, and critical current velocities (Ucrit) for prolonged swimming by adult fish used in the creation of the model were sourced from two primary studies on the Upper Mississippi River (Wilcox et al. 2004; Pitlo et al. 1995). More recent data were used to calculate an estimated Ucrit for adult pallid sturgeon (Braaten et al. 2015) and to make one other change to anticipated swimming speeds of other species; walleye Ucrit was reduced to 3.0 feet/second (Peake et al. 2000). The 14 species used in this model are shown in Table 1-1.

1.3.1.2 For ensuring a good comparison of benefits across fish passage alternatives, the fish species selected for use in this FPCI modeling effort, the thirteen (13) species used by the Corps in 2014 with the addition of pallid sturgeon, for a total of 14 species. The inclusion of pallid sturgeon does not change the ranking of alternatives Because this project is focused on improving fish passage for pallid sturgeon, the project team felt that including it specifically (instead of using shovelnose sturgeon as a surrogate) gives added importance to pallid sturgeon capabilities and provides a better differentiation between similar alternatives. As explained in the Corps (2015) modeling, the other 13 species were selected because they represent the native migratory species typically found in the Yellowstone River at Intake Diversion Dam and the species provide good representation of the various guilds of fish based on their various migration behaviors (benthic (8), pelagic (2), and littoral (3) and swimming abilities (strong (6), medium (5), weak (2)).

1.3.1.3 Habitat preferences/use for each species was considered acceptable as presented in the FPCI with one slight adjustment as noted by the Corps (2015); white sucker, blue sucker and river carpsucker were shown only to be associated with main channel border habitats in the original FPCI. However, for purposes of this study, these species were also assumed to utilize main channel habitats. The “main channel” habitat type in the Upper Mississippi River was defined as a navigation channel, which is very different than main channel habitats in the Yellowstone River, and may be the reason those species were not associated with that habitat type. These three species are known to utilize main channel habitats available in the Yellowstone and Upper Missouri River systems, and as such, were associated with it for purposes of this study. In addition, pallid sturgeon was included and shown with a habitat preference for main channel and main channel border habitats similar to the habitat preferences provided for shovelnose sturgeon.

1.3.1.4 Fish species of concern are well represented. Species of special concern that are included in this analysis include the shovelnose sturgeon, paddlefish, sauger, and blue sucker.

Habitat loss and fish passage barriers have contributed to the decline of these species (Montana AFS 2016). It is important to ensure fish passage alternatives do not reduce passage for these species.

Table 1-1. Species Used in the FPCI Model for Intake Diversion Dam with Swimming Speed and Habitat Preference.

Common Name	Scientific Name	Swimming Behavior	Swimming Performance	Swimming Speed (Ucrit)[1,2,3] (ft/sec)	Habitat Preference
Shovelnose sturgeon	*Scaphirhynchus platorhynchus*	Benthic	Medium	2.7	B,C
Paddlefish	*Polyodon spathula*	Pelagic	Strong	4.2	B,C
Goldeye	*Hiodon tergisus*	Pelagic	Medium	2	A,B,D,E
Smallmouth buffalo	*Ictiobus bubalus*	Benthic	Medium	2.1	B,C,D,E
Blue sucker	*Cycleptus elongatus*	Benthic	Strong	2.6	B,C
White sucker	*Catosomus commersoni*	Benthic	Weak	2.1	B,C
River carpsucker	*Carpiodes carpio*	Benthic	Weak	1.5	B,D,E
Shorthead redhorse	*Moxostoma macrolepidotum*	Benthic	Medium	2	B,C
Channel catfish	*Ictalurus punctate*	Benthic	Strong	2.7	A,B,C,D,E
Smallmouth bass	*Micropterus salmoides*	Littoral	Medium	2.1	A,B,D,E
Walleye	*Sander vitreus*	Littoral	Strong	3[4]	B,C,D
Sauger	*Sander canadensis*	Littoral	Strong	2.6	B,C,D
Freshwater drum	*Aplodinotus grunniens*	Benthic	Strong	2.7	A,B,C,D,E
Pallid sturgeon	*Scaphirhynchus albus*	Benthic	Medium	3.3	B,C

A = Contiguous floodplain lake; B = Main channel border; C = Main channel; D = Secondary channel; E = Tertiary channel; F = Tributary

[1] Pitlo, J., Jr., Van Vooren, A., and Rasmussen, J. (1995). "Distribution and relative abundance of Upper Mississippi River fishes," Upper Mississippi River Conservation Committee Fish Technical Section, Rock Island, IL.

[2] Wilcox, D.B. et al (2004) "Improving fish passage through navigation dams on the Upper Mississippi River system", ENV Report 54, U.S. Army Corps of Engineers, Rock Island, St. Louis, and St. Paul Districts

[3] Braaten, P.J., C.M. Elliott, J.C. Rhoten, D.B. Fuller, & D.J. McElroy. 2015. Migrations and swimming capabilities of endangered pallid sturgeon (*Scaphirhynchus albus*) to guide passage designs in the fragmented Yellowstone River. Restoration Ecology 23(2): 186-195.

[4] Peake, S., R.S. McKinley, & D.A. Scruton. 2000. Swimming performance of walleye (*Stizostedion vitreum*). Canadian Journal of Zoology 78: 1686-1690.

1.3.2 Identify habitat acres made available by passage.

1.3.2.1 Habitat Units are calculated in the model by multiplying the fish passage index by the total acres of available preferred habitat upstream of Intake Diversion Dam for each species. For this analysis, the habitat acres mapped between Intake and Cartersville on low-level aerial photography for the *Yellowstone River Cumulative Effects Analysis* (Corps & YRCDC 2015; Corps 2015; Yellowstone River Corridor Clearinghouse 2016) were used.

1.3.2.2 Habitat types from the Cumulative Effects Analysis (CEA) include the following primary categories:

Scour – (SC) Scour pool occurring in otherwise unconstrained river channel.

Bluff – (BL) Scour pool located at the base of a bedrock bluff. Indicates a relatively permanent pool location bounded by a geologic constraint.

Terrace – (T) Scour pool located at the base of a terrace (Quarternary Alluvium).

Riprap Bottom – (RRB) Scour pool occurring in riprap constrained channel where riprap is located in the middle of the active channel area.

Riprap Margin – (RRM) Scour pool occurring in riprap constrained channel where riprap is located at the edge of the active channel area.

Channel Crossover – (CC) A transitional unit where the river is translating from one bendway or pool to the next.

Bedrock – (BED) Channel is controlled by bedrock bed.

Secondary Channel – (2C) Undifferentiated low flow channel. No additional habitat typing is defined, though the channel likely contains areas of pool and riffle.

Secondary Channel Seasonal – (2CS) Secondary channel High flow channel

Point Bar – (PB) Areas in the bank full lines that show aggradation associated with the insides of a bendway. Can include exposed gravel, or areas with vegetation, as long as they lie within the bank full area.

Side Bar – (SB) Areas in the bank full lines that show aggradation along the sides of a channel. These bar areas create channel sinuosity at low flows but are inundated at higher or bank full flows. Can include exposed gravel, or areas with vegetation, as long as they lie within the bank full area.

Mid-Channel Bar – (MCB) Areas in the bank full lines that show aggradation, creating islands within the low flow area. Can include exposed gravel or areas with emergent vegetation, as long as they lie within the bank full area.

Dry Channel – (DC) This is a general category for areas within the bank full boundaries that do not fit into Point Bar, Side Bar, Mid-channel Bar, or Island categories. They are generally associated with split flows around islands where there is exposed channel bed at low flow, but does not appear to be strictly depositional in nature, though they could still have some depositional characteristics. Can include exposed gravel or areas with vegetation, as long as they lie within the bank full area.

Dam – Habitat unit is influenced by a dam in the main channel.

1.3.2.3 As depicted in Table 1-2, the CEA habitat categories were cross-walked to the habitat categories as defined for the Upper Mississippi River in the FPCI, allowing Yellowstone River habitat acreages to be compatible with the existing layout as presented in the FPCI model. The habitats for the Upper Mississippi River were defined as:

- Contiguous Floodplain Lake
- Main Channel Border
- Main Navigation Channel
- Secondary Channel
- Tertiary Channel
- Tributary Channel

1.3.3 Identify Windows of Opportunity for Upstream Fish Passage

A window of opportunity, or the timing of when fish passage is physically possible at a dam due to typical peak flows (and suitable depths and velocities), compared with the timeframe of when fish typically migrate, is used to estimate the duration of availability (Di) for the baseline condition and each alternative in the FPCI. The Corps (2015) modified the "percent probability of open river conditions" in the original model (which referred to when the dam gates were open on the Upper Mississippi River) and used available literature (Jaeger, et al. 2005; Helfrich et. al. 1999), anecdotal information, and best professional judgment, to assign probabilities that passage opportunities exist on a weekly basis as a function of flow, with highest probabilities being associated with the peak of the typical hydrograph, and very small (1%) probabilities being attributable to the timeframes outside of the peak river flow (September-April). These same probabilities were used in this analysis for the existing conditions. Table 1-3 shows the windows of opportunity for fish passage, as entered into the FPCI model to represent the no action alternative (existing condition).

For the rock ramp alternative, the depths and velocities are suitable at most times, but for some species at some flows, depths may be too shallow or velocities too high to have suitable passage. Thus, the 2D model results for the rock ramp were used to indicate the duration of passage availability for the median flows in each month of interest. Table 1-4 shows the opportunity for passage as used in the FPCI model for the rock ramp alternative.

For the other alternatives, an assumption was made both by the Corps in 2015 and for this application that the duration available for fish passage would be 100% during the pre-spawn and spawning migration season for the bypass channel, modified side channel, and dam removal alternatives because suitable depths and velocities would be provided across all typical flows. Table 1-5 shows the opportunity for passage as used in the FPCI model for these remaining alternatives.

1.3.3.1 Seasonality of Fish Migration

Basic information on fish migratory behaviors and timing from the original FPCI model was modified by Corps (2015) because the actual time of year when migration takes place on the Yellowstone River is different than on the Mississippi River. Movement and spawning periods were pushed back 3-4 weeks later in the year as migrations tend to take place later in the year for cooler, more northern latitudes. Other information considered in establishing the migratory timeframes for the Yellowstone River at Intake Diversion Dam included data found in Elser, et al. (1977), anecdotal data from George Jordan (Mike Backes, Montana Fish Wildlife and Parks survey data) and best professional judgment. Migratory timeframes as utilized in the FPCI modeling for the Intake Dam project are shown in Table 1-6.

In addition, for this analysis, the migratory timing was adjusted for four fish species: shovelnose sturgeon, paddlefish, blue sucker, and sauger based on literature available for these species from recent tracking on the Yellowstone River (Rugg 2014, 2015, 2016; Bramblett et al. 2014). Pallid sturgeon timing was also adjusted based on recent tracking data for the Yellowstone River (Delonay et al. 2015; Rugg 2014, 2015, 2016).

Table 1-2. Habitat crosswalk for area between Intake and Cartersville (Yellowstone River Corridor Clearinghouse 2016).

Low Flow Fisheries Habitat	Acres	Habitats as Defined in UMRC FPCI Model					
		Contiguous Floodplain Lake	Main Channel Border	Main Nav Channel	Secondary Channel	Tertiary Channel	Trib Channel
2C - Secondary low flow channel	1,251				1,251		
2CS - Secondary high flow channel	1,930				1,930		
CC - Channel crossover	3,152			3,152			
DC - Dry Channel not meeting PB, SB, MCB or I categories	1,348					1,348	
I - Islands - vegetated	6,589						
MCB - Mid Channel Bar aggradation area within bankfull lines	772		772				
PB - Point Bar area in bankfull line showing aggradation	1,062		1,062				
SB - Side Bar area in channel showing aggradation at high flow lines at bank	0						
RRB - Scour at riprap - mid active channel	722			723			
RRM - Scour at riprap - margin of active channel	723		723				
SC - Scour in unconstrained river	3,099			3,099			
T - Scour at base of terrace	1,762		1,762				
BL - Scour at base of bedrock bluff	1,293		1,293				
Trib - Large tributary confluences	10						10
Dam	51			51			
TOTAL		0	5,612	7,025	3,181	1,348	10

Table 1-3. Opportunity for Fish Passage at Intake Diversion Dam for the No Action (existing conditions; associated primarily with peak runoff).

Month	Jan-Apr			May			June			July			Aug-Dec		
Week	1-17	18	19	20	21	22	23	24	25	26	27	28	29	30	31-52
% Opportunity for Passage	1	1	1	25	50	100	100	100	100	100	50	25	1	1	1

Table 1-4. Opportunity for Fish Passage for Rock Ramp Alternative

Month	Jan-Mar	Apr	May	June	July	Aug	Sept	Oct-Dec
Week	1-13	14-17	18-21	22-25	26-30	30-34	35-38	39-52
% Opportunity for Passage	1	95	97	100	97	95	95	1

Table 1-5. Opportunity for Fish Passage for the Bypass Channel, Modified Side Channel, and Multiple Pump Alternatives

Month	Jan-Mar	Apr	May	June	July	Aug	Sept	Oct-Dec
Week	1-13	14-17	18-21	22-25	26-30	30-34	35-38	39-52
% Opportunity for Passage	1	100	100	100	100	100	100	1

Table 1-6. Migratory Timing for Species Used in FPCI.

▨ **Pre-spawning movement period** ▩ **Spawning period**

	Month of Year	February				March				April					May				June				July					August				September			
	Week of Year	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1	**Shovelnose sturgeon**														▨	▨	▩	▩																	
2	**Paddlefish**												▨	▨	▨	▨	▩	▩	▩	▩	▩	▩	▩												
3	**Goldeye**												▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩												
4	**Smallmouth buffalo**																	▨	▨	▩	▩	▩	▩	▩											
5	**Blue sucker**													▨	▨	▨	▩	▩	▩	▩	▩	▩													
6	**White sucker**									▨	▨	▩	▩	▩	▩																				
7	**River carpsucker**												▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩	▩	▩	▩									
8	**Shorthead redhorse**												▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩												
9	**Channel catfish**																		▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩	▩					
10	**Smallmouth bass**													▨	▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩										
11	**Walleye**						▨	▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩																	
12	**Sauger**						▨	▨	▨	▨	▩	▩	▩	▩	▩	▩	▩	▩	▩	▩															
13	**Freshwater drum**														▨	▨	▨	▩	▩	▩	▩														
14	**Pallid Sturgeon**											▨	▨	▨	▩	▩	▩	▩	▩	▩	▩	▩													

1.3.4 Identity Potential Fish Passage Connectivity

1.3.4.1 Probability that Fish Encounters Fish Passage Alternative **(Ei)**

E_i simulates the relationship between fishway size (F_s) and ability of a fish to encounter the fishway entrance location (F_l) within the FPCI. (E_i) is expressed as a value ranging from 1 to 5, with 5 being highly likely, and 1 being unlikely. The relationship is represented by the following equation: $E_i= (F_s+F_l)/2$

1.3.4.2 Determine Potential for Fish to Encounter Passage Alternative **(Fl)**

Fl is used to assess the suitability of the fishway entrance location for each fish guild based on swimming performance and behavior. As described in the FPCI, swimming performance and migration behavior are important because they indicate the route as well as vertical and horizontal position within the flow field that a fish would generally select. Guilds of fish species, as defined by swimming performance and behavior. Table 4 in the Corps (2011) model documentation assigned values for the potential for fish species to encounter a fish passageway located in main channel, main channel border (near channel), main channel border (near shore) and lock locations (Table 4 attached). Species that primarily use main channel habitats are highly likely to encounter a main channel passageway (received a score of 5, indicating that the fish passageway entrance would be encountered by a significant portion of the population of that species). Species that primarily use channel border, side channel, or other habitats would be unlikely to encounter a main channel fish passageway (received a score of 1 indicating that it was unlikely the fish passageway entrance would be encountered). Scores ranging from 1 to 5 were assigned based on the location of the fish passageway in comparison to the primary habitat used by the species.

To assign an Fl value to each guild, the Corps (2015) used the same likelihood that was used in the Upper Mississippi system based on monitoring data and the professional judgment of an interagency group of large river fisheries biologists. For this analysis, as additional alternatives were included and additional detailed design had been completed for the proposed bypass channel to maximize the orientation and flows from the bypass channel for main channel fish to locate the channel entrance, the scores were re-evaluated and adjusted. The no action and rock ramp scores were not modified from the scores used by the Corps in 2015 (Table 1-8). For the bypass channel, main channel species including pallid sturgeon, shovelnose sturgeon, paddlefish, and blue sucker were assigned a score of 4 as the bypass channel entrance has been further modeled and designed for its attraction flows to be directed towards the main channel thalweg where these main channel species would be present. Additionally, walleye and sauger were assigned a score of 5 as the bypass channel entrance would be located and directed towards the near channel areas used by these species.

1.3.4.3 Determining the Size of Fish Passage Alternative (Fs)

- This parameter is the size of the fishway relative to the discharge of the river under low flow conditions. For the Yellowstone River, Corps (2014) used the recommendation by the BRT that fish passage alternatives should be capable of conveying up to 30% of river flow. Therefore the following range of inputs for Fs were established by Corps

(2015) for the Intake project; 5 was assigned to fishway designs that pass 30 percent or more of the low flow discharge, 4 = 25 percent, 3 = 20 percent, 2 = 15 percent, and 1 = equal to or less than 10%.

- More recent tracking of pallid sturgeon passing upstream of Intake Diversion Dam by pallid sturgeon in 2014 and 2015 (Rugg 2014, 2015) indicates that passage is possible when flow in the existing side channel is only 2-6% of the river flow (based on HEC-RAS modeling for this study of flow splits into the side channel at river flows from 30,000 to 63,000 cfs, which was the rage of river flows when passage occurred).

The size of fishway for each alternative is listed in

- Table 1-9. The No Action, Rock Ramp, and dam removal alternatives all pass full flows of the river and received inputs of 5, whereas the bypass channel and modified side channel alternatives pass 15% of the flow and received inputs of 2.

Table 1-7. Swimming Performance and Behavior Guilds.

Performance	**Behavior**		
	Benthic	**Littoral**	**Pelagic**
Strong	Pallid sturgeon	Walleye	Paddlefish
	Shovelnose sturgeon	Sauger	
	Blue sucker		
Medium	Channel catfish	Smallmouth bass	Goldeye
	Freshwater drum		
	Shorthead redhorse		
	Smallmouth buffalo		
Weak	River carpsucker		
	White sucker		

Table 1-8. Estimate of Likelihood of Encountering the Fishway Entrance for Each Fish Guild. (Values: 5 – significant portion of population would encounter, 1 –unlikely that fish would encounter)

Estimated Probability of Encountering Fishway Locations (Fl) for Each Fish Guild				
	Fishway Location			
Guild	**Main Channel – Rock Ramp**	**Main Channel Border –Near Channel Thalweg(Bypass Channel)**	**Main Channel Border – Near Shore or Side Channel (Modified Side Channel)**	**No Dam**
Benthic – Strong -Pallid Sturgeon -Shovelnose Sturgeon -Blue sucker	5	4	2	5
Littoral – Strong -Walleye -Sauger	5	5	5	5
Pelagic – Strong -Paddlefish	5	4	2	5
Benthic – Medium -Channel Catfish -Freshwater Drum -Shorthead Redhorse -Smallmouth Buffalo	3	5	5	5
Littoral – Medium -Smallmouth Bass	1	5	5	5
Pelagic – Medium -Goldeye	1	5	5	5
Benthic – Weak -River Carpsucker -White Sucker	1	5	5	5
Littoral – Weak	1	5	5	5
Pelagic – Weak	1	5	5	5

Table 1-9. FPCI input data for Size of the fishway relative to flow (Fs). (Range of inputs for Fs are as follows: 5 = >30% of low flow discharge of river, 4 = 25% to >20% percent, 3 = 20% to >15% percent, 2 = 15% to >10%, and 1 = < 10%)

Size of Fishway (F_s)					
Measure A: No Action	**Measure B: Rock Ramp**	**Measure C: Bypass Channel 15% Flow**	**Measure D: Modified Side Channel 15% Flow**	**Measure E: Multiple Pumps**	**Measures F: Multiple Pumps with Conservation Measures**
F_s - Size of Fishway: 5	F_s - Size of Fishway: 5	F_s - Size of Fishway: 2	F_s - Size of Fishway: 2	F_s - Size of Fishway: 2	F_s - Size of Fishway: 5

1.3.4.4 Determine the Potential (U_i) for Fish to Use Alternative Fish Passage Measures, and the Duration of Availability (D_i) of the Alternative Measures.

The potential for a fish to pass upriver past an obstacle is dependent on its swimming performance, the hydraulic conditions that are encountered, and the likely pathway a fish would use (i.e. main channel vs. bank zone). Critical current velocities (U_{crit}), or the speed at which a fish can maintain prolonged swimming by adult fish used in this analysis are found in Table 1-1. The average current velocity at specific locations within each alternative (at 30,000 or 40,000 cfs) was compared to the U_{crit} speed for each migratory fish species. Scores can be selected over a range from 1 to 5. If velocities did not exceed the U_{crit} speed, the U_i was scored a 5. If velocities exceed U_{crit} speed, but was not likely to exceed burst speed it was scored a 3, and if velocity was likely to exceed burst speeds in a key location (i.e. inlet or outlet), or was widespread without potential for resting, it was scored a 1.

- Scores for Ui can be found in Table 1-10. Explanation of the selection of scores are provided below.
  a. Flow velocities over the existing dam are over 10 ft/sec, with turbulent flow. As such, it scores 1 for the U_i variable for most fish, with the exception of shovelnose sturgeon, paddlefish, blue sucker, walleye and sauger that have been documented to pass over the dam occasionally (Rugg 2016; Bramblett, et al. 2015), thus each getting a score of 2.
  b. The rock ramp has slightly reduced velocities as compared to the existing condition, but exceeds the U_{crit} of all species over a majority of the ramp (i.e. 8 ft/sec) and would likely have turbulent flow. The only fish likely to be able to pass consistently is paddlefish that have high U_{crit}, thus meriting a 5. Walleye is a strong swimmer that may be able to pass high velocities, but based on data from Peake et al. (2000) indicating walleye do not like to transition from slower to faster water readily, thus meriting a slightly reduced score of 4. Fish that are more littoral or pelagic in behavior that may use the margins of the rock ramp received a 3, and strong benthic swimmers other than paddlefish also received a 3, since passage is likely to be somewhat improved and these species have occasionally shown an ability to pass over the dam. Pallid sturgeon are still unlikely to be able to swim through turbulent flows and uneven rocks over such a long distance, although improved from the existing condition, thus receiving a 2 and river carpsucker are weak swimmers, thus receiving a 1.
  c. The bypass channel and modified side channel velocity modeling indicates velocities not greater than the U_{crit} for all species along the sides of the channel, thus allowing passage for all species.
  d. While not a consideration in the modeling, both the bypass and modified side channel alternatives would also have much less turbulence associated with them, as they would both provide channels that are very much like existing side channels of the Yellowstone River in terms of width, gradient and substrate.
  e. The multiple pump alternatives would return the channel to near natural conditions, thus allowing passage for all species.

1.3.4.5 Duration of Availability (Di) of the fish passage structure is the proportion of time when both the fish passage structure is physically available for passage, and migration is actually occurring for a particular species of fish.

Table 1-11 identifies when fish passage alternatives are available to fish for each alternative.

Di for the existing condition is calculated as the fraction of time that upriver movement may generally occur when the physical conditions at the dam allow for passage, typically during runoff. Thus, the Di is highly variable between each species of fish, depending on their migration timing in relation to the runoff period.

The Di for the rock ramp would be more passable with a low-flow channel through the replacement weir and ramp, but does not necessarily provide suitable depths and velocities at all times for all species and would not necessarily be the location where all species would seek passage. Thus, D_i was calculated from the opportunity for passage and migration timing of the species in relation to the runoff period.

The Di for all the other alternatives is available 100% of the time (ranked a 1) when passage is occurring. This is because the channels are all designed to have 13-15% flows at all flows above 7,000 cfs and also still convey flow down to 3,000 cfs, or lower, in the river.

Table 1-10. Potential (Ui) for Fish to Use Alternative Fish Passage Measures.

Scores can be selected on a scale of 1 to 5: If velocities do not exceed the U_{crit} speed for the alternative, the U_i was scored a 5; If velocities exceed U_{crit} speed but did not exceed burst speed it was scored a 3; and if velocities exceed burst speeds at all times it was scored a 1. Scores of 2 or 4 were selected for instances of known, but infrequent passage or limited flows when velocities do not exceed burst speed; or if velocities occasionally exceed U_{crit}, respectively.

Potential for Species to Use Fishway Type						
	Measure A: No Action	**Measure B: Rock Ramp**	**Measure C: Bypass Channel 15% Flow**	**Measure D: Modified Side Channel**	**Measure E: Multiple Pumps**	**Measure F: Multiple Pumps with Conservation Measures**
Fish Species	Ui	Ui	Ui	Ui	Ui	Ui
Shovelnose sturgeon	1	3	5	5	5	5
Pallid sturgeon	1	2	5	5	5	5
Paddlefish	2	5	5	5	5	5
Goldeye	1	3	5	5	5	5
Smallmouth buffalo	1	3	5	5	5	5
Blue sucker	2	3	5	5	5	5
White sucker	1	3	5	5	5	5
River carpsucker	1	1	5	5	5	5
Shorthead redhorse	1	3	5	5	5	5
Channel catfish	1	3	5	5	5	5
Smallmouth bass	1	3	5	5	5	5
Walleye	2	4	5	5	5	5
Sauger	1	3	5	5	5	5
Freshwater drum	1	3	5	5	5	5

Table 1-11. Duration Of Availability (Di) Of The Fish Passage Structure Is The Proportion Of Time When Both The Fish Passage Structure Is Physically Available For Passage, And Migration Is Likely Occurring For A Particular Species Of Fish.

Potential of Availability of Fishway Alternatives						
	Measure A: No Action	**Measure B: Rock Ramp**	**Measure C: Bypass Channel 15% Flow**	**Measure D: Modified Side Channel**	**Measure E: Pumping**	**Measure F: Ranney Wells**
Fish Species	Di	Di	Di	Di	Di	Di
Shovelnose sturgeon	0.19	0.97	1	1	1	1
Pallid sturgeon	0.44	0.98	1	1	1	1
Paddlefish	0.53	0.98	1	1	1	1
Goldeye	0.53	0.98	1	1	1	1
Smallmouth buffalo	0.86	0.99	1	1	1	1
Blue sucker	0.53	0.98	1	1	1	1
White sucker	0.01	0.95	1	1	1	1
River carpsucker	0.47	0.98	1	1	1	1
Shorthead redhorse	0.53	0.98	1	1	1	1
Channel catfish	0.48	0.98	1	1	1	1
Smallmouth bass	0.54	0.98	1	1	1	1
Walleye	0.07	0.72	1	1	1	1
Sauger	0.20	0.76	1	1	1	1
Freshwater drum	0.54	0.98	1	1	1	1

Table 1-12. Connectivity Index and Habitat Units

Migratory Fish Species		Measure A: No Action		Measure B: Rock Ramp		Measure C: Bypass Channel, 15% Flow		Measure D1: Modified Side Channel		Measure E: Multiple Pump		Measure F: Multiple Pumps w/ Conservati	
Common Name	Total Available Preferred Habitat (acres)	€ = Fish Passage Connectivity	Habitat Units (€ X acres)	€ = Fish Passage Connectivity	Habitat Units (€ X acres)	€ = Fish Passage Connectivity	Habitat Units (€ X acres)	€ = Fish Passage Connectivity	Habitat Units (€ X acres)	€ = Fish Passage Connectivity	Habitat Units (€ X acres)	€ = Fish Passage Connectivity	Habitat Units (€ X acres)
Shovelnose sturgeon	12637	0.08	973.0	0.58	7,354.7	0.60	7,582.2	0.40	5,054.8	1.00	12,637.0	1.00	12,637.0
Paddlefish	12637	0.21	2,660.7	0.98	12,349.8	0.60	7,582.2	0.40	5,054.8	1.00	12,637.0	1.00	12,637.0
Goldeye	10141	0.06	640.5	0.35	3,567.8	0.70	7,098.7	0.70	7,098.7	1.00	10,141.0	1.00	10,141.0
Smallmouth buffalo	17166	0.10	1,765.6	0.36	6,100.3	0.70	12,016.2	0.70	12,016.2	1.00	17,166.0	1.00	17,166.0
Blue sucker	5612	0.21	1,192.2	0.59	3,303.6	0.60	3,367.2	0.40	2,244.8	1.00	5,612.0	1.00	5,612.0
White sucker	5612	0.00	6.7	0.34	1,926.0	0.70	3,928.4	0.70	3,928.4	1.00	5,612.0	1.00	5,612.0
River carpsucker	10141	0.06	569.3	0.12	1,187.4	0.70	7,098.7	0.70	7,098.7	1.00	10,141.0	1.00	10,141.0
Shorthead redhorse	5612	0.06	354.5	0.35	1,974.4	0.70	3,928.4	0.70	3,928.4	1.00	5,612.0	1.00	5,612.0
Channel catfish	17166	0.06	995.6	0.35	6,025.3	0.70	12,016.2	0.70	12,016.2	1.00	17,166.0	1.00	17,166.0
Smallmouth bass	15818	0.07	1,032.9	0.35	5,571.1	0.70	11,072.6	0.70	11,072.6	1.00	15,818.0	1.00	15,818.0
Walleye	15818	0.03	448.2	0.58	9,132.3	0.70	11,072.6	0.70	11,072.6	1.00	15,818.0	1.00	15,818.0
Sauger	15818	0.08	1,288.0	0.46	7,226.6	0.70	11,072.6	0.70	11,072.6	1.00	15,818.0	1.00	15,818.0
Freshwater drum	17166	0.06	1,109.4	0.35	6,073.8	0.70	12,016.2	0.70	12,016.2	1.00	17,166.0	1.00	17,166.0
Pallid sturgeon	12637	0.04	551.4	0.20	2,465.4	0.60	7,582.2	0.40	5,054.8	1.00	12,637.0	1.00	12,637.0
		Avg.	971	**Avg.**	5,304	**Avg.**	8,388	**Avg.**	7,766	**Avg.**	12,427	**Avg.**	12,427

Table 1-13 shows the resulting fish passage connectivity index and habitat units for each alternative.

Table 1-13. Fish Passage Connectivity Index Scores and Habitat Units.

Alternative	W/ Pallid, 14 Species		
	Є = Fish Passage Connectivity (Avg.)	**Avg. Habitat Units**	**Δ HUs**
A: No Action	0.08	971	**0**
B: Rock Ramp	0.43	5,304	**4,333**
C: Bypass Channel	0.67	8,388	**7,417**
D: Modified Side Channel	0.61	7,766	**6,795**
E: Multiple Pump Alternative	1	12,427	**11,456**
F: Multiple Pumps with Conservation Measures	1	12,427	**11,456**

2.0 Cost Effectiveness and Incremental Cost Analysis

The plan evaluation process utilized in this study is based upon methods described in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (U.S. Water Resources Council 1983) referred to as the P&G and the associated Corps implementation guidance found in Engineer Regulation (ER) 1105-2-100 Planning Guidance Notebook (U.S. Army Corps of Engineers 2000). The specific plan evaluation and comparison methods applied are from the *Evaluation of Environmental Investments Procedures Manual, Interim: Cost Effectiveness and Incremental Cost Analysis* document (U.S. Army Corps of Engineers 1995). This methodology consists of a series of steps that provide an orderly and systematic approach to comparing the costs and benefits of a range of alternative plans to inform the selection of a recommended plan. Plan formulation and evaluation is a dynamic process, whereby the steps may be iterated one or more times as new information or new alternatives are developed, or as planning objectives are reevaluated.

When planning for the restoration of environmental resources, cost effectiveness (CE) and incremental cost analyses (ICA) may be used as tools for the comparison of alternative plans (CE/ICA). CE/ICA are comparisons of the effects of alternative plans; more specifically, they involve comparisons between the outputs and costs of different solutions. Information about alternative plans and their effects must be developed in order to conduct the CE/ICA comparisons.

Traditional benefit-cost analyses are not applicable to environmental planning because costs and benefits are expressed in different units; however, CE/ICA offers plan evaluation approaches that are consistent with the P&G evaluation framework. The Institute for Water Resources (IWR) Planning Suite software was used to assist in performing the CE/ICA. Alternative plans were evaluated and compared in terms of cost (e.g. construction, operation, and maintenance) and environmental outputs over a 50-year period of analysis. IWR Planning Suite helps determine and present the relative efficiency and effectiveness of alternative plans at generating environmental outputs. The most efficient plans are referred to as "best buys." The Corps' policies for cost effectiveness and incremental cost analysis, ER 1105-2-100, paragraph E.36, states:

> *Cost effectiveness and incremental cost analysis are two distinct analyses that must be conducted to evaluate the effects of alternative plans. First, it must be shown through cost effectiveness analysis that an alternative restoration plan's output cannot be produced more cost effectively by another alternative. "Cost effective" means that, for a given level of nonmonetary output, no other plan costs less and no other plan yields more output for less money. Subsequently, through incremental cost analysis, a variety of implementable alternatives and various-sized alternatives are evaluated to arrive at a "best" level of output within the limits of both the sponsor's and the Corps capabilities. The subset of cost effective plans are examined sequentially (by increasing scale and increment of output) to ascertain which plans are most efficient in the production of environmental benefits. The most efficient plans are called "Best Buys." They provide the greatest increase in output for the least increases in cost. They have the lowest incremental costs per unit of output.*

2.1 Methodology

The CE/ICA analysis utilized the Corps IWR Planning Suite model. The Corps-certified model provides a systematic method for testing all possible combinations of ecosystem restoration measures to identify combinations of measures (alternative plans) which are cost effective, and then ranks cost effective plans according to their efficiency to identify "best buy" plans. Because this analysis considered six complete alternatives which were mutually exclusive, no alternatives were combined in the model. Instead, the software will identified which plans were cost effective, and then ranked the cost effective plans by efficiency to identify "best buy" plans. The CE/ICA model required the following inputs:

Average annual habitat units (AAHUs) for each alternative: Because habitat benefits are non-monetary, the outputs are referred to as "units" of output. In order to compare action alternatives to the No Action Alternative, AAHUs are typically converted to "net AAHUs," which is the change in habitat units versus No Action. Thus, the No Action Alternative is always entered as zero net AAHUs, and each action alternative is entered as the additional AAHUs that would be generated compared to this baseline. AAHUs were developed using the FPCI Model as detailed previously in this appendix.

Average annualized cost for each alternative: Costs used in the analysis included construction, PED/CM, real estate, monitoring and adaptive management, interest during construction, and operation, maintenance, and rehabilitation (OM&R). Annualized costs are presented at an FY16 price level, amortized over a 50-year period of analysis using the FY16 Federal interest rate for Corps of Engineers projects of 3.125% (U.S. Army Corps of Engineers 2015). For each action alternative, net costs above the No Action Alternative are calculated for use in the analysis, consistent with the net habitat output calculation. Detailed cost tables are available in Cost Appendix B.

2.1.1 Annualized Costs and AAHU's

Table 2-1 summarizes AAHUs for each alternative, in total and on net. As defined above, AAHUs are average annual habitat outputs, and net AHHUs are the change in output versus the No Action Alternative.

Table 2-1. AAHU's By Alternative

Alternatives	Habitat Output	
	AAHUs	Net AAHUs
No Action	971	-
Rock Ramp	5,304	4,333
Bypass Channel	8,388	7,417
Modified Side Channel	7,766	6,795
Multiple Pump	12,427	11,456
Multiple Pumps with Conservation Measures	12,427	11,456

Table 2-2 summarizes the annualized cost for each alternative. Like the habitat output calculation, costs for each action alternative are calculated as the net costs above the No Action Alternative. For each alternative, inputs to the model were the net AAHUs and the net annualized project cost. Because the only costs which would be incurred in the No Action Alternative would be OM&R and monitoring, the net cost for each action alternative is equivalent to construction-related costs plus the incremental operational costs above the No Action for each alternative, as noted by the row "Net OM&R and Monitoring" in the following table.

Table 2-2. Net Cost by Alternative ($1000s)

	No Action	**Rock Ramp**	**Bypass Channel**	**Modified Side Channel**	**Multiple Pump Alternative**	**Multiple Pumping w/ Cons.**
Construction First Cost (PV)	$0	$90,454	$57,044	$54,441	$132,028	$477,925
Interest During Construction (PV)	$0	$1,880	$2,002	$1,123	$6,556	$53,789
Adaptive Management (PV)	$0	$796	$538	$476	$1,153	$4,145
OM&R and Monitoring (PV)	$66,420	$71,370	$70,333	$73,046	$124,395	$114,768
Net OM&R and Monitoring (PV)	**$0**	**$4,950**	**$3,913**	**$6,626**	**$57,975**	**$48,348**
Subtotal - Net Alternative Costs (PV)	$0	$98,081	$63,497	$62,665	$197,712	$584,208
Total Annualized Net Cost (AC)	**$0**	**$3,903**	**$2,527**	**$2,494**	**$7,868**	**$23,247**

IDC – interest during construction
OM&R – operation, maintenance, and rehabilitation
PV – Present Value (FY2016)
AC – Annualized Cost (3.125%, 50 years)

2.2 Cost Effectiveness Analysis

Cost effectiveness analysis is a form of economic analysis designed to compare costs and outcomes (or effects) of two or more courses of action. This type of analysis is useful for environmental restoration projects where the benefits are not measured in monetary terms but in environmental output units such as the Habitat Units developed in this study. The purpose of the cost effectiveness analysis is to ensure that the least cost plan alternative is identified for each possible level of environmental output; and that for any level of investment, the maximum level of output is identified. Per IWR 95-R-01, an alternative is <u>*not*</u> to be considered cost effective if any of the following rules are met:

1. The same output level could be produced by another plan at least cost;
2. A larger output level could be produced at the same cost; or
3. A larger output level could be produced at less cost.

Table 2-3 provides the results of the cost effectiveness analysis sorted by increasing output. As shown in the table, alternatives were identified as cost effective only when no other alternative provided the same output for less cost, and no other alternative provided larger output at the same or less cost. The No Action, Bypass Channel, Modified Side Channel and Multiple Pump alternatives were identified as cost effective. The Rock Ramp alternative is not cost effective because the Bypass Channel alternative provides greater output for less cost. The Multiple Pumps with Conservation Measures alternative is not cost effective because the multiple pump stations alternative provides the same level of output for less cost.

Table 2-3. Cost Effectiveness by Alternative

Alternative	Annual Cost ($)	Net AAHUs	Cost per AAHU ($)	Cost Effective?
No Action	$0	0	$0	Yes
Rock Ramp	$3,903,000	4,333	$901	No
Modified Side Channel	$2,494,000	6,795	$367	Yes
Bypass Channel	$2,527,000	7,417	$341	Yes
Multiple Pump	$7,868,000	11,456	$687	Yes
Multiple Pumps w/ Conservation Measures	$23,247,000	11,456	$2,029	No

Figure 2-1 provides a graph of the total output and annualized costs for each of the alternatives while differentiating the cost effective plans from the non-cost effective ones. Per IWR 95-R-01, any alternatives that are not found to be cost effective "should be dropped from further analysis" in the CE/ICA process. Therefore the Rock Ramp and Multiple Pumps with Conservation Measures alternatives are not included in the ICA analysis that follows.

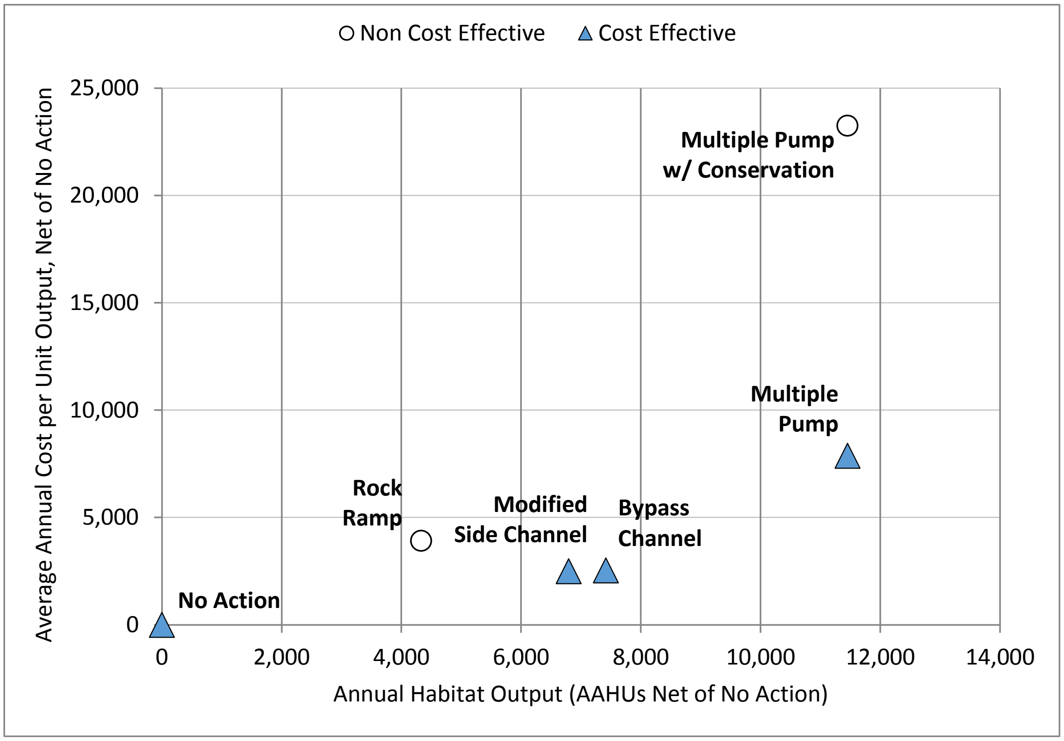


Figure 2-1. Cost Effectiveness Analysis Graph

2.3 Incremental Cost Analysis

Subsequent incremental cost analysis of the cost effective plans is conducted to reveal changes in costs as output levels are increased. Only plans that were deemed as cost effective in the CE analysis have been advanced to ICA. These cost effective plans are the No Action, Bypass Channel, Modified Side Channel and Multiple Pump alternatives. During the ICA, the cost effective plans are examined sequentially (by increasing scale in terms of net AAHUs produced) to ascertain which plans are most efficient in the production of additional environmental benefits.

The first step, per IWR 95-R-01, is to “smooth out fluctuations in incremental costs per unit as project scale increases such that incremental cost per habitat unit are continuously increasing.” This is first completed by calculating the incremental cost per unit for each plan over the “baseline condition,” which is the no action plan. Once the incremental costs per unit are calculated and sorted by increasing output, the alternative with the lowest incremental cost per unit will be selected as the first “best buy” alternative. Table 2-4 shows the calculation of the incremental costs per unit with the no action alternative set as the baseline for the cost effective alternatives.

Table 2-4. Identification of the First Best Buy Plan

Alternative	Annual Cost ($)	Net AAHUs	Incremental Output	Incremental Cost	Incremental Cost per Unit Output
No Action	$0	0	0	$0	$0
Modified Side Channel	$2,494,000	6,795	6,795	$2,494,000	$367
Bypass Channel	$2,527,000	7,417	7,417	$2,527,000	$341
Multiple Pump	$7,868,000	11,456	11,456	$7,868,000	$687

Table 2-4 indicates that the Bypass Channel alternative is the first best buy alternative because it has the lowest incremental cost per unit of output. At this step of the ICA the incremental cost per unit is equal to the average annual cost per unit values calculated in Table 2-3 because complete alternatives are being compared, not combinations of measures.

After selection of this best buy alternative, per IWR 95-R-01, all alternatives which produce fewer net AAHU's (see last column in Table 2-1) are removed from further iterations of the incremental cost analysis. Thus the Modified Side Channel alternative is removed from further analysis in the CE/ICA, and is not considered a best buy plans.

Next, the incremental process should be started anew with the first best buy plan. Thus the Bypass Channel is set as the new baseline. However, for this study only the Multiple Pump alternative is remaining, and is therefore a best buy plan as well, since no other plans can produce more output for lower incremental cost per unit.

The final step in the ICA process is to analyze the incremental cost per incremental unit of output for the best buy alternatives only. This includes the No Action, Bypass Channel, and Multiple Pump alternatives. Incremental costs are calculated between each successive best buy plan. Table 2-5 shows the incremental cost per unit output between the three best buy alternatives.

Table 2-5. Incremental Cost Analysis Summary

Best Buy Alternative	Annual Cost ($)	Net AAHUs	Incremental Cost	Incremental Output	Incremental Cost per Unit Output
No Action	$0	0	$0	0	$0
Bypass Channel	$2,527,000	7,417	$2,527,000	7,417	$341
Multiple Pump	$7,868,000	11,456	$5,341,000	4,039	$1,322

This table shows that the most efficient plan above No Action is the Bypass Channel alternative that provides 7,417 additional habitat units at a cost of $341 each. If more output is desired, the next most efficient plan available is the Multiple Pump alternative that provides an additional 4,039 habitat units, at a cost of $1,322 dollars for each additional unit. Figure 2-2 provides a visual representation of this increase in incremental cost. The figure graphically illustrates the incremental cost and output differences between the two best buy action alternatives. The width of each box in the chart represents the incremental output of that plan, and the height of each box shows the incremental cost per unit of that output. The relatively wide box for the Bypass Channel alternative shows that it provides about 65% of the total output possible at a cost of approximately $341 per unit. The box for the Multiple Pump alternative shows that to achieve the remaining 35% of total possible output would be more expensive per unit than the first 65%. Such breakpoints in incremental cost per unit typically require a higher level of justification if the study team is to recommend the larger output plan.

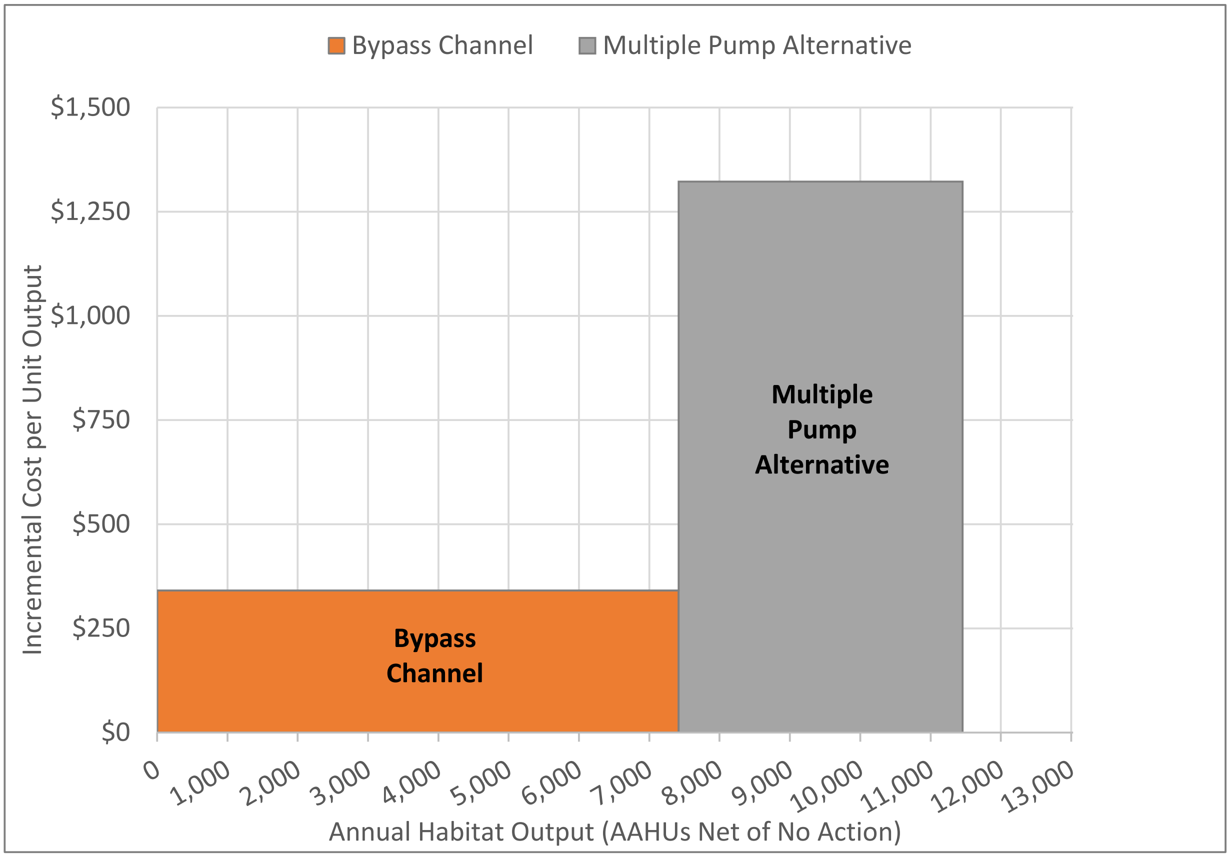


Figure 2-2. Incremental Cost Analysis Chart

2.4 Summary of Conclusions

The results of the CE/ICA do not provide a discrete decision for selecting the preferred plan, but rather they offer organized data on the effectiveness and efficiency of the range of alternatives under consideration to help inform a decision. For Corps ecosystem restoration projects, the selected plan should be the alternative having the maximum excess of non-monetary benefits (habitat output) over costs. This plan occurs where the incremental beneficial effects just equal the incremental costs, or alternatively stated, the recommended plan is selected by identifying the largest plan for which the extra habitat output is still worth the extra costs. Definition of the level of output that is “worth it” is a concern for the study team that will consider specific project factors and information.

Thus, a plan that reasonably maximizes ecosystem restoration benefits compared to costs, consistent with the Federal objective, can be identified as the selected plan. The selected plan should also be cost effective and justified in achieving the desired level of output. In practice, the selected plan is chosen from the suite of cost effective plans identified in the CE/ICA. While the selected plan is not required to be a best buy plan, this is typically the case.

2.5 Sensitivity Analysis

In order to evaluate the sensitivity of the CE/ICA results to changes in the FPCI model outputs, two sensitivity scenarios were modeled. In the first scenario, revised fishway location, the scores were reduced for the bypass channel, which reduces that alternative's habitat outputs. In the second scenario, pallid sturgeon only, only the variable for pallid sturgeon was included, which changes the total habitat outputs for all alternatives. These two scenarios reasonably evaluate the possibility of reduced effectiveness for the bypass channel and a focus on pallid sturgeon-specific benefits. Note that the Modified Side Channel alternative in both scenarios always has been given a lower score than the Bypass Channel Alternative as the location of the entrance for upstream migrating fish is approximately 2 miles downstream of Intake Diversion Dam and distant from the main channel so fish are less likely to find it as compared to the bypass channel.

Tables 2-6 and 2-7 summarizes the FPCI revisions for each scenario. Based on these revised habitat output values, and using the same costs, the CE/ICA model was re-run twice. Tables 2-8 and 2-9 provides the cost effectiveness tables for the two scenarios, and Tables 2-10 and 2-11 provide the best buy plans incremental cost tables. Finally, summary graphics are provided for both scenarios side-by-side.

As shown in the tables and figures, even when components of the FCPI scoring are revised, the order of alternatives in terms of average cost per unit output does not change.

- Scenario 1 – Revised Fishway Scenario: the reduced output of the Bypass Channel alternative makes its average cost per unit output more expensive, though it remains less expensive per unit than the Modified Side Channel, resulting in no changes to the identified cost effective and best buy plans.
- Scenario 2 – Pallid Sturgeon Only: by only considering Pallid Sturgeon in the FPCI, the relative cost effectiveness of the alternatives does not change. The Bypass Channel remains the first best buy plan. However, the total output possible for the Rock Ramp, Modified Side Channel, and Bypass Channel alternatives are all reduced. In this scenario, the Bypass Channel would provide for about 48% of possible habitat output, rather than 65% as in the main analysis which considered 14 species.

In both scenarios, the order of alternatives in terms of average cost per unit output did not change. Based on this analysis, it was determined that there is reasonable confidence that, as currently designed, the Bypass Channel Alternative is less costly per unit than the Multiple Pump Alternative, and that the two best buy action alternatives are the Bypass Channel and the Multiple Pump Alternative.

Table 2-6. Scenario 1 – Revised Fishway Location, FPCI

Alternative	W/ Pallid, 14 Species		
	€ = Fish Passage Connectivity (Avg.)	Avg. Habitat Units	Δ HUs
No Action	0.08	971	0
Rock Ramp	0.43	5,304	4,333
Bypass Channel	0.67	8,077	7,106
Modified Side Channel	0.61	7,766	6,795
Multiple Pump Alternative	1	12,427	11,456
Multiple Pumping w/ Cons.	1	12,427	11,456

Table 2-7. Sensitivity Scenario 2 – Pallid Sturgeon Only, FPCI

Alternative	Pallid Sturgeon Only		
	€ = Fish Passage Connectivity (Avg.)	Avg. Habitat Units	Δ HUs
No Action	0.04	551	0
Rock Ramp	0.2	2,465	1,914
Bypass Channel	0.5	6,319	5,768
Modified Side Channel	0.4	5,055	4,504
Multiple Pump Alternative	1	12,637	12,086
Multiple Pumping w/ Cons.	1	12,637	12,086

Table 2-8. Scenario 1 – Revised Fishway Location, Cost Effectiveness

Alternative	Annual Cost ($)	Net AAHUs	Cost per AAHU ($)	Cost Effective?
No Action	$0	-	$0	Yes
Rock Ramp	$3,903,000	4,333	$901	No
Modified Side Channel	$2,494,000	6,795	$367	Yes
Bypass Channel	$2,527,000	7,106	$356	Yes
Multiple Pump	$7,868,000	11,456	$687	Yes
Multiple Pumps w/ Conservation Measures	$23,247,000	11,456	$2,029	No

Table 2-9. Sensitivity Scenario 2 – Pallid Sturgeon Only, Cost Effectiveness

Alternative	Annual Cost ($)	Net AAHUs	Cost per AAHU ($)	Cost Effective?
No Action	$0	-	$0	Yes
Rock Ramp	$3,903,000	1,914	$2,039	No
Modified Side Channel	$2,494,000	4,504	$554	Yes
Bypass Channel	$2,527,000	5,768	$438	Yes
Multiple Pump	$7,868,000	12,086	$651	Yes
Multiple Pumps w/ Conservation Measures	$23,247,000	12,086	$1,923	No

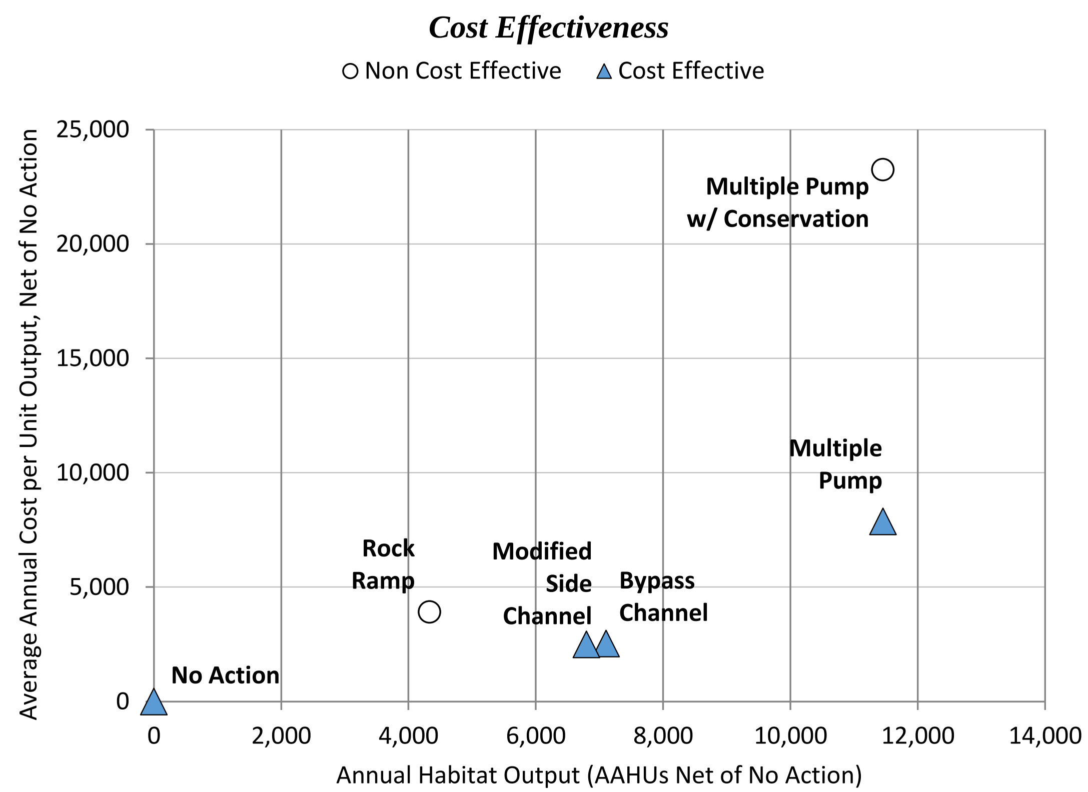
Table 2-10. Scenario 1 – Revised Fishway Location, Incremental Cost

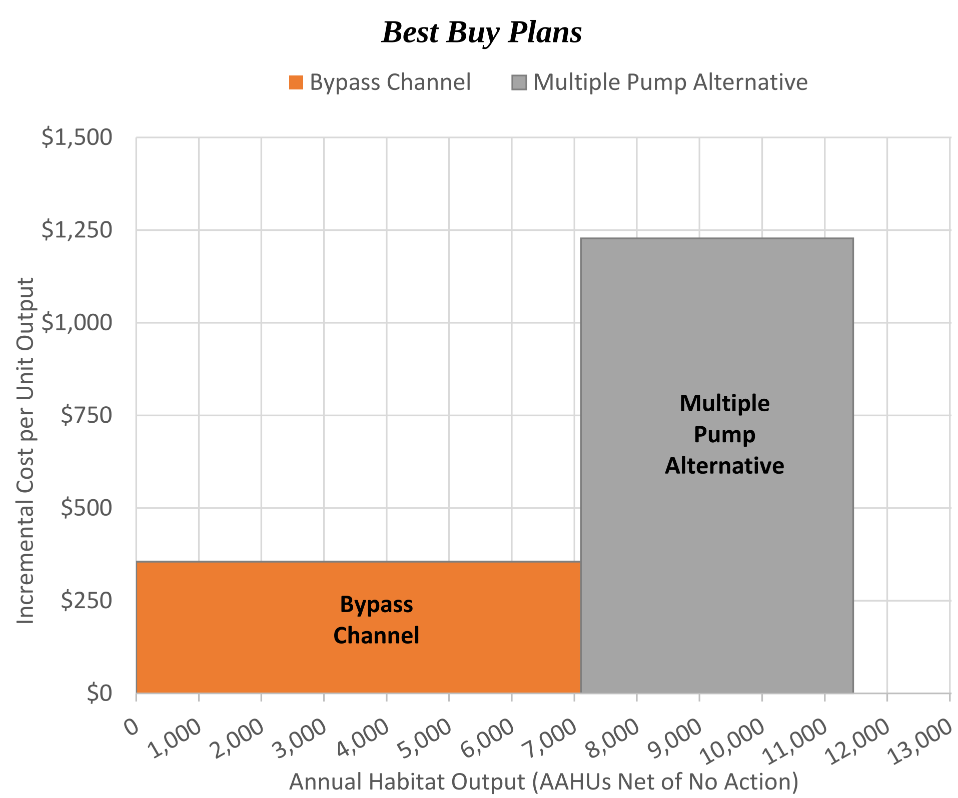
Best Buy Alternative	Annual Cost ($)	Net AAHUs	Incremental Cost	Incremental Output	Incremental Cost per Unit Output
No Action	$0	0	$0	0	$0
Bypass Channel	$2,527,000	7,106	$2,527,000	7,106	$356
Multiple Pump	$7,868,000	11,456	$5,341,000	4,350	$1,228

Table 2-11. Sensitivity Scenario 2 – Pallid Sturgeon Only, Incremental Cost

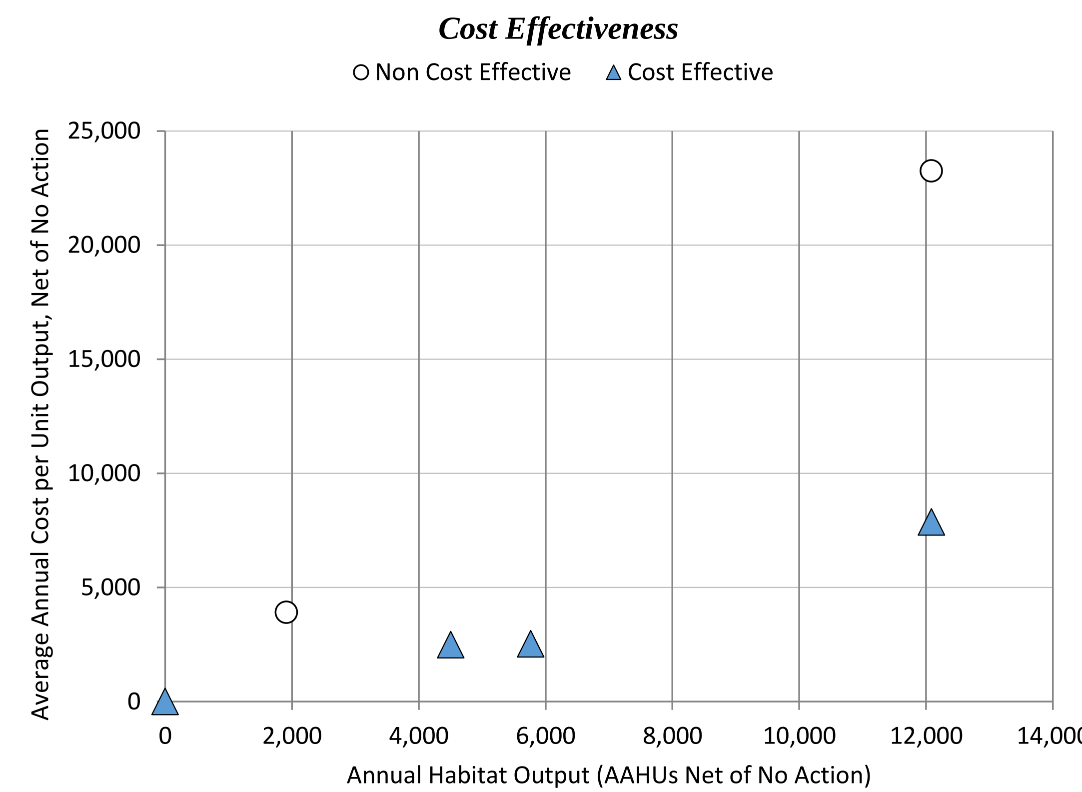
Best Buy Alternative	Annual Cost ($)	Net AAHUs	Incremental Cost	Incremental Output	Incremental Cost per Unit Output
No Action	$0	0	$0	0	$0
Bypass Channel	$2,527,000	5,768	$2,527,000	5,768	$438
Multiple Pump	$7,868,000	12,086	$5,341,00	6,318	$845

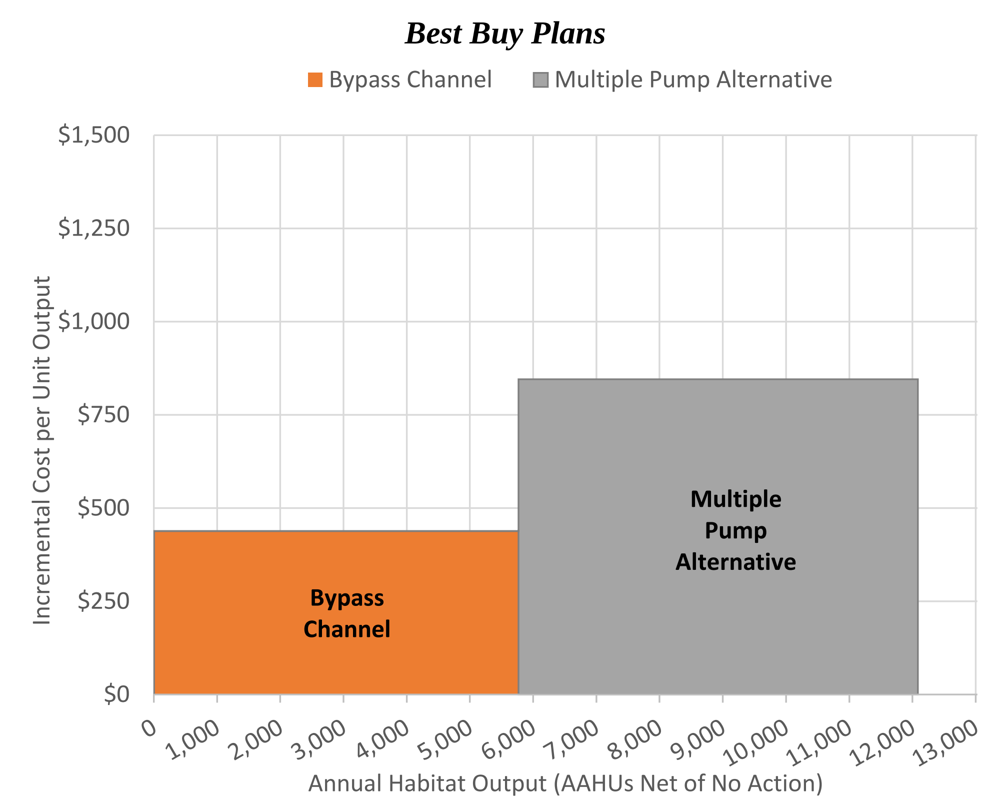
Scenario 1 – Revised Fishway Location





Scenario 2 – Pallid Sturgeon Only





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ATTACHMENTS

Table 4. Estimate Suitability of Fishway Locations (F_I) for Each Fish Guild Based Upon Swimming Performance and Behavior.

	Potential Fishway Location – Lock and Dam 22 example			
Guild	Main Channel	Main Channel Border – near channel	Main Channel Border– near shore; Side Channel; or Bypass Channel	Lock
Benthic – Strong	5	5	3	1
Littoral – Strong	5	5	3	1
Pelagic – Strong	5	5	3	1
Benthic – Medium	1	5	5	1
Littoral – Medium	1	3	5	1
Pelagic – Medium	1	5	5	1
Benthic – Weak	1	5	5	1
Littoral – Weak	1	3	5	1
Pelagic – Weak	1	1	5	1

5 = Entrance would be encountered by a significant portion of the population
3 = Entrance may be encountered
1 = Unlikely that entrance would be encountered

Table 4 is reproduced from Corps (2011) showing the scoring for various guilds of fish relative to general fishway locations.

Enclosure 3

MODEL APPROVAL PLAN

FISH PASSAGE CONNECTIVITY INDEX (FPCI)

for

Intake Diversion Dam Fish Passage Project, Lower Yellowstone Project, Montana

Omaha District

July 19, 2016

US Army Corps of Engineers ®

Model Approval Plan

Fish Passage Connectivity Index

Intake Diversion Dam Fish Passage Project, Lower Yellowstone Project, Montana

Omaha District

1. Purpose

The purpose of this Model Approval Plan is to outline the review process and requirements necessary to assure the applicability of the Fish Passage Connectivity Index, as submitted from the Omaha District to the ECO-PCX in support of the Approval of Single Use of the model in the Intake Diversion Dam Fish Passage Project. Since the model has already been Approved for Use in the Mississippi River Basin, the review will consist of an evaluation of the applicability of the model for the Yellowstone River. The model review will be managed by the Ecosystem Restoration Planning Center of Expertise (ECO-PCX) in accordance with EC 1105-2-412, Assuring Quality of Planning Models. The review team will document the review process and provide an assessment of the technical quality, system quality, and usability of the model.

2. Reference and Guidance

2.1. Engineering Circular 1105-2-412, Assuring Quality of Planning Models, 31 March 2011.

3. Background

The FPCI model was developed by the Navigation and Ecosystem Sustainability Program, Lock and Dam 22 Fish Passage Ecosystem Restoration Project Delivery Team which included fisheries biologists and hydraulic engineers from USACE (MVS, MVR, MVP, ERDC), US Fish and Wildlife Service Ecological Services and Refuges, Illinois Department of Natural Resources, Illinois Natural History, Missouri Department of Conservation, and Iowa Department of Natural Resources. The model calculates Average Annual Habitat Units for each migratory fish species and averages AAHUs for all migratory fish species for each fish passage alternative. Model input includes movement periods for each migratory species, likelihood of species to encounter fishway entrance based on location, species potential to use passage route; and availability of suitable passage conditions during movement and spawning periods. The result is a 0-1 index that represents the suitability of the fish passage alternative measure to a given species. The fish passage connectivity index is multiplied by the acres of connected, upstream habitat types that are suitable to the individual migratory species to get Average Annual Habitat Units. The model documentation includes the model report (Enclosure 1) and an Excel worksheet (Enclosure 2). The worksheet utilizes good spreadsheet practices including protecting cells, data validation, color-coding input/output cells and including a worksheet with instructions on how to use the model.

Prior review concluded that the FPCI meets model criteria of technical and system quality and usability. The model addresses the key factors associated with fish passage and was easily modified for application at any geographic location. The ECO-PCX updated the Excel Workbook to make it applicable for use nationwide. For a given project area, users will input data on migratory species such as timing of migratory movements, swimming abilities and behavior and input data on habitat available to the migrating fish. This input data will be technically reviewed as part of District Quality Control and Agency Technical Review.

Although the model was developed to measure benefits of fish passage in the Upper Mississippi River, the model is applicable (with slight adjustments) to fish passage projects on other large river systems, especially those with very similar fish communities. This model, with minor adjustment, was used as a planning tool for comparing benefits of alternative measures for provide fish passage at Intake Dam. Below is a summary of the input data used and minor adjustments made to the model to demonstrate ecological benefits of the Yellowstone River Intake Diversion Dam fish passage alternatives.

- The approved FPCI model does not include pallid sturgeon as a modeled species, therefore pallid sturgeon were added. The inclusion of pallid sturgeon does not change the ranking of alternatives, but provides a better differentiation between similar alternatives.

- Habitat preferences/use for each species was considered acceptable as presented in the FPCI with one slight adjustment as noted by the Corps (2015); white sucker, blue sucker and river carpsucker were shown only to be associated with main channel border habitats in the original FPCI. However, for purposes of this study, these species were also assumed to utilize main channel habitats. The “main channel” habitat type in the Upper Mississippi River was defined as a navigation channel, which is very different than main channel habitats in the Yellowstone River, and may be the reason those species were not associated with that habitat type.

- The Di variable accounts for the timing of when fish passage is physically possible at a dam compared with the timeframe of when fish typically migrate. The District modified the “percent probability of open river conditions” in the original model (which referred to when the dam gates were open on the Upper Mississippi River) and used available literature (Jaeger, et al. 2005; Helfrich et. al. 1999), anecdotal information, and best professional judgment, to assign probabilities that passage opportunities exist on a weekly basis as a function of flow, with highest probabilities being associated with the peak of the typical hydrograph, and very small (1%) probabilities being attributable to the timeframes outside of the peak river flow (September-April).

- Basic information on fish migratory behaviors and timing from the original FPCI model was modified by because the actual time of year when migration takes place on the Yellowstone River is different than on the Mississippi River. Movement and spawning periods were pushed back 3-4 weeks later in the year as migrations tend to take place later in the year for cooler, more northern latitudes.

4. Documentation Provided by Proponent

4.1. **Model Technical Documentation**

- Fish Passage Connectivity Index, Upper Mississippi River System Fish Passage Improvement Ecosystem Restoration Projects, 17 August 2011 (Enclosure 1)

4.2. **Model User Documentation**

- Fish Passage Connectivity Index Excel Worksheet, dated 22 March 2013 (Enclosure 2)

4.3. **Model Support Literature**

- N/A

4.4. **Model QA/QC Documentation/Activities**

- District Quality Control and Agency Technical Review has been conducted. Comments and revisions made as a result will be included in the model certification review package.

5. Type/Scope of Review

Per EC-1105-2-412, 31 March 2011, the ECO-PCX recommends a limited review which would include ATR of applicability of use of this model on the Yellowstone River.

The following language defines the scope of the review and will be provided to the model reviewers:

5.1. **Preliminary charge for reviewers of the Fish Passage Connectivity Index**

Input being sought to help the US Army Corps of Engineers ECO-PCX determine the degree to which the subject model can be described as technically sound relative to its design objectives. Reviewers are asked to comment on aspects of the model that potentially affect its applicability on the Yellowstone River as a potential producer of information to be used to influence planning decisions.

While the specific review questions included below are intended to prompt the reviewer for information specific to the efforts to Approve for Single Use, please feel free to offer comments believed relevant and appropriate to any elements of the technical quality and usability of the model as documented in the provided review materials. Accordingly, please provide responses to the sought scientific and technical topics listed below and perform a broad review of the Fish Passage Connectivity Index focusing on your areas of expertise, experience, and technical knowledge. Listed below are the model review charge questions.

Technical Quality:

1. To what extent is the model suitable for the expressed intended uses?
2. Comment on the geographic range/applicability of the model. Is the model applicable for the Yellowstone River considering it was developed for the Mississippi River Basin.
3. Does the model adequately emulate or otherwise address the suite of critical attributes necessary to characterize system/resources?
4. Are the modifications to the model detailed in the analysis and summarized above appropriate?

System Quality:

1. Where changes in the spreadsheet made accurately and without error?

6. Description of Tasks.

The model review tasks are:

6.1. **Kick-Off Meeting.** Once the ECO-PCX has received approval to proceed, a teleconference will be held assure all reviewers understand the scope and the approach for review of the models. The reviewers will review the provided model documentation and, if necessary, identify additional information required to conduct the model review. The meeting will include representatives of the ECO-PCX, the model proponent, and the reviewer. CECW will be notified of the meeting and invited to attend.

6.2. **Conduct Review of Model.** The reviewers will conduct an assessment of the models using all documentation provided by the model proponent and the ECO-PCX. Reviewers will provide comments regarding the model and should follow a four part structure to include: 1) the review concern, 2) the basis for the concern (reviewer should note if the comment relates to technical quality, system quality, or usability), 3) the significance/impact of the concern, and 4) the probable specific action needed to resolve the concern.

6.3. **Meeting to Discuss Initial Findings.** The reviewers will meet with the ECO-PCX, model proponent, and CECW to discuss initial review comments and recommendations, and outline a plan for the Draft Model Review Report.

6.4. **Proponent and ECO-PCX Summary.** Based on the review comments and the Final Model Review Report, the ECO-PCX will identify actions or modifications the proponent needs to undertake in order to gain a recommendation for approval. The ECO-PCX will close-out the review when it determines identified issues have been resolved to its satisfaction.

6.5. **ECO-PCX Recommendation Package to HQ.** Based on the resolution of all comments/issues, the ECO-PCX will compile and send the recommendation package to HQ. This package will include, at a minimum, some combination of the following based on the level of review and whether it is a certification or approval for use.

7. Review Team Composition.

The ECO-PCX proposes review of the model documentation and supporting literature. The review will address all technical quality, system quality and usability certification criteria, including the criteria regarding whether the model properly incorporates Corps policies and accepted procedures.

The ECO-PCX proposes an internal review as part of the EIS ATR consisting of the following disciplines:

The following disciplines are proposed as part of the review team:

- Review Project Manager – The project review manager will be responsible for facilitation of the model review process. This person should have prior experience facilitating ecosystem habitat benefit evaluation reviews.

- Senior Fisheries Biologist – the reviewer should be a senior biologist with familiarity with large river warmwater fisheries. The reviewer shall be familiar with the FPCI model and knowledge of the Mississippi and Missouri River system.

8. Schedule.

The following is a draft schedule for the model review. Revisions to the model to address model deficiencies will require adjustments to the schedule below.

Begin Model Review	30 July – 30 August 2016
Model Review Complete	August 2016
Model Review Report	Sept 2016
ECO-PCX Summary	Oct 2016
ECO-PCX Recommendation Package to HQ	Nov 2016

9. Cost.

The model review is expected to cost $10,000.

10. Points of Contact.

ECO-PCX Point of Contact:	Nathan Richards - MVR	(309) 794-5286
Model Proponent Point of Contact:	Tiffany Vanosdall – NWO	(402) 995-2695

Enclosure 4

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Comment Report: Comment Evaluation/Backcheck Contribution by Elliott Stefanik
Project: Intake EIS **Review**: Intake DEIS ATR (*00002*)
(sorted by Discipline , ID)

Displaying 15 comments for the criteria specified in this report.

Id	Discipline	Section/Figure	Page Number	Line Number
6558641	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: It's unclear from Table 2-1 whether this is a list of all alternatives considered, or if it's a refined list.
Reason for Concern: Given concerns with alternative formulation and given the table is a summary of this process, it's important the table clearly explains what is being provided within.
Significance: Moderate.
Recommendation: Clarify in the table heading if this is a list of all alternatives identified or considered (comprehensive list), a refined list that has been paired down, or what exactly this list of alternatives represents. Also the list should probably focus on fish passage alts (remove the "removable rotating drum screen").

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0 Evaluation **Concurred**
As described starting on page 2-25 (Section 2.2 Background and History of Alternatives) this section is a summary of the project history including alternatives that have been developed and analyzed since 2006. Following the table are paragraphs referencing the various documentation (with citations) to the steps of the process. The table includes all of the alternatives including the headworks which were screened to reduce entrainment, and that is why the screens are included in this table.

Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016

1-1 Backcheck Recommendation **Close Comment**
Explanation is acceptable.

Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 21 2016.

Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558643	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Section 1.1.2.3 Collaboration is missing.
Reason for Concern: Discussion of collaboration is important to demonstrate thorough scoping of an eco restoration project.
Significance: Minor
Recommendation: Include this missing section.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0 Evaluation **Concurred**
This is a typo that will be corrected, section 1.1.2.3 and 1.1.2.4 were combined and this header didn't get deleted for some reason.

Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016

1-1	Backcheck Recommendation **Close Comment** Revision will be acceptable when implemented. Revision will be confirmed during the Final ATR. Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 20 2016.
	Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558645	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Section 1.1.3 discusses other dams and irrigation projects on the Yellowstone River but does not mention any projects or activities related to Pallid sturgeon or ecorestoration. Touch on this briefly, even if there isn't anything (mention that).
Reason for Concern: Demonstrates we are considering all activities related to our project. This is important as project is eco-restoration (at this point, exclusively since the diversion improvements have been made).
Significance: Minor
Recommendation: Include a brief description of any similar efforts or activities in the area or region.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0	Evaluation **Concurred** Will add brief discussion of on-going studies on the Yellowstone and recommendations from Yellowstone Cumulative Effects Analysis related to broader management of the river. For the most part, there are not other specific actions planned on the Yellowstone for pallid sturgeon. Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016
1-1	Backcheck Recommendation **Close Comment** Revision will be acceptable when implemented. Revision will be confirmed during the Final ATR. Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 20 2016.
	Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558646	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Section 2.3.4 states: Based on rock requirements, rock will need to be purchased from quarries in Wyoming or Minnesota and delivered to Glendive. Be advised that the Fargo-Moorhead FRM project (St. Paul District) will likely use large quantities of field stone for various H&H features, including fish passage. There has been some question if there is enough field stone in the region to meet demand. That project will likely begin construction in 2017.
Reason for Concern: This could actually drive up cost further for the Rock Ramp alternative.
Significance: Low
Recommendation: Given the rock ramp isn't the selected plan this is a minor issue. But if that were to change it could become an issue. Recommend inserting sentence in the section that further evaluation may be needed on rock availability which could influence cost of this alternative.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0	

Evaluation **Concurred**
Comment noted, the costs for hauling of rock made assumptions that it would be obtained from MN or WY so there are already high hauling costs included. For alternative comparison purposes the cost of rock was kept consistent with that used in the 2015 EA, and escalated to current dollars, and approximately a 30% contingency is added to that.

Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016

1-1 Backcheck Recommendation **Close Comment**
Response is acceptable.

Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 20 2016.

Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558647	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Section 2.3.5 states the dam would be replaced with the bypass channel alternative. It's unclear why this is needed.
Reason for Concern: Incorporating a new dam obviously drives up cost of the alternative. It's also unclear why this is needed for ecosystem restoration project. The need for a new dam isn't expressed in the "purpose and need" statement, other than "allow for continued viable and effective operation of the LYP." No where is the need for a new dam discussed.
Significance: Moderate to major, depending on the reasoning for inclusion.
Recommendation: Specify why a new dam needs to be included in this alternative, as well as other similar alts (e.g., side channel alternative). If it's not needed as a specific function of ecosystem restoration it should be removed from the alternative and the EIS revised to reflect this change.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0 Evaluation **Non-concurred**
Please see the second paragraph of Section 2.3.5 Bypass Channel (Page 2-46) which describes why the dam would be replaced. "A concrete replacement weir would be constructed that would provide water surface elevations similar to no action conditions, which would be adequate for flow into the new bypass channel, ensuring delivery of irrigation water, eliminating concern as to whether continued displacement of rock from the crest of the dam by ice flows could adversely affect the downstream entrance to the bypass channel.. Construction of a replacement weir would eliminate the need to routinely place rock along the crest of the Intake Diversion Dam. While head requirements could theoretically be met through rock placement, a permanent structure provides more reliable flows into the bypass channel, reduces the amount of fill placed into the Yellowstone River, and eliminates concern as to whether continued displacement of rock from the crest of the dam by ice flows could adversely affect the downstream entrance to the bypass channel."

Submitted By: Scott Estergard (602-241-8543) Submitted On: Jul 11 2016

1-1 Backcheck Recommendation **Close Comment**
The response is acceptable provided the costs of a new weir are generally similar to those of continued O&M of existing features. Cost numbers to this end are still in preparation. The ATRT will verify during review of the Final EIS that costs are similar enough to warrant including a new weir as a part of the bypass channel alternative.

Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Aug 22 2016.

Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558648	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Section 2.4.4.1 and 2.4.4.2 discuss CE/ICA outputs. Although OK for an EIS, it would be helpful to include the CE figure from IWRPlan to help demonstrate how the benefits shake out. Moreover, it's unclear why Modified Sidechannel and Multiple Pumps with Conservation Measures were not included in the Incremental Cost Analysis.
Reason for Concern: We need to ensure all of our alts carried forward for detailed consideration get full consideration.
Significance: Moderate.
Recommendation: First, provide a figure from IWRPlanning Suite show the CE analysis, including demonstration of "Best Buy" plans and "Cost Effective" plans. Then, better explain why only certain alternatives are carried forward for detailed consideration. Table 2-30 does mention "Best Buy" plans, but this concept should be described and identified earlier.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0 Evaluation **Concurred**

1) The last sentence of Sec 2.4.4 (main report) cites an appendix. The reference was incorrect, and will be revised to cite Appendix D.
2) Apx D Fig 2-1 will be added to main report after Table 2-28 with this text: "Figure 2-1 provides a graph of the total output and annualized costs for each of the alternatives while differentiating the cost effective plans from the non-cost effective ones. Per IWR 95-R-01, any alternatives that are not found to be cost effective "should be dropped from further analysis" in the CE/ICA process. Therefore the Rock Ramp and Multiple Pumps with Conservation Measures alternatives are not included in the ICA analysis that follows."
3) These text and figures from Apx D will be added between paragraphs 2 and 3 of Sec 2.4.4.2:
"The first step, per IWR 95-R-01, is to "smooth out fluctuations in incremental costs per unit as project scale increases such that incremental cost per habitat unit are continuously increasing." This is first completed by calculating the incremental cost per unit for each plan over the "baseline condition," which is the no action plan. Once the incremental costs per unit are calculated and sorted by increasing output, the alternative with the lowest incremental cost per unit will be selected as the first "best buy" alternative. Table 2-4 shows the calculation of the incremental costs per unit with the no action alternative set as the baseline for the cost effective alternatives.
[Apx D Table 2-4]
Table 2-4 indicates that the Bypass Channel alternative is the first best buy alternative because it has the lowest incremental cost per unit of output. At this step of the ICA the incremental cost per unit is equal to the average annual cost per unit values calculated in Table 2-3 because complete alternatives are being compared, not combinations of measures.
After selection of this best buy alternative, per IWR 95-R-01, all alternatives with lower average annual output are removed from further iterations of the incremental cost analysis. Thus the No Action and Modified Side Channel alternatives are removed from further analysis and are not considered best buy plans.
Next, the incremental process should be started anew with the first best buy plan. Thus the Bypass Channel is set as the new baseline. However, for this study only the Multiple Pump alternative is remaining, and is therefore a best buy plan as well since no other plans can produce more output for lower incremental cost per unit.
The final step in the ICA process is to analyze the incremental cost per incremental unit of output for the best buy alternatives only. This includes the No Action, Bypass Channel, and Multiple Pump alternatives. Incremental costs are calculated between each successive best buy cost-effective plans are examined sequentially (by increasing scale in terms of net AAHUs produced) to ascertain which plans are most efficient in the production of additional environmental benefits."

Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016

1-1 Backcheck Recommendation **Close Comment**

Revision will be acceptable when implemented. Revision will be confirmed during the Final ATR.

Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 20 2016.

Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558650	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Sections 2.5.2 spends describes reasoning for section of the recommended plan. But it leaves a lot of uncertainty on whether or not a $54 million dollar project will work.
Reason for Concern: Should be investing such a large amount of federal funding on something with so much uncertainty?
Significance: Moderate
Recommendation: include some type of brief summary sentence that basically states: although there remains uncertainty, biologists on the agency team collectively agree that the preferred alternative represents the best balance of cost, likely benefits, and uncertainty of effectiveness amongst the alternatives considered. It would also meet the needs of the Bureau of Reclamation for ESA compliance (*assuming this last part is in fact true).

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0 Evaluation **Concurred**
Concur, will add a summary paragraph stating that the best available science indicates the preferred alternatives is the best way to achieve passage and continue to provide irrigation diversions/water right. And, the ESA consultation for the project and both interim/future O&M by Reclamation will ensure ESA compliance for both agencies.

Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016

1-1 Backcheck Recommendation **Close Comment**
Revision will be acceptable when implemented. Revision will be confirmed during the Final ATR.

Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 20 2016.

Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558651	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Section 4.4 does briefly discuss influence of alternatives on flood heights. Are there any agency concerns, or potential permit ramifications, of any alternatives on flood heights? Any indication that any of the alternatives might not be permit-able because of flood height impacts.
Reason for Concern: Flood height increases has become an issue in some parts of the country with habitat restoration projects.
Significance: Minor
Recommendation: Mention somewhere whether or not potential changes in flood height would make an alternative more or less likely to be permitted.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0 Evaluation **Concurred**
While there are anticipated small changes in flood water surface elevations during construction due to coffer dams, etc., they are relatively minor (i.e. less than a foot) and similar for all alternatives.

Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016

1-1	Backcheck Recommendation **Close Comment** Comment is closed. However, be advised that in some states flood height increases of less than an inch have been problematic. Encourage the PDT confirms this is not a late issue that causes headaches. Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 20 2016.
	Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558653	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Under Section 4.6, Effects to Geomorphology, and Section 4.7, Water Quality. The impacts to sediment transport, both erosion and accretion, are not spelled out for both dam removal and dam construction. For alts where this occurs there will be releases of trapped sediments behind the existing dam; and trapping of new sediment from the new dam. This should be discussed for both geomorphology and water quality impacts.
Reason for Concern: Complete geomorphic understanding associated with dam removal and construction.
Significance: Moderate
Recommendation: For applicable alternatives be sure to discuss sediment movement, both erosion and accretion, associated with dam removal and new dam construction.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0	Evaluation **Concurred** Partially concur. Text will be clarified to ensure the following information is clearly conveyed. The new weir/dam will be constructed at the same elevation as the existing weir so there should not be more than minimal effects to sediment erosion/accretion. During construction, when coffer dams are in place and the river flow is confined to a narrower channel, there could be some localized erosion/accretion, but the river substrate is coarse and the banks are also riprapped in many locations, so this is not anticipated to be more than a minor effect either. For dam removal alternatives, because the dam/weir is fairly low, there is not a large quantity of sediment trapped behind it, and it is primarily coarse material (cobbles). However, this sediment will erode and transport downstream over time, but in the scale of the river channel width this will also only be a minor effect. Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016
1-1	Backcheck Recommendation **Close Comment** Revision will be acceptable when implemented. Revision will be confirmed during the Final ATR. Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 20 2016.
	Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558656	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Impact discussion often doesn't note direct mortality to biota (usually inverts) from disturbance.
Reason for Concern: Disclosure of all anticipated impacts.
Significance: Minor
Recommendation: Include this in the impact discussion, where applicable, for all construction impacts.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0	Evaluation **Concurred** Concur. Will add additional text to indicate invertebrates would experience direct mortality where construction activities occur in the river. Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016
1-1	Backcheck Recommendation **Close Comment** Revision will be acceptable when implemented. Revision will be confirmed during the Final ATR. Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 20 2016.
	Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558658	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Section 5.2.4 states the Biological Assessment is included as Appendix D. However, Appendix D was never provided for review, and the Table of Contents listed Appendix D as the Fish Passage Connectivity Index and CE/ICA. Thus no review was performed on the BA. Moreover, the impacts discussion in Section 4.10 does not specify the ESA-specific impacts determination. Thus the impacts determination can't be concluded.
Reason for Concern: Final ESA determinations are uncertain and unavailable.
Significance: Moderate to Major.
Recommendation: At a minimum, make the Biological Assessment available for public review. Assuming it has been prepared, bring some of that impact discussion into the EIS, including the ESA-specific effects determinations.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0	Evaluation **Concurred** The portion of the sentence that references Appendix D will be deleted. This is a typo. The BA is not being provided for public review as part of the Draft EIS. Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016
1-1	Backcheck Recommendation **Close Comment** Revision will be acceptable when implemented. Revision will be confirmed during the Final ATR. Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 20 2016.
	Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558660	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Section 4.11 and elsewhere in the document. Obviously there are some adverse effects from project alternatives, including the preferred alternative. This can include some disturbance, tree clearing, wetland fill, and other actions. Somewhere we should explain why these impacts are acceptable. Not only wetlands but other resource categories.
Reason for Concern: We should provide an explantion why we can perform these activities. The public may be interested why we do this without a need for permits.
Significance: Minor
Recommendation: Include a brief explanation of how this project is collectively better environmentally, even with some of the adverse tradeoffs.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0 Evaluation **Concurred**
Concur, will add additional text describing collective benefits and how that outweighs the adverse effects (either during construction or long-term).

Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016

1-1 Backcheck Recommendation **Close Comment**
Revision will be acceptable when implemented. Revision will be confirmed during the Final ATR.

Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 20 2016.

Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558661	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: Section 4.18.2 References impacts discussion under historic properties extends to ground disturbance in unsurveyed portions of rock quarry. I don't think we should discuss potential impacts with quarries. That's broader than any other impact category we've analyzed. We haven't considered this range of potential effects for other resource categories. If we do that here we would need to do that elsewhere, including consideration of ESA, wetlands and other resource concerns.
Reason for Concern: Consistency with the area of effects and impacts analysis.
Significance: Major
Recommendation: Keep the discussion on historic properties consistent with the rest of the EIS in terms of the focus areas and Area of Potential Effects.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0 Evaluation **Concurred**
The quarry referenced in Section 4.18.2 is the one adjacent to Joe's Island, not other quarries within the region. It is currently used for rocking and was addressed due to the potential for it to be a source for materials for O&M in the future.

Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016

1-1 Backcheck Recommendation **Close Comment**
Per a discussion between ATRT and PDT on 8/19/2016, it was agreed that impacts to other resource categories from use of the quarry would be added to all other resource discussions. This isn't reflected in the DrChecks response above provided 6/30/1016, but is understood as the action moving forward. This revision would satisfy the ATR comment. This revision to the EIS will be confirmed during the ATR of the Final EIS later this year.

Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Aug 22 2016.

Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558663	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: It's uncertain if the FPCI model is approved in this instance for use on the Yellowstone River.
Reason for Concern: EC 1105-2-412 requires that models used in planning studies work through some level of certification or approval for use.
Significance: Moderate
Recommendation: Clarify if in fact the FPCI model has been approved for use here.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0 Evaluation **Concurred**
The FPCI model is currently undergoing review by the ECO-PCX. For the FEIS, it will be stated that approval has been completed.

Submitted By: James Carney (206-728-9655) Submitted On: Jul 07 2016

1-1 Backcheck Recommendation **Close Comment**
Revision will be acceptable when implemented. Revision will be confirmed during the Final ATR.

Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 20 2016.

Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6558665	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Concern: I have concern that the value of Ei within the FPCI may not be calculated correctly. This variable uses an average of two assumed values to compute Ei. The first variable measures the amount of flow conveyed through the fish passage structure. The second variable, Fishway Location, measures the ability of fish to find the fishway. "Finding the fishway" was more of an issue on the Upper Mississippi River where the model was first developed for fishways that wouldn't convey all flow and fish behavior was more important in finding a structure entrance that passes only a portion of total river flow. However, in situations where all flow is provided through the fishway (like on the Yellowstone), the ability to encounter the fishway is the same as the first variable which measures amount of water conveyed through the structure. In my opinion that value may need to be a constant "5" for all species. Fish behavior and their ability to use the structure would be captured in variable Ui.
Reason for Concern: This difference in calculations could undervalue the benefits from the rock ramp alternative. Without the model going through some form of model review for application here it's uncertain if the assumed values are appropriate, or if the concern outlined above is valie.
Significance: Moderate. It's likely that changes to benefits calculations won't impact selection of a recommended plan, but the issue above, along with model certification needs, should be addressed.
Recommendation: Explain if the model, including inputs, will go through some type of detailed review. Also address the concern above and explain whether or not the Ei variable should be calculated as is, or along the line of what is addressed above.

Submitted By: Elliott Stefanik (651-290-5260). Submitted On: Jun 14 2016

1-0 Evaluation **Non-concurred**
The fishway size is not the entire river for either the bypass channel or modified side channel alternatives (they have a fishway size score of 2). Also, the fishway location is not the same for all alternatives, most pronounced for the modified side channel alternative that is located nearly 2 miles downstream of the dam and is on the opposite bank from the river's thalweg, thus having low likelihood for fish that use the main channel (i.e. sturgeon) to encounter it. Do not agree that it should be 5 for all alternatives.

Submitted By: James Carney (206-728-9655) Submitted On: Jun 30 2016

1-1 Backcheck Recommendation **Close Comment**
This comment has been passed on to the EcoPCX for consideration during the model review process. The

	comment above should have been better worded to describe concerns wtih input assumptions between the bypass channel alternative and the rock ramp alternative. The ATR reviewer remains concerned that the assumptions may bias alternatives comparison, and this concern has been passed on to the EcoPCX. The ATR Report also should highlight this concern and the path for resolution as it relates only to closing this ATR. Submitted By: Elliott Stefanik (651-290-5260) Submitted On: Jul 21 2016.
	Current Comment Status: **Comment Closed**

Report Complete

Comment Report: All Comments
Project: Intake EIS
Review: Intake FPCI Model Review
Displaying 2 comments for the criteria specified in this report.

Id	Discipline	Section/Figure	Page Number	Line Number
6655556	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: The ATR comment #6558665 expressed concern that the habitat model undervalued fish encounters with a rock ramp and overvalued fish encounters with the bypass channel. The reviewer felt the PDT's biases favored the bypass channel alternative. The ATR comment concluded that the model reviewer (J. Jordan) should look into this concern and make an independent review and conclusion.

BASIS FOR THE CONCERN: Please reference ATR Comment #6558665 (E. Stefanik). I agree with the ATR comment that a rock ramp spanning a stream or river should be encountered by all fish and there will be fewer fish species recognizing a bypass channel depending on the bypass size, location, and flow. Perhaps the word "encounter" is confusing; a better phrase maybe "passage success". A fish may encounter the rock ramp but will not traverse it due to depth, turbulence, ample resting spots, etc. Likewise a fish may enter a bypass channel but may turn around due to unacceptable physical limitations.

SIGNIFICANCE OF THE CONCERN: The significance of the original comment can be high. Biases should not come into play in a habitat model. The model should be able to be replicated by an independent team of professional fisheries biologists and get similar results. However, after reviewing the literature including the project report and correspondence from then USFWS, I found the species in question (particularly the pallid sturgeon) would encounter the rock ramp, but would find the depths, and turbulence unacceptable to successfully traverse past the dam.

PROBABLE SPECIFIC ACTION NEEDED TO RESOLVE THE CONCERN: No action is necessary. Please consider rewording the word "encounter" if the District proposes to advance the model review for regional or national use.

Submitted By: Joe Jordan (309-794-5791). Submitted On: Aug 31 2016

1-0 Evaluation **Concurred**

At this time, the District is not proposing to advance the model review for regional or national use.

Submitted By: Eric Laux ((402)221-7186) Submitted On: Sep 01 2016

1-1 Backcheck Recommendation **Close Comment**

1-1 Backcheck Recommendation **Close Comment**
No additional action is needed.

Submitted By: Joe Jordan (309-794-5791) Submitted On: Sep 01 2016
Current Comment Status: **Comment Closed**

6655563	Environmental	n/a	15	Table 1-10

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: The Lower Yellowstone Intake Diversion fish passage model documentation (page 15, table 1-10 requires Potential (Ui) data scored as 5, 3, or 1, yet a value of 2 is assigned to certain fish for certain measures. This special adjustment was not described in the model description.

BASIS FOR THE CONCERN: The model description states one thing but the spreadsheet does not follow the guidance. Without any explanation why this occurred demonstrates a shortcoming in the model.

SIGNIFICANCE OF THE CONCERN: Weaknesses or gaps in a habitat model tend to be overcome by sensitivity analysis which is code for making the model reflect you bias or professional judgement. This can led to decisions not based on peer review literature or other documented scientific evidence. In this case, the PDT's deviation from the original model are relatively minor and are in fact justified with either documentation or independent professional judgement from the various resource biologists.

PROBABLE SPECIFIC ACTION NEEDED TO RESOLVE THE CONCERN: There are two options to correct this action. 1.) Leave the model as is, and document why you deviated from the model in the project report and in the model documentation. 2.) Modify the model to reflect addition increments such as .5, 2, and 4. In either case you must document the deviation or model revision with enough narrative (and backing) to justify your action. Be sure to check the Ui formula in the Excel spreadsheet to ensure any adjustments are accurately calculated.

Submitted By: Joe Jordan (309-794-5791). Submitted On: Aug 31 2016

1-0 Evaluation **Concurred**
We plan to leave the model as is, and document why we deviated from the model in the project report and in the model documentation.

Submitted By: Eric Laux ((402)221-7186) Submitted On: Sep 01 2016

1-1 Backcheck Recommendation **Close Comment**
Be sure to cite your source of data/coordination supporting your deviation.

Submitted By: Joe Jordan (309-794-5791) Submitted On: Sep 01 2016
Current Comment Status: **Comment Closed**

Lower Yellowstone Intake Diversion Dam Fish Passage Project, Montana

FINAL - Appendix E

Monitoring and Adaptive Management

OCTOBER 2016

Contents

LIST OF TABLES

1.0 Introduction

The Lower Yellowstone Intake Diversion Dam Fish Passage Project (Project) is a proposal to improve pallid sturgeon fish passage at Intake Diversion Dam, a feature of the Lower Yellowstone Project which provides irrigation water to approximately 58,000 acres of cropland in eastern Montana and western North Dakota. The Lower Yellowstone Intake Diversion Dam Fish Passage Project Environmental Impact Statement (EIS) was developed based on the best available scientific information for pallid sturgeon and identifies the Bypass Channel Alternative as the preferred alternative.

This Monitoring and Adaptive Management Plan (AMP) has been prepared by U.S. Bureau of Reclamation (Reclamation) in cooperation with the Corps of Engineers (Corps) consistent with the Memorandum of Agreement between the two agencies (See Section 1.7 – Agency Roles, Responsibilities and Funding) to provide a structured framework for decision making that can adjust Project features and operations if monitoring results indicate the Project is not meeting performance objectives as contemplated in the Final Environmental Impact Statement (FEIS). This AMP has been prepared in a manner consistent with the processes described in the report, *Adaptive Management, The U.S. Department of Interior Technical Guide* (Department Guide) (Williams et al. 2012). The Department Guide frames adaptive management within the context of structured decision making, with an emphasis on uncertainty about resource responses to management actions and the value of reducing that uncertainty to improve management.

The Department Guide describes implementing projects in two phases. The first phase sets up the AMP's key components. This phase was essentially completed through project planning and the development of the EIS. The second phase is an iterative phase in which the components are linked in a sequential iterative decision process of monitoring, assessment, and decision-making, that is repeated at least annually to advance and improve the process and Project over time. This is being developed as part of this AMP.

1.1 Scope and Timeline

The scope of this AMP is limited to the area surrounding the Lower Yellowstone Project. This area includes three miles upstream of the existing weir structure and 70 miles downstream to the Yellowstone and Missouri River confluence. All adaptive management measures are specific to each alternative. All potential changes to these structures are considered modifications of features or operations.

This AMP is a living document that will evolve over time as research and knowledge of pallid sturgeon expands. However, this plan is only intended to last for the first 8 years of the Project. After 8 years, Reclamation will initiate discussions with the U.S. Fish and Wildlife Service (Service) to determine if the existing AMP should continue or if significant modifications to the AMP are necessary. Final monitoring requirements and timelines are subject to change following completion of appropriate NEPA and ESA compliance.

1.2 Project Overview

1.2.1 Description of the Lower Yellowstone Project

Reclamation's Lower Yellowstone Project (LYP) is an irrigation project located in eastern Montana and western North Dakota operated by the Lower Yellowstone Irrigation Project Board of Control (LYIP), Reclamation's authorized agent. The LYP includes the Intake Diversion Dam, which is a rock-filled timber crib weir crossing the Yellowstone River about 70 miles upstream of its confluence with Missouri River and 18 miles downstream of Glendive, Montana. The Intake Diversion Dam raises the river water elevation to divert water from the Yellowstone River through the recently constructed headworks to the LYP's Main Canal on the north side of the river.

River ice and high flows can cause rocks on the Intake Diversion Dam to be displaced. Such displaced rocks have been transported downstream over the years, creating a boulder field on the downstream side of the weir. A side channel on the south side of the Yellowstone River diverges from the main channel upstream of the Intake Diversion Dam and reconnects with the main channel downstream of the weir. The side channel holds water through its entire length when the Lower Yellowstone flow exceeds 20,000 cfs, but does not effectively provide passage until flows exceed 40,000 cfs.

1.2.2 Project Purpose

The purpose of the Project is to improve fish passage for pallid sturgeon and other native fish at the Intake Diversion Dam, continue the viable and effective operation of the LYP, and contribute to ecosystem restoration.

1.3 Project Goals and Objectives

1.3.1 Project Goals

The project goal is to improve pallid sturgeon fish passage at the Intake Diversion Dam. This would make approximately 165 miles of additional habitat available for pallid sturgeon migration and spawning in the Yellowstone River, upstream of Intake Diversion Dam. Under current conditions, the majority of the spawning activity takes place within the lowest 10 to 20 miles of the Yellowstone River (Delonay et al 2016; Bramblett 1996), which does not allow for adequate drift distance for free embryos and larval pallid sturgeon to mature and settle out before they reach the headwaters of Lake Sakakawea, where they are believed to succumb to hypoxia (Bramblett & Scholl 2016; Guy et al. 2015).

By improving passage at Intake Diversion Dam, the majority of adult pallid sturgeon that migrate up to the weir would be able to migrate and spawn further upstream, increasing the available drift distance and improving survival, which could ultimately contribute to increased recruitment of pallid sturgeon within the Great Plains Management Unit (Upper Missouri River and Yellowstone River area as defined by the U.S. Fish and Wildlife Service [Service] in the Pallid Sturgeon Recovery Plan [2014]).

The following specific objectives are based on the physical and biological criteria developed by the Service's Biological Review Team (BRT) and assumptions made in the FEIS. Physical criteria developed earlier for a rock ramp are displayed in parentheses as they have some slight differences (BRT 2009). Physical criteria do not apply to weir removal alternatives as removing the weir would return the river channel to essentially natural conditions. The biological criteria apply to all alternatives.

Water reliability is critical to the success of this project. Under current conditions, diversions range from 600 cfs to the full water right of 1,374 cfs. Alternatives that include a weir structure (Rock Ramp, Bypass Channel, Modified Side Channel) are all expected to continue reliable diversions. However, the pumping alternatives (Multiple Pumps and Multiple Pumps with Conservation Measures) have uncertainties associated with water diversion which are discussed in Chapter 2 of the FEIS. To address these uncertainties an additional objective has been added to address this concern (Objective 4).

1.3.2 Project Objectives

Objective 1: Construct and maintain appropriate physical criteria parameters that allow pallid sturgeon passage. The physical criteria are:

- **Objective 1a - Depth**
    1) Minimum depths in fish passageway measured at the lower discharge range of 7,000 cfs to 14,999 cfs at any sampled cross-section must be greater than or equal to 4.0 feet across 30 contiguous feet of the measured channel cross section profile.

    2) Minimum depths in the fish passageway measured at the discharge range of 15,000 cfs to 63,000 cfs at any sampled cross-section must be greater than or equal to 6.0 feet across 30 contiguous feet of the measured channel cross sectional profile.

- **Objective 1b - Velocities**
    1) Mean cross-sectional velocities must be equal or greater than 2.0 feet/second, but less than or equal to 6.0 feet/second over the discharge range of 7,000 cfs to 14,999 cfs (equal to or less than 4.0 feet/second for a rock ramp).

    2) Mean cross-sectional velocities must be equal or greater than 2.4 feet/second, but less than or equal to 6.0 feet/second over the discharge range of 15,000 cfs to 63,000 cfs (equal to or less than 4.0 feet/second for a rock ramp).

Objective 2: Upstream and downstream passage of pallid sturgeon:

- **Objective 2a - Upstream Adult Passage**
  1) Greater than or equal to 85% of motivated adult pallid sturgeon (fish that move up to the weir) annually pass upstream of the weir location during the spawning migration period (April 1 to June 15) within a reasonable amount of time without substantial delay (≥0.19 miles/hour).

- **Objective 2b - Upstream Juvenile Passage**
  1) No Criteria Set - Develop decision criteria to trigger adaptive management options to improve passage for juveniles if the lack of juvenile passage is demonstrated to result in negative population level effects.

- **Objective 2c - Downstream Adult Passage**
  1) Mortality of adult pallid sturgeon that migrate downstream of the weir location cannot exceed 1% annually during first 10 years. Document any injury or evidence of adverse stress.

- **Objective 2d – Pallid Sturgeon Free Embryo and Larval Downstream Passage**
  1) Assess impingement and entrainment of free-embryo, larval, and young-of-year sturgeon at headworks/screens, irrigation canal and downstream of the weir location.

Objective 3: Upstream and Downstream Passage of Native Fish:

- **Objective 3a – Native Species Upstream Passage**
  1) Determine if native fish are migrating upstream of the weir location at a level greater than or equal to existing conditions.

- **Objective 3b – Native Species Downstream Passage**
  1) Determine if native fish are migrating downstream of the weir location at a level greater than or equal to existing conditions.

Objective 4: Reliable Delivery of Water for Irrigation (Pumping Alternatives Only)*:

1) Determine if 1,374 cfs of water can be reliably diverted (Multiple Pump Alternative).
2) Determine if 608 cfs of water can be reliably diverted (Multiple Pumps with Conservation Measures).

*Objective 4 could be assessed under all alternatives however, past experience has shown that a diversion weir at elevation 1991.0 feet, as proposed under the rock ramp, bypass channel and modified side channel alternatives, generally meets current crop demands and enables 1,374 cfs to be diverted from the Yellowstone River. As discussed below and Chapter 2 of the FEIS there are questions whether the current design of the pumping alternatives would meet current crop demand or have the ability to divert the water needed by the Lower Yellowstone Project.

1.4 Monitoring Plan

Monitoring is used in adaptive management to track resource system behavior and, in particular, the responses to the management actions over time. Monitoring is an ongoing activity, producing new data after each monitoring period to evaluate management actions and ensure that goals and objectives are being met. Monitoring also includes a means to validate assumptions and prioritize management actions during follow-up monitoring periods. In general, monitoring provides data in adaptive management for three key purposes:

- Evaluate progress toward achieving Project goals and objectives.
- Track resource behavior in response to management actions.
- Increase understanding of resource dynamics via the comparison of predictions against monitoring results.

Project monitoring included in this AMP is designed to be coordinated with existing and proposed monitoring programs conducted by the Corps' Missouri River Recovery Program, State of Montana Fish, Wildlife and Parks (MFWP), and the U.S. Geological Survey (USGS). The monitoring program commitments in this AMP are designed to be inclusive of the monitoring commitments between the Corps and Reclamation as described in the Memorandum of Agreement signed April 7, 2015 (see section 1.7 - Agency Roles, Responsibilities and Funding).

Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the Project. Monitoring of the physical criteria and the biological responses to these criteria would begin the first migration season after construction is complete. Once the field season is complete, Reclamation will work with field crews to compile monitoring results for the Technical Team's assessment (Section 1.5).

Specific monitoring plans for each alternative can be found below.

1.5 Assessment

This step includes the process of determining whether unanticipated changes to any of the alternatives are necessary or responses by pallid sturgeon and native fish have occurred. Data collected from physical and biological monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with a Technical Team in the winter/spring of each year. The Technical Team will consist of qualified engineers and fisheries biologists. The Technical Team (see Section 1.5.1) will use their findings from the assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team (see Section 1.6.1).

1.5.1 Technical Team

Below are the agencies and disciplines to be represented on the Technical Team. Additional support and disciplines would be added as necessary to address specific team needs.

- **Bureau of Reclamation (Lead)**
  - Project Manager
  - Fisheries Biologist
  - Engineer
- **Army Corps of Engineers**
  - Project Manager
  - Fisheries Biologist
  - Engineer
- **U.S. Fish and Wildlife Service**
  - Fisheries Biologist
- **U.S. Geological Survey**
  - Fisheries Biologist
- **Montana Fish, Wildlife, and Parks**
  - Fisheries Biologist
- **Montana Department of Natural Resources and Conservation**
  - Engineer/Irrigation Specialist
- **Lower Yellowstone Irrigation Project**
  - District Manager

1.5.2 Adaptive Management Measures

To address any potential problems with any of the alternatives, Reclamation has identified some potential modifications that could be implemented. Tables are included under each alternative containing potential measures that could be implemented in response to various findings related to the physical performance and pallid sturgeon biological performance related to passage success. The decision to implement any of the potential adaptive management actions will be a joint effort between the Technical Team (1.5.1) and the Executive Team (1.6.1) as described below.

1.5.3 Technical Team Recommendations

The Technical Team will make recommendations on implementation of adaptive management measures or changes to the monitoring plan on a case by case basis to the Executive Team. Consensus recommendations are desirable but not required. Recommendations from Technical Team members that differ from the majority recommendation shall be noted in the Technical Team recommendations.

In order for the Technical Team to make recommendations to the Executive Team, the following questions (which may be revised based upon Technical Team input) need to be considered and addressed during this assessment stage:

1) Is the Project meeting Physical Criteria?

- If Yes, move onto #2
- If no, identify potential reasons why
    - If enough information is available, identify a potential adaptive management measure
    - If not enough information is available, identify modifications to the monitoring plan that will help gather additional information needed to identify the problem

2) Is the Project Meeting Biological Criteria?

- If yes, move onto #3
- If no, identify potential reasons why
    - If enough information is available, identify a potential adaptive management measure
    - If not enough information is available, identify modifications to the monitoring plan that will help gather additional information needed to identify the problem

3) Does the current monitoring effort need to be intensified or modified?

- If yes, what are the suggested changes?
- If no, continue with current monitoring plan

4) Does an adaptive management measure(s) need to be implemented?

- If yes, what are they?
- If no, no measure is identified

5) What is the Technical Team's recommendation to the Executive Team?

- Development of a recommendations report to Executive Team

1.6 Decision-Making

This step in the process represents adaptive management decision-making based on the current level of understanding and anticipation of the consequences of decision-making. Once the Technical Team has had a chance to review the results and make recommendations (continue monitoring or implement an adaptive management measure) they will provide a report and brief the Executive Team. The Executive Team will be responsible for making decisions about the proposed path forward and funding strategy. Reclamation's Regional Director or his delegate will be the final decision-maker on implementation of continued or new monitoring and adaptive management measures stemming from this AMP.

1.6.1 Executive Team Members

- Bureau of Reclamation – Regional Director or Delegated Official
- Army Corps of Engineers – Northwest Division Commander or Delegated Official
- U. S. Fish and Wildlife Service – Regional Director or Delegated Official

The Executive Team, while making a decision will consider the following:

- Funding
- Authorities
- Contribution to Science
- Time-frame
- Effects to Pallid Sturgeon
- Effects to the Operation and Maintenance of Lower Yellowstone Project

1.7 Agency Roles, Responsibilities and Funding

Reclamation and the Corps signed a Memorandum of Agreement (MOA) (April 7, 2015) outlining each agencies' roles and responsibilities as it pertains to this AMP. The MOA states the following:

Bureau of Reclamation

Using its own funds, or funding identified through partnerships or contractual agreements, Reclamation shall perform the following activities:

- Develop an action specific Adaptive Management and Monitoring Plan in consultation with the Corps, the Service, and Montana Fish, Wildlife and Parks.
- Provide funding and coordinate post-construction adaptive management and monitoring consistent with applicable success criteria specified by the BRT, conferred by the Service, and agreed upon by Reclamation for any Adaptive Management and Monitoring plan modifications.

- Provide Reclamation staff to lead and execute implementation of any Adaptive Management and Monitoring Plan. Implementation will consist of establishing a Technical Team, and Executive Managers who will coordinate and recommend appropriate strategies for any actions as a result of implementing the Adaptive Management and Monitoring Plan. Such recommended action may be carried out with the approval of the parties.
- Coordinate the execution of operation and maintenance activities consistent with Reclamation's obligations through ESA consultation with the Service for continued operation of the Lower Yellowstone Project. Operation and maintenance of the new headworks and screens; as well as the fish passage, will commence on each feature as the physical construction of each feature is completed or at the date that feature is deemed substantially complete and put in service and the one year construction warranty on the feature starts. Warranty covers issues related to construction defects. If the defect is caused by O&M activities, then it would not be covered under warranty. Operation and maintenance activities will be conducted concurrent with the Adaptive Management and Monitoring Plan.
- Additional responsibilities as designated and described further in any Adaptive Management and Monitoring Plan, to the extent not inconsistent with the MOA dated April 7, 2015.

Additionally Reclamation recognizes there may be adaptive management measures or additional monitoring that the Technical and Executive teams believe are beneficial to implement in response to monitoring or other data, which are not planned in Reclamation's budget (i.e., actions that should be implemented with some immediacy). To address this, Reclamation plans to provide additional funding for these measures through transfers or other means within existing authorities.

Historically, Reclamation's annual appropriations bill has included authority to perform fund transfers. Based on current authority, a fund transfer may be performed to provide "up to $300,000 for any program, project, or activity for which less than $2,000,000 is available at the beginning of the fiscal year". The Lower Yellowstone Project (Project) falls into this category and could benefit from this authority in the year of execution.

Reclamation has used its authority to fund these types of unanticipated monitoring and investigations associated with pallid sturgeon entrainment monitoring and passage planning activities over the last several years. As an example, Reclamation used the fund transfer authority in FY 2016 to provide an additional $229,000 to the Project's enacted level of $380,000, resulting in total funding of $609,000 for Project use. Because the benefits of this monitoring, data gathering, and analysis are not limited to the Project, expenditure of these funds is considered non-reimbursable.

U.S. Army Corps of Engineers

Consistent with its authority under Section 3109 of WRDA 2007, P.L. 110-114, and using its own funds, the Corps shall:

- Demonstrate and ensure that project design and hydraulic performance criteria have been met. In coordination with the Service and Reclamation, develop the monitoring and measurement plan that will be used to verify that the completed construction project meets the design and hydraulic performance criteria. The plan shall include measurement of flow split to the bypass channel, bypass channel depth, and bypass channel velocity within the range specified in the design criteria. Additionally, the plan shall account for uncertainty and inherent variability of flow conditions in the bypass channel.
- The Corps, in coordination with Reclamation, will complete any construction modifications required to meet the design and hydraulic performance criteria (i.e. correction of any design and/or construction related deficiencies) identified within the one year warranty period after substantial completion.
- Additional responsibilities as designated and described further in any Adaptive Management and Monitoring Plan, to the extent not inconsistent with the MOA dated April 7, 2015.

1.8 Reporting

Reclamation will provide annual reports to the Service documenting monitoring results and previous management actions. Recommendations for changes to monitoring or management actions will be proposed as necessary and this document may be updated and reissued.

For each monitoring element, the report will document the methods and results. Results will be evaluated with respect to the goals and objectives of the adaptive management program, and may indicate that changes in monitoring priorities and management activities are warranted.

1.9 Data Management

All monitoring data will be stored electronically on a secured server maintained by Reclamation and will comply with Reclamation's proposed data stewardship guidelines. All data collected by contractors will be provided to Reclamation in an agreed upon electronic format. Additionally, contractors will provide hard copies of any field notes or data sheets. Upon completion of the Monitoring and Adaptive Management Program, all data, results of analyses, and reports will be archived.

2.0 Rock Ramp Alternative

This alternative is intended to provide fish passage past Intake Diversion Dam by constructing a low gradient rock ramp on the downstream side of the replacement weir to reduce the drop at the weir and also to reduce velocities and turbulence and thus encourage fish passage. The existing side channel would remain as a possible migration corridor when flows exceed 40,000 cfs in the river. The key features of the Rock Ramp Alternative include:

> Headworks. A screened headworks was completed in 2012 and has been in operation since 2012. The structure spans 300 feet and is equipped with 12 rotating cylindrical screens designed to reduce entrainment of fish larger than 40 mm into the Main Canal.
>
> Rock Ramp. The rock ramp would extend for 1,200 feet downstream of the replacement weir, burying the existing boulder field, with variable slopes from 0.2 to 0.7%. The ramp would be constructed with large rock (1 to 4 feet in diameter) with cobbles filling in the voids. A low flow channel would be constructed into the shape of the ramp to concentrate flows during low flow periods and also to mimic a deeper main channel route for main channel oriented fish such as pallid sturgeon.
>
> Replacement Concrete Weir. To maintain irrigation diversion capabilities with the screened headworks, a concrete weir would be constructed to an elevation of 1991.0 feet. The concrete weir would preclude the necessity of adding large rock to the crest of the existing diversion structure to maintain diversion capabilities.
>
> Weir Notch. A low-flow notch would be constructed in the new weir with a bottom elevation of 1988 feet, with an 80 ft bottom width and approximately 350 ft top width. This notch would connect to the low flow channel in the ramp.

2.1 Uncertainties

There are uncertainties relative to the physical and biological performance of the rock ramp that could affect the ability to meet the project goals of improving fish passage, particularly for pallid sturgeon. Modeling conducted by the Corps indicates that the rock ramp would not meet the Service's BRT physical criteria for pallid sturgeon passage under all flow conditions (i.e. velocities exceed criteria at the toe of the ramp at flows above 30,000 cfs and the depths are lower than criteria at flows less than 7,000 cfs). There are also concerns about whether the rock would remain in place without frequent maintenance due to ice and flood damage which occur annually on the Yellowstone River.

The use of rock will also introduce roughness that will likely create turbulent flows, which pallid sturgeon appear to avoid or have difficulty passing through (White and Medford 2002; Kynard et al. 2002, 2008). Further, sturgeon can be injured by large rock or bedrock as they swim close to the substrate (Kynard et al. 2012).

2.2 Monitoring

The following monitoring plan is proposed to evaluate if the Rock Ramp Alternative is maintained as designed and constructed, meets the physical criteria, and that biological assumptions were correct. Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the project. Monitoring of the physical criteria and the biological responses to these criteria would begin the first migration season after construction is complete.

Table 1: Monitoring Plan - Rock Ramp Alternative

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Physical Criteria Monitoring (Objective 1a and 1b)	
1	An Acoustic Doppler Current Profiler (ADCP) will be deployed at 5 cross-sections across the rock ramp to analyze depths and velocities. These locations include: 1. Downstream toe (bottom) of the rock ramp 2. Cross-sections at 300, 600, and 900 feet up from the toe of the rock ramp 3. Low-flow notch The ADCP unit will be deployed by boat or line across the rock ramp during the spring moderate (April - May) and high runoff (June - July) conditions and summer low flow baseline (August). This will document depth and velocity conditions during three different flow conditions. If pallid sturgeon are tracked up the rock ramp during a particular river flow regime, ADCP sampling will be done during the time period of highest fish use. This will help determine which hydraulic conditions upstream migrating pallid sturgeon prefer.	Corps of Engineers
2-3	Same as year one.	LY Irrigation Project Board of Control
4-6	The ADCP unit will be deployed in the same locations as described above. Monitoring will take place in the spring before peak runoff (April - May) and then again during summer baseline (August) flows to provide data on pre-migration and post-migration conditions.	LY Irrigation Project Board of Control
7+	Once a baseline and an understanding of how the rock ramp performs under different hydraulic scenarios has been established, the monitoring program will be scaled back. The primary concern will be to determine if a severe or unique event occurs (major flooding or ice jam) and changes the physical and hydraulic characteristics, in which case the ADCP will be deployed.	LY Irrigation Project Board of Control

Year (Post Const.)	Monitoring Activity	Responsible Entity
Adult Pallid Sturgeon Upstream Passage (Objective 2a)		
1-8	Seven telemetry stations will be positioned at strategic locations to track the movement of radio tagged fish. These stations will be located at: 1. One mile downstream of the Project on the Lower Yellowstone River 2. At the toe (bottom) of the rock ramp 3. At the replacement weir (top of the ramp) 4. One mile upstream of the project 5. At the downstream end of the existing side channel 6. At the midpoint of the existing side channel 7. At the upstream end of the existing side channel Currently, the USGS, Service, Reclamation, and MFWP capture and tag both adult and juvenile pallid sturgeon in the spring. This effort is expected to continue to ensure a portion of the population is tagged and can be tracked every year. During this effort, fish are also checked for sexual maturity which is critical for determining what their movements mean in a given year. Because the LYP does not influence whether pallid sturgeon are motivated to migrate up the Yellowstone River or the Missouri River in a given year, only radio tagged pallid sturgeon that come within one mile of the project will be monitored for passage success. It is assumed that if pallid sturgeon are within the vicinity of the project, they are seeking to migrate further upstream. The telemetry station located one mile downstream of the project will be used to establish the number of pallid sturgeon migrating upstream in any given year. The telemetry station(s) at the toe of the ramp, replacement weir, and one mile upstream of the project will be used to determine if pallid sturgeon try and succeed in using the rock ramp. The stations located in the existing side channel will document if pallid sturgeon use the side channel. The station located one mile upstream from the project will confirm how many radio tagged fish successfully migrated through the existing side channel or over the rock ramp. Because telemetry station data only indicates when a fish was present near the station, mobile tracking would be used to supplement the stations once fish are detected at the downstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities, and other physical factors influence passage.	Reclamation

Year (Post Const.)	Monitoring Activity	Responsible Entity
8+	Reclamation, in consultation with the Service, will determine the long-term need and scope of adult pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
	Juvenile Pallid Sturgeon Upstream Passage (Objective 2b)	
1-3	Monitoring plan is the same as Adult Pallid Sturgeon Upstream Passage (Object 2a) Conduct field and laboratory swimming capability studies of juvenile pallid sturgeon to determine if upstream juvenile passage is reasonably expected to occur and if upstream passage would benefit condition, growth, and survival of juveniles.	Reclamation
3	Establish upstream juvenile passage criteria if possible	Fish and Wildlife Service
4-8	Continue monitoring juvenile upstream passage	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of juvenile pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
	Adult Pallid Sturgeon Downstream Passage (Objective 2c)	
1-8	Downstream monitoring will begin with the station located one mile upstream of the Project. This will provide a base number of radio tagged pallid sturgeon attempting to move downstream over the replacement weir and rock ramp or through the existing side channel. If pallid sturgeon attempt to move back downstream over the weir and rock ramp they will be monitored using that station located near the replacement weir. The stations within the existing side channel will detect pallid sturgeon using the side channel to migrate downstream. The station located one mile downstream of the Project will detect the total number of pallid sturgeon successfully migrating downstream through either pathway. Mobile tracking via boat would be used to supplement the land based stations once fish are detected at the upstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities and other physical factors influence passage. This will also help determine whether mortality or injury occurred during downstream migration through the Project area.	Reclamation

Year (Post Const.)	Monitoring Activity	Responsible Entity
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of adult pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
Pallid Sturgeon Free Embryo and Larval Downstream Passage (Objective 2d)		
1-8	The existing headworks monitoring will continue. This consists of hanging entrainment nets behind headworks gates in the Main Canal for 3 weeks during late June and early July. This effort will identify any entrainment of free embryo or larval pallid sturgeon into the Main Canal. Free embryos and larval pallid sturgeon will also be monitored downstream of the replacement weir and rock ramp to ensure these organisms are successfully passing downstream. Larval nets will be deployed at the river side of the headworks (as feasible) to evaluate larval drift. Experiments could be undertaken including the release of free-embryo pallid or shovelnose sturgeon upstream of the weir to assess entrainment or impingement at the screens and injury from drift over the diversion weir and through the rock ramp.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of free embryo and larval pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
Native Species Upstream and Downstream Passage (Objective 3a & 3b)		
1-3	Currently, Reclamation and MFWP capture and tag native species and species of special concern in the spring of each year. These fish will be monitored using the same telemetry system that will be deployed for the pallid sturgeon monitoring. As identified above, Reclamation will locate seven land based telemetry stations at strategic locations to track the movement of radio tagged native fish. Reclamation and MFWP will be monitoring paddlefish, shovelnose sturgeon, blue sucker, and sauger within the immediate area of the Project. These species were selected because, like pallid sturgeon, they are known to make long migrational movements during the spring of the year for spawning and have also shown difficulty in passing the existing weir. The telemetry stations located one mile upstream and downstream of the project will be used to establish the base number of native fish migrating upstream or downstream through the project area. The telemetry stations within the existing side channel will be used to determine whether these native species are using the natural side channel. If native species are migrating over the weir and rock ramp, they will be monitored using the stations located on or near the rock ramp.	Reclamation

2.3 Adaptive Management Measures

Data collected from physical monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with the Technical Team in the winter/spring of each year. The Technical Team will use their findings from assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team.

Tables 2 and 3 outline possible adaptive management measures that could be undertaken to address physical criteria problems and biological criteria problems, respectively.

Table 2: Physical Criteria – Potential Rock Ramp AM Measures

Finding	Principal Measure	Secondary Measures	Responsible Party
Minimum depths in rock ramp do not meet criteria.	Modify low flow channel to be deeper or narrower.	Modify low-flow notch in weir. Create pools in the ramp	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Water velocities in rock ramp do not meet criteria.	Modify low flow channel to be wider.	Create low velocity pools in the ramp	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Rock is moved frequently by ice	Incorporate larger rock into the ramp	Anchor boulders into place with concrete	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.

Table 3: Biological Criteria – Potential Rock Ramp AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2a and 2b)		
No use of rock ramp	1-3	1) Conduct additional ADCP monitoring on rock ramp 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Velocities too high; implement modifications based on ADCP findings: • Modify low flow channel • Incorporate low velocity pools into rock ramp • Extend rock ramp to reduce slope 2) Too much turbulence: • Reconfigure rock ramp to smooth out surface • Extend rock ramp to reduce slope 3) Depths too shallow • Modify low flow channel • Modify low-flow notch in weir 4) Conduct additional ADCP monitoring along rock ramp
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Use of a portion of the rock ramp; no passage	1-3	1) Conduct additional ADCP monitoring along rock ramp 2) Change location of land based telemetry stations to better determine where the potential passage barrier occurs 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Velocities too high; implement modifications based on ADCP findings: • Modify low flow channel • Incorporate low velocity pools into rock ramp

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
		• Extend rock ramp to reduce slope 2) Too much turbulence: • Reconfigure rock ramp to smooth out surface • Extend rock ramp to reduce slope 3) Depths too shallow • Modify low flow channel • Modify low-flow notch in weir 4) Conduct additional ADCP monitoring along rock ramp
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs; <85% of motivated adult pallid sturgeon	1-3	1) Conduct additional ADCP monitoring 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Velocities too high; implement modifications based on ADCP findings: • Modify low flow channel • Incorporate low velocity pools into rock ramp • Extend rock ramp to reduce slope 2) Too much turbulence: • Reconfigure rock ramp to smooth out surface • Extend rock ramp to reduce slope 3) Depths too shallow • Modify low flow channel • Modify low-flow notch in weir

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
		4) Conduct additional ADCP monitoring along rock ramp
	6 - 8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs, but does not occur annually;	1 - 3	1) Conduct additional ADCP monitoring 2) Adjust location of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Issues meeting physical criteria in all years likely; • Depths - change low flow channel invert • Velocities - change low flow channel width and depth
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs	1-8	No adaptive management measures required.
Downstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2c)		
No downstream passage occurs	1-3	1) Conduct additional ADCP monitoring 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir or through the notch • Fill - Removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure • Wing wall or jetty - placement of wing wall or jetty to direct pallid sturgeon towards the weir notch • Weir notch - modification of weir notch, could be increased in size or depth
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Downstream passage occurs but >1% mortality	1-3	1) Conduct additional ADCP monitoring 2) Adjust location of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir, or through the notch • Fill - removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure • Wing wall or jetty - placement of wing wall or jetty to direct pallid sturgeon towards the weir notch • Weir notch - modification of weir notch; could be increased in size or depth 2) Rock ramp a potential hazard • Rock – Reconfigure to have a smoother surface
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful downstream passage - no observed mortality	1-8	No adaptive management measures required
Downstream Drift of Free Embryo and Larval Pallid Sturgeon (Objective 2d)		
No successful passage of free embryo/larval pallid sturgeon post spawning events	1-3	1) Conduct larval drift study 2) Continue entrainment study on the headworks fish screens 3) Utilize 3-D mapping unit to determine route of free embryos and larvae through the project area
	3-5	1) Inadequate depth over weir or through the notch • Fill - removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure • Wing wall or jetty - placement of wing wall to direct free embryo and larvae towards the weir notch • Weir notch - modification of weir not, could be increased in size or depth

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
		2) Rock ramp a potential hazard • Rock – Reconfigure to have a smoother surface
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful passage of free embryo/larval pallid sturgeon	1-8	No adaptive management measures required
Upstream Passage of Native Fish (Objective 3a)		
Less than baseline upstream passage	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Velocities too high; implement modifications based on ADCP findings: • Modify low flow channel • Incorporate low velocity pools into rock ramp • Extend rock ramp to reduce slope 2) Too much turbulence: • Reconfigure rock ramp to smooth out surface • Extend rock ramp to reduce slope 3) Depths too shallow • Modify low flow channel • Modify low-flow notch in weir 4) Conduct additional ADCP monitoring along rock ramp
Same as baseline or improvement	1-8	No adaptive management measures required

<table>
<tr><th>Pallid Sturgeon Response</th><th>Year (Post Const.)</th><th>Adaptive Management Measures</th></tr>
<tr><td colspan="3"><u>Downstream Passage of Native Species (Objective 3b)</u></td></tr>
<tr><td rowspan="2">Less than baseline condition</td><td>1-3</td><td>1) Conduct additional ADCP monitoring at fish entrance
2) Adjust locations of land based telemetry stations
3) Continue active tracking via boat and land based telemetry stations</td></tr>
<tr><td>3-5</td><td>1) Inadequate depth over weir, or through the notch
• Fill - Removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure
• Wing Wall - placement of wing wall to direct free embryo and larvae towards the weir notch
• Weir Notch - modification of weir notch, could be increased in size or depth
2) Rock ramp a potential hazard
• Rock – Reconfigure to be smoother</td></tr>
<tr><td>Same as baseline or improvement from baseline</td><td>1-8</td><td>No adaptive management measures required</td></tr>
</table>

3.0 Bypass Channel Alternative

The Bypass Channel Alternative is intended to improve fish passage by creating a 2.1 mile long, low-gradient channel around the replacement weir, existing weir and rock field. The primary features of this alternative are described below. The effectiveness of these features to provide passage will be monitored, and if needed, modifications will be made in an effort to achieve Project objectives.

Headworks. A screened headworks was completed in 2012 and has been in operation since 2012. The structure spans 300 feet and is equipped with 12 rotating cylindrical screens that reduce entrainment of fish larger than 40 mm into the Main Canal.

Bypass Channel. The bypass channel would be excavated from the inlet of the existing side channel to just downstream of the existing weir and rock field. The bypass channel alignment is approximately 11,150 feet long at a slope of 0.07 percent. The channel cross section has a 40-foot bottom width with side slopes varying from 1V:8H to 1V:4H. The bypass channel would divert on average 13-15% of the total flow of the Yellowstone River.

Upstream Control Structure. A buried riprap control structure designed to control flow split and stabilize the water entrance (fish exit) to the bypass channel would be situated on the upstream end of the channel.

Existing Side Channel Plug. Fill will be placed in the existing side channel to keep all split flows within the bypass channel.

Vertical Control Structures. Two buried vertical control structures (riprap sills) are proposed within the bypass channel for maintaining channel slope and allowing for early identification of channel migration.

Downstream Vertical Control Structure. A buried riprap sill is proposed at the downstream end of the bypass channel to maintain channel elevations.

Armor Layer. The bed of the bypass channel would be armored with sorted sands, gravels and cobbles to reduce the risk of bed degradation. The proposed armor layer would be similar to naturally-formed bed material in the Yellowstone River.

Replacement Concrete Weir. To maintain irrigation and bypass channel diversion capabilities a replacement concrete weir would be constructed to an elevation of 1991.0 feet. The new weir would preclude the necessity of adding large rock to the crest of the existing diversion structure to maintain diversion capabilities.

Weir Notch. A low-flow notch would be constructed in the new weir with a bottom elevation of 1989 feet, with an 85 foot bottom width and approximately 125 foot top width.

Downstream Fill. Fill is proposed near the downstream entrance of the bypass channel to reduce eddy formation and to increase attraction flows.

3.1 Uncertainties

There are uncertainties relative to the physical and biological performance of the bypass channel that could affect the ability to meet the project goals of improving fish passage, particularly for pallid sturgeon. Existing modeling indicates that the bypass channel would meet BRT criteria under all flow conditions, but it remains to be seen if the channel maintains these characteristics over the long term and if these physical criteria result in biological performance.

3.2 Monitoring

The following monitoring plan is proposed to evaluate if the bypass channel is maintained as designed and constructed, meets the physical criteria, and that biological assumptions were correct. Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the project. Monitoring of the physical criteria and the biological responses to these criteria would begin the first migration season after construction is complete.

Table 4: Monitoring Plan – Bypass Channel Alternative

Year (Post Const.)	Monitoring Activity	Responsible Entity
Physical Criteria Monitoring (Objective 1a and 1b)		
1	An Acoustic Doppler Current Profiler (ADCP) will be deployed at 5 cross-sections across the bypass channel to analyze depths and velocities. These locations include: 1. Downstream entrance to the bypass channel. 2. Cross-sections at 1,000, 5,000 and 10,000 feet up from the downstream entrance or representative cross-sections at rock sills and at intermediate sections. 3. Upstream outlet to the river. The ADCP unit will be deployed by boat or line across the bypass channel during the spring moderate (April - May) and high runoff (June - July) conditions and summer low flow baseline (August). This will document depth and velocity conditions during three different flow conditions. If pallid sturgeon are tracked in the bypass channel during a particular river flow regime, ADCP sampling will be done during the time period of highest fish use of the channel. This will help determine which hydraulic conditions upstream migrating pallid sturgeon prefer.	Corps of Engineers
2-3	Same as year one.	LY Irrigation Project Board of Control
4-6	The ADCP unit will be deployed in the same locations as described above. Monitoring will take place in the spring before peak runoff (April - May) and then again during summer baseline (August) flows to provide data on pre-migration and post-migration conditions.	LY Irrigation Project Board of Control
7+	Once a baseline and an understanding of how the bypass channel performs under different hydraulic scenarios has been established, the monitoring program will be scaled back. The primary concern will be to determine if a severe or unique event occurs (major flooding or ice jam) and changes the physical and hydraulic characteristics, in which case the ADCP will be deployed.	LY Irrigation Project Board of Control

Year (Post Const.)	Monitoring Activity	Responsible Entity
Adult Pallid Sturgeon Upstream Passage (Objective 2a)		
1-8	Eight telemetry stations will be positioned at strategic locations to track the movement of radio tagged fish. These stations will be located at: 1. One mile downstream of the Project on the lower Yellowstone River 2. The downstream entrance to the bypass channel 3. Two locations within the bypass channel 4. The upstream outlet of the bypass channel 5. One mile upstream of the project on the lower Yellowstone River 6. The downstream entrance to the existing side channel 7. The old headworks structure Currently, the USGS, Service, Reclamation, and MFWP capture and tag both adult and juvenile pallid sturgeon in the spring. This effort is expected to continue to ensure a portion of the population is tagged and can be tracked every year. During this effort, fish are also checked for sexual maturity which is critical for determining what their movements mean in a given year. Because the LYP does not influence whether pallid sturgeon are motivated to migrate up the Yellowstone River or the Missouri River in a given year, only radio tagged pallid sturgeon that come within one mile of the project will be monitored for passage success. It is assumed that if pallid sturgeon are within the vicinity of the project, they are seeking to migrate further upstream. The telemetry station located one mile downstream of the project will be used to establish the number of pallid sturgeon migrating upstream in any given year. The telemetry station(s) at the bypass channel entrance, within the bypass channel (two locations), and at the upstream outlet of the bypass channel will determine if pallid sturgeon try and succeed in using the bypass channel. The station located at the existing side channel will document if pallid sturgeon try to use the side channel after it no longer has flows. The station located one mile upstream from the project will confirm how many radio tagged fish successfully migrated through the bypass channel and continued migrating upstream. Because telemetry station data only indicates when a fish was present near the station, mobile tracking would be used to supplement the stations once fish are detected at the downstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities, and other physical factors influence passage.	Reclamation

Year (Post Const.)	Monitoring Activity	Responsible Entity
8+	Reclamation, in consultation with the Service, will determine the long-term need and scope of adult pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Juvenile Pallid Sturgeon Upstream Passage (Objective 2b)		
1-3	Monitoring plan is the same as Adult Pallid Sturgeon Upstream Passage (Objective 2a) Conduct field and laboratory swimming capability studies of juvenile pallid sturgeon to determine if upstream juvenile passage is reasonably expected to occur and if upstream passage would benefit condition, growth, and survival of juveniles.	Reclamation
3	Establish upstream juvenile passage criteria if possible	Fish and Wildlife Service
4-8	Continue monitoring juvenile upstream passage	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of juvenile pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Adult Pallid Sturgeon Downstream Passage (Objective 2c)		
1-8	Downstream monitoring will begin with the station located one mile upstream of the Project. This will provide a base number of radio tagged pallid sturgeon attempting to move downstream through the area. If pallid sturgeon attempt to move back downstream over the weir they will be monitored using that station located on the old headworks structure. The stations within the bypass channel will detect pallid sturgeon using the bypass channel to migrate downstream. The station located one mile downstream of the Project will detect the total number of pallid sturgeon successfully migrating downstream for either pathway. Mobile tracking via boat would be used to supplement the land based stations once fish are detected at the upstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities and other physical factors influence passage. This will also help determine whether mortality or injury occurred during downstream migration through the Project area.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of adult pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Pallid Sturgeon Free Embryo and Larval Downstream Passage (Objective 2d)		
1-8	The existing headworks monitoring will continue. This consists of hanging entrainment nets behind headworks gates in the Main Canal for 3 weeks during late June and early July. This effort will identify any entrainment of free embryo or larval pallid sturgeon into the Main Canal. Free embryos and larval pallid sturgeon will also be monitored downstream of the new weir to ensure these organisms are successfully passing downstream. Larval nets will be deployed at the river side of the headworks (as feasible) to evaluate larval drift. Experiments could be undertaken including the release of free-embryo pallid or shovelnose sturgeon upstream of the weir to assess entrainment or impingement at the screens and injury from drift over the diversion weir and through the boulder field.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of free embryo and larval pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
Native Species Upstream and Downstream Passage (Objective 3a and 3b)		
1-3	Currently, Reclamation and MFWP capture and tag native species and species of special concern in the spring of each year. These fish will be monitored using the same telemetry system that will be deployed for the pallid sturgeon monitoring. As identified above, Reclamation will locate eight land based telemetry stations at strategic locations to track the movement of radio tagged native fish. Reclamation and MFWP will be monitoring paddlefish, shovelnose sturgeon, blue sucker, and sauger within the immediate area of the Project. These species were selected because, like pallid sturgeon, they are known to make long migrational movements during the spring of the year for spawning and have also shown difficulty in passing the existing weir. The telemetry stations located one mile upstream and downstream of the project will be used to establish the base number of native fish migrating upstream or downstream through the project area. The telemetry stations within the bypass channel will be used to determine whether these native species are using the bypass channel. If native species are migrating over the weir, they will be monitored using the stations located on the old headworks structure.	Reclamation

3.3 Adaptive Management Measures

Data collected from physical monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with the Technical Team in the winter/spring of each year. The Technical Team will use their findings from assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team.

Tables 5 and 6 outline possible adaptive management measures that could be undertaken to address physical criteria problems and biological criteria problems, respectively.

Table 5: Physical Criteria – Potential Bypass Channel AM Measures

Finding	Principal Measure	Secondary Measures	Responsible Party
Minimum depths in bypass channel do not meet criteria.	Modify upstream or downstream control structures – these structures are critical to flows in the bypass channel and are therefore the first physical feature that would be modified to achieve the criteria; modification would consist of either excavation to lower the control structure(s) or excavation in the bypass channel.	Modify vertical control structures	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Water velocities in bypass channel do not meet criteria.	Modify upstream or downstream control structures – these structures are critical to flows in the bypass channel and are therefore the first physical feature that would be modified to achieve the criteria; modification would consist of either excavation to lower the control structure(s) or excavation in the bypass channel).	Modify vertical control structures	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Flows splits do not meet criteria	Modify upstream control structure – this structure controls the amount of flow that is allowed into the bypass channel; modification would consist of excavating the channel invert to a lower elevation.	Modify upstream control structure	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.

Table 6: Biological Criteria – Potential Bypass Channel AM Measures

<table>
<tr><th>Pallid Sturgeon Response</th><th>Year (Post Const.)</th><th>Adaptive Management Measures</th></tr>
<tr><td colspan="3"><u>Upstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2a and 2b)</u></td></tr>
<tr><td rowspan="3">No use of bypass channel</td><td>1-3</td><td>1) Conduct additional ADCP monitoring at fish entrance

2) Adjust locations of land based telemetry stations

3) Continue active tracking via boat and land based telemetry stations</td></tr>
<tr><td>3-5</td><td>1) Inadequate attraction flows likely; implement modifications based on ADCP findings:
Boulders – during low flows, use tracked equipment to remove or relocate
Sand/gravel bar – dredge material
Guidance structure – construct jetty, wing wall or similar structure to aid location of bypass channel fish entrance
Channel invert - excavation of the bypass channel deeper to provide increased flow splits into the bypass channel.
2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings:
Boulders - during low flows, use tracked equipment to remove
Fill - remove or add additional fill near the entrance to smooth out transitions zone between the bypass channel and the Yellowstone River
3) Sediment build up or rock displacement into bypass channel entrance
Boulders - during low flows, use equipment to remove
Sediment - dredge material
4) Entrance location and design determined to be cause
Entrance angle - adjust the entrance angle to the bypass channel to provide better transition into Yellowstone River.
Entrance width - adjust the entrance to be larger or smaller to increase passage success.
Entrance location - move entrance upstream or downstream
5) Conduct additional ADCP monitoring at fish entrance</td></tr>
<tr><td>6-8</td><td>1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation</td></tr>
</table>

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Use of a portion of the bypass channel; no passage	1-3	1) Conduct additional ADCP monitoring within bypass channel 2) Change location of land based telemetry stations to better determine where the potential passage barrier occurs 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Issues meeting physical criteria likely; • Depths - change channel invert, removal of sediment or excavate bypass channel deeper • Velocities - change channel invert, change control structures, increase depths in bypass channel • Flow Split - change channel invert or change control structures 2) Passage barrier at control structure or low water crossing, implement modification based on ADCP Data ● Control Structure - add fill to bypass channel to provide better transition over control structure
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs; less than 85% of motivated adult pallid sturgeon	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate attraction flows likely; implement modifications based on ADCP findings: • Boulders – during low flows, use tracked equipment to remove or relocate • Sand/gravel bar – dredge material • Guidance structure – construct jetty, wing wall or similar structure to aid location of bypass channel fish entrance • Channel invert - excavation of the bypass channel deeper to provide increased flow splits into the bypass channel. 2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings: • Boulders - during low flows, use tracked equipment to remove • Fill - remove or add additional fill near the entrance to smooth out transitions zone between the bypass channel and the Yellowstone River 3) Conduct additional ADCP monitoring at fish entrance
	6 - 8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

<table>
<tr><th>Pallid Sturgeon Response</th><th>Year (Post Const.)</th><th>Adaptive Management Measures</th></tr>
<tr><td rowspan="3">Upstream passage occurs, but does not occur annually;</td><td>1 - 3</td><td>1) Conduct additional ADCP monitoring within bypass channel
2) Change location of land based telemetry stations to better determine where the potential passage barrier occurs
3) Continue active tracking via boat and land based telemetry stations</td></tr>
<tr><td>3-5</td><td>1) Issues meeting physical criteria in all years likely;
• Depths - change channel invert, removal of sediment or excavate bypass channel deeper
• Velocities - change channel invert, change control structures, increase depths in bypass channel
• Flow Split - change channel invert or change control structures</td></tr>
<tr><td>6-8</td><td>1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation</td></tr>
<tr><td>Upstream passage occurs</td><td>1-8</td><td>No adaptive management measures required.</td></tr>
<tr><td colspan="3"><u>Downstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2c)</u></td></tr>
<tr><td rowspan="3">No downstream passage occurs</td><td>1-3</td><td>1) Continue active tracking via boat and land based telemetry stations</td></tr>
<tr><td>3-5</td><td>1) Inadequate depth over weir or through the notch
• Fill - Removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure and rubble field
• Wing wall or jetty - placement of wing wall or jetty to direct pallid sturgeon towards the weir notch
• Weir notch - modification of weir notch, could be increased in size or depth</td></tr>
<tr><td>6-8</td><td>1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation</td></tr>
</table>

<table>
<tr><th>Pallid Sturgeon Response</th><th>Year (Post Const.)</th><th>Adaptive Management Measures</th></tr>
<tr><td rowspan="3">Downstream passage occurs but greater than 1% mortality</td><td>1-3</td><td>1) Continue active tracking via boat and land based telemetry stations</td></tr>
<tr><td>3-5</td><td>1) Inadequate depth over weir, or through the notch
Fill - removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure and rock field
Wing wall or jetty - placement of wing wall or jetty to direct pallid sturgeon towards the weir notch
Weir notch - modification of weir not, could be increased in size or depth
2) Rock field a potential hazard
Rock - removal of a portion of the downstream rock field</td></tr>
<tr><td>6-8</td><td>1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation</td></tr>
<tr><td>Successful downstream passage - no observed mortality</td><td>1-8</td><td>No adaptive management measures required</td></tr>
<tr><td colspan="3"><u>Downstream Drift of Free Embryo and Larval Pallid Sturgeon (Objective 2d)</u></td></tr>
<tr><td rowspan="3">No successful passage of free embryo/larval pallid sturgeon post spawning events</td><td>1-3</td><td>1) Conduct Larval Drift Study

2) Continue entrainment study on the headworks fish screens

3) Utilize 3-D mapping unit to determine route of free embryos and larvae through the project area</td></tr>
<tr><td>3-5</td><td>1) Inadequate depth over weir or through the notch
Fill - removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure and rock field
Wing wall or jetty - placement of wing wall to direct free embryo and larvae towards the weir notch
Weir notch - modification of weir notch, could be increased in size or depth
2) Rock field a potential hazard
Rock - removal of a portion of downstream rock field</td></tr>
<tr><td>6-8</td><td>1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation</td></tr>
</table>

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Successful passage of free embryo/larval pallid sturgeon	1-8	No adaptive management measures required
Upstream Passage of Native Fish (Objective 3a)		
Less than baseline upstream passage	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate attraction flows likely; implement modifications based on ADCP findings: • Boulders – during low flows, use tracked equipment to remove or relocate • Sand/gravel bar – dredge material • Guidance structure – construct jetty, wing wall or similar structure to aid location of bypass channel fish entrance • Channel invert - excavation of the bypass channel deeper to provide increased flow splits into the bypass channel. 2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings: • Boulders - during low flows, use tracked equipment to remove • Fill - remove or add additional fill near the entrance to smooth out transitions zone between the bypass channel and the Yellowstone River 3) Conduct additional ADCP monitoring at fish entrance
Same as baseline or improvement	1-8	No adaptive management measures required
Downstream Passage of Native Species (Objective 3b)		
Less than baseline condition	1-3	1) Conduct additional ADCP monitoring at fish entrance 2) Adjust locations of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
	3-5	1) Inadequate depth over weir, or through the notch • Fill - Removal or placement of additional fill material to provide better transition over new weir structure, existing weir structure and rock field • Wing Wall - placement of wing wall to direct free embryo and larvae towards the weir notch • Weir Notch - modification of weir not, could be increased in size or depth 2) Rock field a potential hazard • Rock - removal of a portion of downstream rock field
Same as baseline or improvement from baseline	1-8	No adaptive management measures required

4.0 Modified Side Channel

The Modified Side Channel Alternative is intended to improve fish passage by meeting the Service's BRT criteria for flows, depths, and velocities by modifying the existing side channel that has already been demonstrated to be used by upstream migrating pallid sturgeon to bypass around Intake Diversion Dam (Rugg 2014, 2015). The primary features of this alternative are described below. The effectiveness of the deeper channel to provide passage will be monitored, and if needed, modifications will be made in an effort to achieve project objectives.

Headworks. A screened headworks was completed in 2012 and has been in operation since 2012. The structure spans 300 feet and is equipped with 12 rotating cylindrical screens that reduce entrainment of fish larger than 40 mm into the Main Canal.

Existing Weir. The existing weir would remain as is for this alternative.

Existing Side Channel. The existing side channel would be excavated along the majority of its length to be deep enough to achieve the 13-15 percent flow volumes in the Service's BRT criteria. The modified side channel would be slightly shorter than the existing side channel by cutting off three meander bends to ensure the desired volume of flow can be achieved across the range of flows in the river. The modified side channel would be approximately 20,350 ft long at a slope of 0.06 percent. The channel cross section has a 40-ft bottom width with side slopes varying from 1V:4H to 1V:8H.

Upstream Control Structure. A buried riprap control structure designed to control discharge and stabilize the entrance to the modified side channel would be situated on the upstream end of the channel.

Vertical Control Structures. Two buried vertical control structures (buried riprap sills) are proposed within the modified side channel for maintaining channel slope and allowing for early identification of channel movement.

Downstream Vertical Control Structure. A buried riprap sill is proposed at the downstream end of the modified side channel to maintain channel elevations.

Armor Layer. The bed of the modified side channel would be armored with sorted sands, gravels and cobbles to reduce the risk of bed degradation. The proposed armor layer would be similar to naturally-formed bed material in the Yellowstone River.

4.1 Uncertainties

There are uncertainties relative to the physical and biological performance of the modified side channel that could affect the ability to meet the project goals of improving fish passage, particularly for pallid sturgeon. Modeling conducted by Tetra Tech (Appendix A of the EIS) indicates that the modified side channel would meet the Service's BRT criteria under all flow conditions, except at the upstream connection to the river, which might be slightly higher than the BRT criteria of 6 feet/second, at 6.7 feet/second. However, these velocities are consistent with those calculated for the Yellowstone River channel at this location and may not represent the high-flow channel due to the velocity averaging within the 1D model. If this design moves forward, a 2D model would be recommended to provide detailed design parameters.

It also remains to be seen if the channel would maintain these characteristics over the long term and if the physical criteria result in the desired biological performance.

4.2 Monitoring

The following monitoring plan is proposed to evaluate if the Modified Side Channel Alternative is maintained as designed and constructed, meets the physical criteria, and that biological assumptions were correct. Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the project. Monitoring of the physical criteria and the biological responses to these criteria would begin the first migration season after construction is complete.

Table 7: Monitoring Plan - Modified Side Channel Alternative

Year (Post Const.)	Monitoring Activity	Responsible Entity
Physical Criteria Monitoring (Objective 1a and 1b)		
1	An Acoustic Doppler Current Profiler (ADCP) will be deployed at 5 cross-sections across the modified side channel to analyze depths and velocities. These locations include: 1. Downstream entrance to the modified side channel 2. Cross-sections at 5,000, 12,000 and 20,000 feet up from the downstream entrance 3. Upstream outlet to the river The ADCP unit will be deployed by boat or line across the modified side channel during the spring moderate (April - May) and high runoff (June - July) conditions and summer low flow baseline (August). This will document depth and velocity conditions during three different flow conditions. If pallid sturgeon are tracked in the modified side channel during a particular river flow regime, ADCP sampling will be done during the time period of highest fish use of the channel. This will help determine which hydraulic conditions upstream migrating pallid sturgeon prefer.	Corps of Engineers
2-3	Same as year one.	LY Irrigation Project Board of Control
4-6	The ADCP unit will be deployed in the same locations as described above. Monitoring will take place in the spring before peak runoff (April - May) and then again during summer baseline (August) flows to provide data on pre-migration and post-migration conditions.	LY Irrigation Project Board of Control
7+	Once a baseline and an understanding of how the modified side channel performs under different hydraulic scenarios has been established, the monitoring program will be scaled back. The primary concern will be to determine if a severe or unique event occurs (major flooding or ice jam) and changes the physical and hydraulic characteristics, in which case the ADCP will be deployed.	LY Irrigation Project Board of Control

Year (Post Const.)	Monitoring Activity	Responsible Entity
	<u>Adult Pallid Sturgeon Upstream Passage (Objective 2a)</u>	
1-8	Eight telemetry stations will be positioned at strategic locations to track the movement of radio tagged fish. These stations will be located at: 1. One mile downstream of the Project on the lower Yellowstone River 2. The downstream entrance to the modified side channel 3. Two locations within the modified side channel 4. The upstream outlet of the modified side channel 5. One mile upstream of the project on the lower Yellowstone River 6. Immediately downstream of the existing weir structure 7. The old headworks structure Currently, the USGS, Service, Reclamation, and MFWP capture and tag both adult and juvenile pallid sturgeon in the spring. This effort is expected to continue to ensure a portion of the population is tagged and can be tracked every year. During this effort, fish are also checked for sexual maturity which is critical for determining what their movements mean in a given year. Because the LYP does not influence whether pallid sturgeon are motivated to migrate up the Yellowstone River or the Missouri River in a given year, only radio tagged pallid sturgeon that come within one mile of the project will be monitored for passage success. It is assumed that if pallid sturgeon are within the vicinity of the project, they are seeking to migrate further upstream. The telemetry station located one mile downstream of the project will be used to establish the number of pallid sturgeon migrating upstream in any given year. The telemetry station(s) at the modified side channel entrance, within the modified side channel (two locations), and at the upstream outlet of the modified side channel will determine if pallid sturgeon try and succeed in using the channel. The station located one mile upstream from the project will confirm how many radio tagged fish successfully migrated through the modified side channel or over the weir structure and continued migrating upstream. Because telemetry station data only indicates when a fish was present near the station, mobile tracking would be used to supplement the stations once fish are detected at the downstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities, and other physical factors influence passage.	Reclamation
8+	Reclamation, in consultation with the Service, will determine the long-term need and scope of adult pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Juvenile Pallid Sturgeon Upstream Passage (Objective 2b)		
1-3	Monitoring plan is the same as Adult Pallid Sturgeon Upstream Passage (Object 2a) Conduct field and laboratory swimming capability studies of juvenile pallid sturgeon to determine if upstream juvenile passage is reasonably expected to occur and if upstream passage would benefit condition, growth, and survival of juveniles.	Reclamation
3	Establish upstream juvenile passage criteria if possible	Fish and Wildlife Service
4-8	Continue monitoring juvenile upstream passage	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of juvenile pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Adult Pallid Sturgeon Downstream Passage (Objective 2c)		
1-8	Downstream monitoring will begin with the station located one mile upstream of the Project. This will provide a base number of radio tagged pallid sturgeon attempting to move downstream through the project. If pallid sturgeon attempt to move back downstream over the weir they will be monitored using that station located on the old headworks structure. The stations within the modified side channel will detect pallid sturgeon using the channel to migrate downstream. The station located one mile downstream of the Project will detect the total number of pallid sturgeon successfully migrating downstream for either pathway. Mobile tracking via boat would be used to supplement the land based stations once fish are detected at the upstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities and other physical factors influence passage. This will also help determine whether mortality or injury occurred during downstream migration through the Project area.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of adult pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Pallid Sturgeon Free Embryo and Larval Downstream Passage (Objective 2d)		
1-8	The existing headworks monitoring will continue. This consists of hanging entrainment nets behind headworks gates in the Main Canal for 3 weeks during late June and early July. This effort will identify any entrainment of free embryo or larval pallid sturgeon into the Main Canal. Free embryos and larval pallid sturgeon will also be monitored downstream of the weir to ensure these organisms are successfully passing downstream. Larval nets will be deployed at the river side of the headworks (as feasible) to evaluate larval drift. Experiments could be undertaken including the release of free-embryo pallid or shovelnose sturgeon upstream of the weir to assess entrainment or impingement at the screens and injury from drift over the diversion weir and through the boulder field.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of free embryo and larval pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
Native Species Upstream and Downstream Passage (Objective 3a and 3b)		
1-3	Currently, Reclamation and MFWP capture and tag native species and species of special concern in the spring of each year. These fish will be monitored using the same telemetry system that will be deployed for the pallid sturgeon monitoring. As identified above, Reclamation will locate eight land based telemetry stations at strategic locations to track the movement of radio tagged native fish. Reclamation and MFWP will be monitoring paddlefish, shovelnose sturgeon, blue sucker, and sauger within the immediate area of the Project. These species were selected because, like pallid sturgeon, they are known to make long migrational movements during the spring of the year for spawning and have also shown difficulty in passing the existing weir. The telemetry stations located one mile upstream and downstream of the project will be used to establish the base number of native fish migrating upstream or downstream through the project area. The telemetry stations within the modified side channel will be used to determine whether these native species are using the channel. If native species are migrating over the weir, they will be monitored using the stations located in the area of the existing weir.	Reclamation

4.3 Adaptive Management Measures

Data collected from physical monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with the Technical Team in the winter/spring of each year. The Technical Team will use their findings from assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team.

Tables 8 and 9 outline possible adaptive management measures that could be undertaken to address physical criteria problems and biological criteria problems, respectively.

Table 8: Physical Criteria – Potential Modified Side Channel AM Measures

Finding	Principal Measure	Secondary Measures	Responsible Party
Minimum depths in modified side channel do not meet criteria.	Modify upstream or downstream control structures – these structures are critical to flows in the modified side channel and are therefore the first physical feature that would be modified to achieve the criteria; modification would consist of either excavation to lower the control structure(s) or excavation in the channel.	Modify vertical control structures	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Water velocities in modified side channel do not meet criteria.	Modify upstream or downstream control structures – these structures are critical to flows in the modified side channel and are therefore the first physical feature that would be modified to achieve the criteria; modification would consist of either excavation to lower the control structure(s) or excavation in the channel.	Modify vertical control structures	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.
Flow splits do not meet criteria	Modify upstream control structure – this structure controls the amount of flow that is allowed into the modified side channel; modification would consist of excavating the channel invert to a lower elevation.	Modify upstream control structure	- Corps during warranty period - LY Irrigation Project Board of Control in out-years.

Table 9: Biological Criteria – Potential Modified Side Channel AM Measures

<table>
<tr><th>Pallid Sturgeon Response</th><th>Year (Post Const.)</th><th>Adaptive Management Measures</th></tr>
<tr><td colspan="3"><u>Upstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2a and 2b)</u></td></tr>
<tr><td rowspan="3">No use of the modified side channel</td><td>1-3</td><td>1) Conduct additional ADCP monitoring at fish entrance

2) Adjust locations of land based telemetry stations

3) Continue active tracking via boat and land based telemetry stations</td></tr>
<tr><td>3-5</td><td>1) Inadequate attraction flows likely; implement modifications based on ADCP findings:
• Boulders – during low flows, use tracked equipment to remove or relocate
• Sand/gravel bar – dredge material
• Guidance structure – construct jetty, wing wall or similar structure to aid location of modified side channel fish entrance
• Channel invert - excavation of the channel deeper to provide increased flow splits into the modified side channel.

2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings:
• Boulders - during low flows, use tracked equipment to remove
• Fill - remove or add additional fill near the entrance to smooth out transitions zone between the modified side channel and the Yellowstone River

3) Sediment build up or rock displacement into the channel entrance
• Boulders - during low flows, use equipment to remove
• Sediment - dredge material

4) Entrance location and design determined to be cause
● Entrance angle - adjust the entrance angle to the modified side channel to provide better transition into Yellowstone River.
● Entrance width - adjust the entrance to be larger or smaller to increase passage success.
● Entrance location - move entrance upstream or downstream

5) Conduct additional ADCP monitoring at fish entrance</td></tr>
<tr><td>6-8</td><td>1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation</td></tr>
</table>

<table>
<tr><th>Pallid Sturgeon Response</th><th>Year (Post Const.)</th><th>Adaptive Management Measures</th></tr>
<tr><td rowspan="3">Use of a portion of the modified side channel; no passage</td><td>1-3</td><td>1) Conduct additional ADCP monitoring within the channel

2) Change location of land based telemetry stations to better determine where the potential passage barrier occurs

3) Continue active tracking via boat and land based telemetry stations</td></tr>
<tr><td>3-5</td><td>1) Issues meeting physical criteria likely;
• Depths - change channel invert, removal of sediment or excavate channel deeper
• Velocities - change channel invert, change control structures, increase depths in the modified side channel
• Flow Split - change channel invert or change control structures

2) Passage barrier at control structure or low water crossing, implement modification based on ADCP Data
• Control Structure - add fill to modified side channel to provide better transition over control structure(s)</td></tr>
<tr><td>6-8</td><td>1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation</td></tr>
<tr><td rowspan="3">Upstream passage occurs; less than 85% of motivated adult pallid sturgeon</td><td>1-3</td><td>1) Conduct additional ADCP monitoring at fish entrance

2) Adjust locations of land based telemetry stations

3) Continue active tracking via boat and land based telemetry stations</td></tr>
<tr><td>3-5</td><td>1) Inadequate attraction flows likely; implement modifications based on ADCP findings:
• Boulders – during low flows, use tracked equipment to remove or relocate
• Sand/gravel bar – dredge material
• Guidance structure – construct jetty, wing wall or similar structure to aid location of the modified side channel fish entrance
• Channel invert - excavation of the channel deeper to provide increased flow splits into the modified side channel.

2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings:
• Boulders - during low flows, use tracked equipment to remove
• Fill - remove or add additional fill near the entrance to smooth out transitions zone between the modified side channel and the Yellowstone River

3) Conduct additional ADCP monitoring at fish entrance</td></tr>
<tr><td>6 - 8</td><td>1)Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation</td></tr>
</table>

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream passage occurs, but does not occur annually;	1 - 3	1) Conduct additional ADCP monitoring within the modified side channel 2) Adjust location of land based telemetry stations 3) Continue active tracking via boat and land based telemetry stations
	3-5	1) Issues meeting physical criteria in all years likely; • Depths - change channel invert, removal of sediment or excavate channel deeper • Velocities - change channel invert, change control structures, increase depths in modified side channel • Flow Split - change channel invert or change control structures
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs	1-8	No adaptive management measures required.
Downstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2c)		
No downstream passage occurs	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir • Fill - Removal or placement of additional fill material to provide better transition over existing weir structure and rubble field • Weir notch – add weir notch to existing structure
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Downstream passage occurs but greater than 1% mortality	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Inadequate depth over weir • Fill - removal or placement of additional fill material to provide better transition over existing weir structure and rock field • Weir notch – add weir notch to existing structure 2) Rock field a potential hazard • Rock - removal of a portion of the downstream rock field
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful downstream passage - no observed mortality	1-8	No adaptive management measures required
<u>Downstream Drift of Free Embryo and Larval Pallid Sturgeon (Objective 2d)</u>		
No successful passage of free embryo/larval pallid sturgeon post spawning events	1-3	1) Conduct Larval Drift Study 2) Continue entrainment study on the headworks fish screens 3) Utilize 3-D mapping unit to determine route of free embryos and larvae through the project area
	3-5	1) Inadequate depth over weir • Fill - removal or placement of additional fill material to provide better transition over existing weir structure and rock field • Weir notch – add a weir notch to the existing structure 2) Rock field a potential hazard • Rock - removal of a portion of downstream rock field
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful passage of free embryo/larval pallid sturgeon	1-8	No adaptive management measures required

<table>
<tr><th>Pallid Sturgeon Response</th><th>Year (Post Const.)</th><th>Adaptive Management Measures</th></tr>
<tr><td colspan="3"><u>Upstream Passage of Native Fish (Objective 3a)</u></td></tr>
<tr><td rowspan="2">Less than baseline upstream passage</td><td>1-3</td><td>1) Conduct additional ADCP monitoring at fish entrance
2) Adjust locations of land based telemetry stations
3) Continue active tracking via boat and land based telemetry stations</td></tr>
<tr><td>3-5</td><td>1) Inadequate attraction flows likely; implement modifications based on ADCP findings:
• Boulders – during low flows, use tracked equipment to remove or relocate
• Sand/gravel bar – dredge material
• Guidance structure – construct jetty, wing wall or similar structure to aid location of modified side channel fish entrance
• Channel invert - excavation of the channel deeper to provide increased flow splits into the modified side channel.
2) Shear flows or eddy formation determined to be a problem; implement modification based on ADCP findings:
• Boulders - during low flows, use tracked equipment to remove
• Fill - remove or add additional fill near the entrance to smooth out transitions zone between the modified side channel and the Yellowstone River
3) Conduct additional ADCP monitoring at fish entrance</td></tr>
<tr><td>Same as baseline or improvement</td><td>1-8</td><td>No adaptive management measures required</td></tr>
<tr><td colspan="3"><u>Downstream Passage of Native Species (Objective 3b)</u></td></tr>
<tr><td rowspan="2">Less than baseline condition</td><td>1-3</td><td>1) Conduct additional ADCP monitoring at fish entrance
2) Adjust locations of land based telemetry stations
3) Continue active tracking via boat and land based telemetry stations</td></tr>
<tr><td>3-5</td><td>1) Inadequate depth over weir
• Fill - Removal or placement of additional fill material to provide better transition over existing weir structure and rock field
• Weir Notch – adding weir notch to existing structure
2) Rock field a potential hazard
• Rock - removal of a portion of downstream rock field</td></tr>
<tr><td>Same as baseline or improvement from baseline</td><td>1-8</td><td>No adaptive management measures required</td></tr>
</table>

5.0 Multiple Pump Alternative

The Multiple Pump Alternative is intended to improve fish passage by removing the existing weir and rock rubble field down to river grade and returning the river to a more natural channel. The depths and velocities in the natural channel are not required to meet the Service's BRT criteria, because it is presumed that this is essentially a natural condition and the channel is passable for most species during most flows. The one exception would be that the weir would only be removed down to grade. It is possible that buried portions of the existing weir could become exposed over time and create a fish passage barrier. The primary features of this alternative are described below.

Headworks. A screened headworks was completed in 2012 and has been in operation since 2012. The structure spans 300 feet and is equipped with 12 rotating cylindrical screens that reduce entrainment of fish larger than 40 mm into the main irrigation canal.

Existing Weir and Rock Rubble Field. The existing weir and the rock rubble field will be removed from the river channel to grade. The accumulated wedge of coarse sediment upstream from the existing weir will be allowed to naturally transport downstream over time.

Pump Stations. Five pump stations would be installed over a distance of about 20 miles from the existing weir and downstream that would withdraw surface water from the Yellowstone River to supplement gravity flow into the main irrigation canal. Each of the pump stations would be equipped with V-screens that would reduce entrainment of fish larger than 40 mm into the pumps. Additionally, a fish return pump would be installed to return fish to the river that are swept or swim past the screens.

5.1 Uncertainties

There are uncertainties relative to the physical and biological performance of the pumping alternative that could affect whether the project meets the goal and objectives. As mentioned above, only a portion of the existing weir would be removed down to river grade, if the channel begins to migrate or head cutting occurs the remaining portion of the structure may need to be removed.

Also, pump and water delivery reliability is uncertain with this alternative. Channel migration, ice and sediment accumulations are concerns that could have a large impact on the success of this alternative. Because water delivery would occur from 6 locations (existing gravity headworks and 5 pump stations) instead of one primary location, entrainment levels is also an uncertainty associated with this alternative.

5.2 Monitoring

The following monitoring plan is proposed to evaluate if the Multiple Pumps Alternative as designed and constructed, meets the water delivery criteria, and that biological assumptions were correct. Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the project. Monitoring of the biological responses to these criteria would begin the first migration season after construction is complete. Because this alternative would provide an open river no physical criteria will be monitored (Objective 1a and 1b).

As mentioned under Section 1.3.2 and 5.1 pump and water reliability (Objective 4) are uncertain under this alternative. Pump and water reliability would be monitored from April 15 – October 15 (typical irrigation season). This monitoring would also begin the first year of operation.

Table 10: Monitoring Plan – Multiple Pump Alternative

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Adult Pallid Sturgeon Upstream Passage (Objective 2a)	
1-8	Five telemetry stations will be positioned at strategic locations to track the movement of radio tagged fish. These stations will be located at: 1. One mile downstream of Pump Station #5 on the lower Yellowstone River 2. Between pump station #5 and #3 3. Between pump station #3 and #2 4. Between pump station #2 and #1 5. One mile upstream of the headworks structure/pump station #1 Currently, the USGS, Service, Reclamation, and MFWP capture and tag both adult and juvenile pallid sturgeon in the spring. This effort is expected to continue to ensure a portion of the population is tagged and can be tracked every year. During this effort, fish are also checked for sexual maturity which is critical for determining what their movements mean in a given year. Because the LYP does not influence whether pallid sturgeon are motivated to migrate up the Yellowstone River or the Missouri River in a given year, only radio tagged pallid sturgeon that come within one mile of the project (pump station #5) will be monitored for passage success. It is assumed that if pallid sturgeon are within the vicinity of the project, they are seeking to migrate further upstream. The telemetry station located one mile downstream of the project will be used to establish the number of pallid sturgeon migrating upstream in any given year. The telemetry station(s) between the pumping stations will determine if pallid sturgeon successfully migrate upstream through the area. The station located one mile upstream from the project will confirm how many radio tagged fish successfully migrated through the project and over the former weir location. Because telemetry station data only indicates when a fish was present near the station, mobile tracking would be used to supplement the stations once fish are detected at the downstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities, and other physical factors influence passage.	Reclamation
8+	Reclamation, in consultation with the Service, will determine the long-term need and scope of adult pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Juvenile Pallid Sturgeon Upstream Passage (Objective 2b)		
1-3	Monitoring plan is the same as Adult Pallid Sturgeon Upstream Passage (Object 2a) Conduct field and laboratory swimming capability studies of juvenile pallid sturgeon to determine if upstream juvenile passage is reasonably expected to occur and if upstream passage would benefit condition, growth, and survival of juveniles.	Reclamation
3	Establish upstream juvenile passage criteria if possible	Fish and Wildlife Service
4-8	Continue monitoring juvenile upstream passage	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of juvenile pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Adult Pallid Sturgeon Downstream Passage (Objective 2c)		
1-8	Downstream monitoring will begin with the station located one mile upstream of the Project near the headworks and pump station #1. This will provide a base number of radio tagged pallid sturgeon attempting to move downstream through the area. The station located one mile downstream of the Project, near pump station #5 will detect the total number of pallid sturgeon successfully migrating downstream. Entrainment monitoring in the feeder canals to each pumping station would also be monitored to ensure screens are working as designed, and any fish that gets entrained would be safely returned to the Yellowstone River via the fish return pump. Additional details on entrainment monitoring are found below. Mobile tracking via boat would be used to supplement the land based stations once fish are detected at the upstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities and other physical factors influence passage. This will also help determine whether mortality or injury occurred during downstream migration through the Project area.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of adult pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Pallid Sturgeon Free Embryo and Larval Downstream Passage (Objective 2d)		
1-8	The existing headworks monitoring will continue. This consists of hanging entrainment nets behind headworks gates in the Main Canal for 3 weeks during late June and early July. This effort will identify any entrainment of free embryo or larval pallid sturgeon into the Main Canal. Entrainment monitoring would also occur at the 5 pumping stations for the same 3 weeks identified above. Entrainment nets would be hung behind the screens to ensure the screens are working properly. Fish that do get entrained and returned to the Yellowstone River via the fish return pump would also be capture to determine effects to fish.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of free embryo and larval pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
Native Species Upstream and Downstream Passage (Objective 3a and 3b)		
1-3	Currently, Reclamation and MFWP capture and tag native species and species of special concern in the spring of each year. These fish will be monitored using the same telemetry system that will be deployed for the pallid sturgeon monitoring. As identified above, Reclamation will locate five land based telemetry stations at strategic locations to track the movement of radio tagged native fish. Reclamation and MFWP will be monitoring paddlefish, shovelnose sturgeon, blue sucker, and sauger within the immediate area of the Project. These species were selected because, like pallid sturgeon, they are known to make long migrational movements during the spring of the year for spawning. The telemetry stations located one mile upstream and downstream of the project will be used to establish the base number of native fish migrating upstream or downstream through the project area.	Reclamation

<table>
<tr><th>Year
(Post Const.)</th><th>Monitoring Activity</th><th>Responsible Entity</th></tr>
<tr><td colspan="3"><u>Reliable Delivery of Water for Irrigation (Objective 4)</u></td></tr>
<tr><td>1-8</td><td>Under this alternative water would be delivered through six primary locations:

1. Headworks
2. Pump station #1
3. Pump station #2
4. Pump station #3
5. Pump station #4
6. Pump Station #5

When water is being diverted through the existing headworks structure the flows would be measured at the Main Canal Bridge located approximately .5 miles down the Main Canal. When water is diverted through the pumping stations flows would be measured in the discharge pipes that lead from each pumping station into the main canal. Once in the main canal, water diversions will be measured and monitored using a SCADA system and several flow measuring devices (weirs or flumes).

Channel migration will also be monitored near each feeder canal to determine the level of movement. Banks will be monitored 1,000 feet both upstream and downstream of the feeder canal entrance location.

Sediment accumulation within each feeder canal will be monitored to ensure the entrance does not become blocked and that the screens are functioning as designed.</td><td>LY Irrigation Project Board of Control</td></tr>
</table>

5.3 Adaptive Management Measures

Data collected from physical monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with the Technical Team in the winter/spring of each year. The Technical Team will use their findings from assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team.

Tables 11 and 12 outline possible adaptive management measures that could be undertaken to address physical criteria problems and biological criteria problems, respectively.

Table 11: Biological Criteria – Potential Multiple Pump AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream Passage of Adult and Juvenile Pallid Sturgeon (Objectives 2a and 2b)		
Upstream passage occurs; less than 85% of motivated adult pallid sturgeon	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Entrainment occurring at pump stations • Install trash racks with smaller spacing
	6 - 8	1)Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs, but does not occur annually;	1 - 3	1) Change location of land based telemetry stations to better determine where the potential passage barrier occurs 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Entrainment occurring at pump stations • Install trash racks with smaller spacing
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream passage occurs	1-8	No adaptive management measures required.
Downstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2c)		
No downstream passage occurs	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 3) Entrainment occurring at pump stations • Install trash racks with smaller spacing • Modify Screen structure 4) Problems with fish return pumps • Modify or redesign fish return pump
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Downstream passage occurs but greater than 1% mortality	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 5) Entrainment occurring at pump stations • Install trash racks with smaller spacing • Modify Screen structure 6) Problems with fish return pumps • Modify or redesign fish return pump
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Successful downstream passage – no observed mortality	1-8	No adaptive management measures required
		Downstream Drift of Free Embryo and Larval Pallid Sturgeon (Objective 2d)
No successful passage of free embryo/larval pallid sturgeon post spawning events	1-3	1) Conduct Larval Drift Study 2) Continue entrainment study on the headworks fish screens 3) Utilize 3-D mapping unit to determine route of free embryos and larvae through the project area
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Entrainment occurring at pump stations/headworks • Install trash racks with smaller spacing (pumps stations) • Modify Screen structure (headworks and pump stations) • Install wing wall to deflect larval fish away from feeder canal (headworks and pump stations) 3) Problems with fish return pumps • Modify or redesign fish return pump
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful passage of free embryo/larval pallid sturgeon	1-8	No adaptive management measures required
		Upstream Passage of Native Fish (Objective 3a)
Less than baseline upstream passage	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Entrainment occurring at pump stations • Install trash racks with smaller spacing • Modify Screen structure 3) Problems with fish return pumps • Modify or redesign fish return pump
Same as baseline or improvement	1-8	No adaptive management measures required
Downstream Passage of Native Species (Objective 3b)		
Less than baseline condition	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Entrainment occurring at pump stations/headworks • Install trash racks with smaller spacing (pumps stations) • Modify Screen structure (headworks and pump stations) • Install wing wall to deflect larval fish away from feeder canal (headworks and pump stations) 3) Problems with fish return pumps • Modify or redesign fish return pump
Same as baseline or improvement from baseline	1-8	No adaptive management measures required

Table 12: Water Delivery Criteria – Potential Multiple Pump AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
		Reliable Delivery of Water for Irrigation (Objective 4)
Reduced diversions to LYP/Less than 1,374 cfs delivered	1-3	1) Debris and sediment accumulation • Widen or deepen feeder canals • Increased sediment removal by LYIP • Install trash racks with smaller spacing • Install automated trash rack • Redesign fish screen structure • Install wing wall to deflect debris 2) Yellowstone River channel migration • Increase bank protection on either side of the river • Construct headworks structure 3) Physically unable to divert full water right • Install additional pumping stations • Increase bank protection to keep Yellowstone River thalweg next to pumping stations 4) Unable to maintain Main Canal water elevations • Modify canal operations • Install additional check structures • Reduce size of main canal • Pump water from main canal into laterals 5) Impacts from Ice • Install bank stabilization • Install headworks structure
	3-8	1) Conduct modeling and value engineering study to identify further adaptive management measures
Diversion Requirement Met	1-8	No adaptive management measures required

6.0 Multiple Pumps with Conservation Measures Alternative

The Multiple Pumps with Conservation Measures Alternative is intended to improve fish passage by removing the existing weir and rock field and returning the river to a more natural channel. The one exception would be that the weir would only be removed down to riverbed grade. It is possible that buried portions of the existing weir could become exposed over time and create a fish passage barrier. The depths and velocities are not required to meet the Service's BRT criteria, because it is presumed that this is a natural condition and the channel is passable for most species during most flows. The key features of this alternative are described below.

Headworks. A screened headworks was completed in 2012 and has been in operation since 2012. The structure spans 300 feet and is equipped with 12 rotating cylindrical screens that reduce entrainment of fish larger than 40 mm into the Main Canal.

Existing Weir and Rock Rubble Field. The existing weir and rock field will be removed to grade to return it to a natural channel. The accumulated wedge of coarse sediment upstream of the weir will be allowed to naturally transport downstream over time.

Ranney Wells. Seven alluvial groundwater pump stations (i.e. Ranney Wells) would be installed along the river from the site of the existing weir down to below Sidney. These pump stations would not pump surface water, but would pump shallow groundwater in the alluvial aquifer associated with the river to supplement gravity flows into the Main Canal.

Water Conservation. The LYP irrigation canal system would be upgraded through a variety of measures to reduce water consumption and leakage, including lining the canals, converting open canals to pipes, and converting on-farm irrigation systems to pivot sprinklers and other more efficient mechanisms. These measures are proposed to reduce the need to divert more than 608 cfs of water into the LYP.

6.1 Uncertainties

There are uncertainties relative to the physical and biological performance of the pumping alternative that could affect whether the project meets the goal and objectives. As mentioned above only a portion of the existing weir would be removed down to river grade, if the channel begins to migrate or head cutting occurs the remaining portion of the structure may need to be removed.

Also, pump and water delivery reliability is uncertain with this alternative. Channel migration, sedimentation, and aquifer draw down are concerns that could have a large impact on the success of this alternative.

6.2 Monitoring

The following monitoring plan is proposed to evaluate if the Multiple Pumps with Conservation Measures Alternative as designed and constructed, meets the water delivery criteria, and that biological assumptions were correct. Biological monitoring is expected to take place from April 1 – July 15 of each year. This covers the expected time frame for pallid sturgeon upstream migration, spawning, and downstream migration through the project. Monitoring of the biological responses to these criteria would begin the first migration season after construction is complete. Because this alternative would provide an open river no physical criteria will be monitored (Objective 1a and 1b).

As mentioned under Section 1.3.2 and 6.1 pump and water reliability (Objective 4) are uncertain under this alternative. Pump and water reliability would be monitored from April 15 – October 15 (typical irrigation season). This monitoring would also begin the first year of operation.

Table 13: Monitoring Plan – Multiple Pump w/ Conservation Measures Alternative

Year (Post Const.)	Monitoring Activity	Responsible Entity
	Adult Pallid Sturgeon Upstream Passage (Objective 2a)	
1-8	Three telemetry stations will be positioned at strategic locations to track the movement of radio tagged fish. These stations will be located at: 1. One mile downstream of the former weir location 2. At the former weir location 3. One mile upstream from the former weir location Currently, the USGS, Service, Reclamation, and MFWP capture and tag both adult and juvenile pallid sturgeon in the spring. This effort is expected to continue to ensure a portion of the population is tagged and can be tracked every year. During this effort, fish are also checked for sexual maturity which is critical for determining what their movements mean in a given year. Because the LYP does not influence whether pallid sturgeon are motivated to migrate up the Yellowstone River or the Missouri River in a given year, only radio tagged pallid sturgeon that come within one mile of the project will be monitored for passage success. It is assumed that if pallid sturgeon are within the vicinity of the project, they are seeking to migrate further upstream. The telemetry station located one mile downstream of the project will be used to establish the number of pallid sturgeon migrating upstream in any given year. The station located one mile upstream from the project will confirm how many radio tagged fish successfully migrated through the project and over the former weir location. Because telemetry station data only indicates when a fish was present near the station, mobile tracking would be used to supplement the stations once fish are detected at the downstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities, and other physical factors influence passage.	Reclamation
8+	Reclamation, in consultation with the Service, will determine the long-term need and scope of adult pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Juvenile Pallid Sturgeon Upstream Passage (Objective 2b)		
1-3	Monitoring plan is the same as Adult Pallid Sturgeon Upstream Passage (Objective 2a) Conduct field and laboratory swimming capability studies of juvenile pallid sturgeon to determine if upstream juvenile passage is reasonably expected to occur and if upstream passage would benefit condition, growth, and survival of juveniles.	Reclamation
3	Establish upstream juvenile passage criteria if possible	Fish and Wildlife Service
4-8	Continue monitoring juvenile upstream passage	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of juvenile pallid sturgeon upstream passage monitoring.	Reclamation, Fish and Wildlife Service
Adult Pallid Sturgeon Downstream Passage (Objective 2c)		
1-8	Downstream monitoring will begin with the station located one mile upstream of the Project. This will provide a base number of radio tagged pallid sturgeon attempting to move downstream through the area. The station located one mile downstream of the Project will detect the total number of pallid sturgeon successfully migrating downstream. Mobile tracking via boat would be used to supplement the land based stations once fish are detected at the upstream station to provide supplemental information on the route that fish use in the Project area to better understand what particular depths, velocities and other physical factors influence passage. This will also help determine whether mortality or injury occurred during downstream migration through the Project area.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of adult pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service

Year (Post Const.)	Monitoring Activity	Responsible Entity
Pallid Sturgeon Free Embryo and Larval Downstream Passage (Objective 2d)		
1-8	The existing headworks monitoring will continue. This consists of hanging entrainment nets behind headworks gates in the Main Canal for 3 weeks during late June and early July. This effort will identify any entrainment of free embryo or larval pallid sturgeon into the Main Canal.	Reclamation
8+	Reclamation, in consultation with the Service, will meet to determine the long-term need and scope of free embryo and larval pallid sturgeon downstream passage monitoring.	Reclamation, Fish and Wildlife Service
Native Species Upstream and Downstream Passage (Objective 3a and 3b)		
1-3	Currently, Reclamation and MFWP capture and tag native species and species of special concern in the spring of each year. These fish will be monitored using the same telemetry system that will be deployed for the pallid sturgeon monitoring. As identified above, Reclamation will locate three land based telemetry stations at strategic locations to track the movement of radio tagged native fish. Reclamation and MFWP will be monitoring paddlefish, shovelnose sturgeon, blue sucker, and sauger within the immediate area of the Project. These species were selected because, like pallid sturgeon, they are known to make long migrational movements during the spring of the year for spawning. The telemetry stations located one mile upstream and downstream of the project will be used to establish the base number of native fish migrating upstream or downstream through the project area.	Reclamation

Year (Post Const.)	Monitoring Activity	Responsible Entity
Reliable Delivery of Water for Irrigation (Objective 4)		
1-8	Under this alternative water would be delivered through eight primary locations: 1. Headworks structure 2. Pump site #1 3. Pump site #2 4. Pump site #3 5. Pump site #4 6. Pump site #5 7. Pump site #6 8. Pump site #7 When water is being diverted through the existing headworks structure the flows would be measured at the Main Canal Bridge located approximately .5 miles down the Main Canal. When water is diverted through Ranney Wells, flows would be measure in the discharge pipes that lead from each pumping site to the Main Canal. Once in the Main Canal, water diversions will be measured and monitored using a SCADA system and several flow measuring devices (weirs or flumes). Additional monitoring wells would be installed and monitored to determine affects to ground water levels around each pump site.	LY Irrigation Project Board of Control

6.3 Adaptive Management Measures

Data collected from physical monitoring would be evaluated and compared to each other as well as the modeling, objectives, assumptions, and anticipated results contained in the EIS and Biological Opinion. Assessment will be conducted through annual consultation with the Technical Team in the winter/spring of each year. The Technical Team will use their findings from assessment of the monitoring data to recommend monitoring changes or adaptive management measures to the Executive Team.

Tables 14 and 15 outline possible adaptive management measures that could be undertaken to address physical criteria problems and biological criteria problems, respectively.

Table 14: Biological Criteria – Potential Multiple Pump w/ Conservation AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Upstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2a and 2b)		
Upstream passage occurs; less than 85% of motivated adult pallid sturgeon	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
	6 - 8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs, but does not occur annually;	1 - 3	1) Change location of land based telemetry stations to better determine where the potential passage barrier occurs 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Upstream passage occurs	1-8	No adaptive management measures required.

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Downstream Passage of Adult and Juvenile Pallid Sturgeon (Objective 2c)		
No downstream passage occurs	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Downstream passage occurs but greater than 1% mortality	1-3	1) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful downstream passage – no observed mortality	1-8	No adaptive management measures required
Downstream Drift of Free Embryo and Larval Pallid Sturgeon (Objective 2d)		
No successful passage of free embryo/larval pallid sturgeon post spawning events	1-3	1) Conduct Larval Drift Study 2) Continue entrainment study on the headworks fish screens 3) Utilize 3-D mapping unit to determine route of free embryos and larvae through the project area
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure 2) Significant Entrainment occurring at headworks • Modify Screen structure • Install wing wall to deflect larval fish away from feeder canal (headworks and pump stations)

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
	6-8	1) Conduct modeling and value engineering study to identify further adaptive management measures; reinitiate consultation
Successful passage of free embryo/larval pallid sturgeon	1-8	No adaptive management measures required
Upstream Passage of Native Fish (Objective 3a)		
Less than baseline upstream passage	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
Same as baseline or improvement	1-8	No adaptive management measures required
Downstream Passage of Native Species (Objective 3b)		
Less than baseline condition	1-3	1) Adjust locations of land based telemetry stations 2) Continue active tracking via boat and land based telemetry stations
	3-5	1) Remaining weir structure possible barrier • Remove remaining weir structure
Same as baseline or improvement from baseline	1-8	No adaptive management measures required

Table 15: Water Delivery Criteria – Potential Multiple Pump w/ Conservation AM Measures

Pallid Sturgeon Response	Year (Post Const.)	Adaptive Management Measures
Reliable Delivery of Water for Irrigation (Objective 4)		
Reduced diversions to LYP/Less than 608 cfs delivered	1-3	1) Sediment accumulation • Install a back flush system • Install additional Ranney Wells 2) Yellowstone River channel migration • Increase bank protection on either side of the river 3) Physically unable to divert full water right (reduced aquifer recharge) • Install additional Ranney wells • Investigate surface water diversions 4) Unable to maintain Main Canal elevations • Modify canal operations • Install additional check structures • Reduce size of main canal • Pump water from main canal into laterals
	3-8	1) Conduct modeling and value engineering study to identify further adaptive management measures
Diversion Requirement Met	1-8	No adaptive management measures required

7.0 References

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