Appendix A.1
Plan Formulation

Introduction

This appendix presents the history and process for development of the alternatives and the screening criteria used to identify the action alternatives evaluated in the 2010 Intake EA as well as this supplement. It also explains how the project complies with the Implementation Guidance issued by Headquarters, U.S. Army Corps of Engineers (HQUSACE) in December, 2008. Preliminary action alternatives were formulated through an iterative process initiated during informal ESA consultations. Since 2008 the NEPA process (including public involvement, technical information, interdisciplinary and interagency discussions, and professional judgment) has been used to identify the reasonable and feasible action alternatives described in Intake EA Addendum Chapter 2. The No Action Alternative was developed in consultation with the Service. While much of the information in this appendix is duplicative of Appendix A from the 2010 EA, it is necessary to tell the larger story of how alternatives were formulated throughout the process.

Planning Goals, Objectives and Constraints

Planning goals, objectives, and constraints serve to focus project specific opportunities and requirements through incorporating feedback from Federal and state agencies, Tribes, cooperating entities, and the public through the project scoping process. For the Intake Dam Modification Project a series of three public scoping meetings as well as several informational meetings with various cooperating entities were held to gather input on issues of concern related to the project. A cooperating agency team was established and engaged in participation and provided input throughout the preparation of the 2010 EA. The cooperating agency team was again contacted to provide input into the formulation of the supplement. The final planning goals, objectives, and constraints for this project are summarized below. Additional detailed information is included in the “Purpose and Need” section of the 2010 EA.

Goals

The broad goal of any Federal water resources project is to thoroughly evaluate alternatives by comparing project outputs (benefits) against project costs to achieve an optimized solution that maximizes benefits, minimizes costs, and produces outputs which are sustainable. Since the Intake Dam Modification Project involves compliance with the Endangered Species Act (ESA) additional goals are included for both Reclamation and the Corps.

- Goal 1 (Corps) – Implement elements from the Reasonable and Prudent Alternative (RPA) from the Missouri River Biological Opinion (BiOp) to avoid jeopardy and recover endangered pallid sturgeon through aiding with the establishment of natural recruitment and ultimately self-sustaining populations on the Yellowstone River and the Missouri River between Fort Peck Dam and Lake Sakakawea.
- Goal 2 (Reclamation and Corps) – Correct unsatisfactory passage conditions for endangered pallid sturgeon and other native fish in the lower Yellowstone River.
- Goal 3 (Reclamation) – Comply with the ESA by completing consultation under Section 7(a)(2) for operation of Intake Diversion Dam and the Lower Yellowstone Project.

Objectives

Since this project is being pursued jointly by Reclamation and the Corps, the final objectives and constraints for the project are all jointly held objectives.

- Objective 1 – Improve upstream and downstream fish passage for adult pallid sturgeon and other native fish in the lower Yellowstone River.
- Objective 2 – Minimize entrainment of pallid sturgeon and other native fish into the Lower Yellowstone Project main canal. (Construction of a new headworks and fish screens was completed in 2012 under Phase I of this project, therefore entrainment reduction has been addressed).
- Objective 3 – Continue effective operation of the Lower Yellowstone Project in compliance with the ESA.
- Objective 4 – Contribute to restoration of the lower Yellowstone River ecosystem.

Constraints

- Constraint 1 (Reclamation) – Reclamation has contractual obligations to deliver Project water needed to continue viable and effective operation of the Lower Yellowstone Project. The “viable and effective operation” component repeatedly was brought up through the Lower Yellowstone Irrigation Districts due to concerns over the operation and maintenance costs of the alternatives under consideration. The Lower Yellowstone Irrigation Districts currently operate and maintain the facility and will inherit that responsibility for the modified facility, so consideration of long-term operation and maintenance costs was a critical constraint during project formulation.

Problems and Opportunities

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 diversion dam is likely a total barrier to the endangered pallid sturgeon, due to increased turbulence and velocities associated with the rocks at the dam and in the reach immediately downstream from the dam (Jaeger et al., 2005; Fuller et al., 2008; Helfrich et al., 1999; White & Mefford, 2002; Bramblett & White, 2001; U.S. Fish and Wildlife Service (Service), 2000a, 2003, 2007). Appendices L and M of the 2010 EA address this issue in detail. Monitoring of radio-tagged fish indicates that pallid sturgeon currently can move no further upstream than Intake Diversion Dam and some attempt to spawn below the dam. If spawning occurs below the dam, newly-hatched pallid sturgeon (larvae) likely drift into Lake Sakakawea before they are able to swim. Biologists believe that like other river spawning species, pallid sturgeon need a river environment to survive (Jaeger et al., 2002; 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). Biologists also suspect that pallid sturgeon larvae are intolerant of sediments in the river-reservoir transition zone (Wildhaber et al., 2007). The cause of larval deaths in the reservoir is unknown but could be due to the lack of food, predation, or related to sedimentation in reservoirs (Bergman et. al., 2008).

The proposed Intake Project would contribute to recovery of pallid sturgeon by providing up to an additional 165 miles of the Yellowstone River for migration, spawning, and development. The distance between the next upstream barrier on the Yellowstone River, Cartersville Diversion Dam, and Lake Sakakawea is about 317 miles. This substantial increase in free-flowing river habitat likely would provide adequate drift distance for at least a portion of the larvae (Upper Missouri River Basin Pallid Sturgeon Work Group, 2009). Access to tributaries, such as the Tongue and Powder Rivers, would provide additional spawning habitat and could increase larval drift distance.

Inventory and Forecast

The Yellowstone River is one of the largest river systems in the Continental U.S. It retains much of its natural geomorphologic and hydrologic condition due to the low population density and the lack of flow regulating reservoirs along the main stem. The Supplemental EA presents detailed analyses of the updated environmental and socio-economic conditions and effects associated with the alternatives considered. Rather than repeat that information in this appendix, the two most important resources are summarized here, pallid sturgeon riverine habitat and the diversion dam and appurtenant facilities themselves.

The action alternative’s scope of effects for the following resources is very similar to the scope of effects evaluated in the 2010 EA for the Rock Ramp and Relocate Main Channel alternatives. As such, the previously analyzed effects are incorporated by reference and the following resources are not re-evaluated in the supplemental EA.

- Climate
- Air Quality
- Hydrology
- Lower Yellowstone Project irrigation districts
- Environmental justice
- Indian trust assets

Existing Conditions

Pallid Sturgeon

Pallid sturgeon occupy the Missouri and Yellowstone Rivers in Montana and North Dakota. These sturgeon use the Missouri River year-round and the Yellowstone River primarily during spring and summer spawning. Klungle and Baxter (2005) estimated 158 wild adult pallid sturgeon inhabit Recovery-Priority Management Area 2 (RPMA 2). This includes the Missouri

River from Fort Peck Dam to the headwaters of Lake Sakakawea and the Yellowstone River below Intake Diversion Dam (Dryer & Sandvol, 1993).

Several population estimates have been developed for the Fort Peck and Yellowstone River reaches (Krentz, 1996; Kapuscinski, 2002; Klungle & Baxter, 2005), with the most recently developed estimate showing 158 wild adults in 2004 (Klungle & Baxter, 2005). This estimate and current sampling efforts indicate the reproductive adults in the Yellowstone and Missouri Rivers remain very rare. Supplemental stocking of pallid sturgeon has been ongoing sporadically since 1998, with various numbers being stocked based on hatchery success for any given year (Service, 2006) in the upper Missouri River basin. Hatcheries involved with propagation of Missouri River pallid sturgeon stocked a combined 15,781 fingerling and yearling-sized pallid sturgeon during 2011, with approximately 4,000 of those being stocked in the RPMA 2, which includes the lower Yellowstone River and Missouri River between Lake Sakakawea and Fort Peck Reservoirs. Pallid sturgeons are stocked to ensure survival of the species in the short term and preserve existing genetics of the wild population. Monitoring data collected through the Pallid Sturgeon Population Assessment Program indicate that stocked pallid sturgeon are surviving, growing, and reaching a size and age that is capable of spawning. Recent survival estimates for hatchery fish stocked into the Missouri River show relatively high rates of survival (Hadley & Rotella, 2009; Steffensen et al., 2010) that are similar to other sturgeon species (Irelands et al., 2002).

Bramblett (1996) documented that pallid sturgeon prefer the Yellowstone River over the Missouri River below Fort Peck. Evidence from Bramblett (1996) strongly suggests that pallid sturgeon spawning occurs in the lower 6 - 9 river miles of the Yellowstone River. This evidence includes many fish moving into the lower Yellowstone River during spawning season, ripe fish occurring in the Yellowstone River, and fish aggregating during the spawning season (late May and early June). While spawning is suspected to have occurred in the Yellowstone River, there is no evidence that any resulting young survive to adulthood and reproduce (Bergman et al., 2008; [reported as M. Jaeger and D. Fuller personal communication in 2009 Draft Recovery Plan for the Pallid Sturgeon]). While in most years it appears that sturgeon migrate up the Yellowstone River, during the 2011 spawning season, the opposite appeared to be true, likely as a consequence to the high runoff in the Missouri River. This atypical run up the Missouri River resulted in the first documented naturally spawned pallid sturgeon above Gavins Point Dam. A naturally spawned pallid sturgeon was confirmed when a day old larvae was found upstream of Wolf Point Montana in the Missouri River (Fuller, 2012).
Pallids in the Yellowstone River prefer sandy substrates and deep channels and select reaches with numerous islands (Bramblett & White, 2001). They primarily inhabit about a 70-mile stretch of river below Intake Diversion Dam. More recently radio-tagged hatchery-reared pallid sturgeon have been placed above the dam (Jaeger et al., 2005). Most of these fish stayed above the Intake Diversion Dam, but some were found in the main canal of the Lower Yellowstone Irrigation Project (LYIP) (Jaeger et al., 2004).

Despite recent evidence of spawning in the lower Yellowstone River, there are no detectable levels of recruitment occurring (Bergman et al., 2008 [reported as M. Jaeger and D. Fuller personal communication in 2009 Draft Recovery Plan for the Pallid Sturgeon]). The Service (1993) has suggested that the Intake Diversion Dam is a barrier to upstream passage that may prevent pallid sturgeon from accessing upstream reaches. The best available science suggests that the diversion dam is a partial barrier to some species (Helfrich et al., 1999; Jaeger et al., 2004; Backes et al.,1994; Stewart, 1986, 1988, 1990, 1991). It is likely a total barrier to other species, including pallid sturgeon, due to impassable turbulence and velocities associated with the rocks at the dam and downstream (Jaeger et al., 2008; Fuller et al., 2008; Helfrich et al., 1999; White & Mefford, 2002; Bramblett & White, 2001; Service, 2000a, 2003, 2007).

Braaten et al. (2008) suggests larval drift distance presently available below Intake Diversion Dam is insufficient in length and settling habitat. Braaten et al. (2012) recently showed via a recapture study that pallid sturgeon originally released as free embryos and larvae can survive beyond the first year of life, indicating the importance and ability of the Yellowstone River and Missouri River to provide conditions that support survival, feeding, and growth of pallid sturgeon early life stages. Without sufficient drift distances, larvae could drift into the headwaters of Lake Sakakawea where it is thought that survival is unlikely. The Garrison reach of the Missouri River is outside the recovery priority areas identified in the Pallid Sturgeon Recovery Plan (Service, 1993). Reaches outside the recovery priority areas are not excluded from recovery actions but are designated as lower priority, because these areas have been altered to the extent that major modifications would be needed to restore natural physical and hydrologic characteristics.

Existing Dam and Facilities

The first and major portion of the Lower Yellowstone Project was authorized by the Secretary of the Interior on May 10, 1904. The collective features of the Lower Yellowstone Project provide a dependable water supply sufficient to irrigate approximately 54,300 acres of land along the Yellowstone River in east-central Montana and western North Dakota. The Lower Yellowstone Project is primarily a gravity diversion and distribution system, with up to 1,374 cubic feet per second (cfs) of water diverted from the Yellowstone River into the main canal by the Intake Diversion Dam. The collective Lower Yellowstone Project facilities include the Intake Diversion Dam, canal headworks structure, 4 primary pumping plants (including the Intake and Savage pumping plants), 4 supplemental river pumps, 79 miles of main canal, approximately 234 miles of laterals, and 118 miles of open drains, and over 2,500 water control structures. The total irrigated acreage is 54,300 acres, with an average annual water diversion of 327,000 acre-ft. Electric pumping power service to five of the pumping plants is supplied by the Pick-Sloan Missouri Basin Program.

Since the early 1950s, both the agricultural economy and lands served by the Lower Yellowstone Project have remained relatively stable. In contrast to a dry-land farming trend towards larger, consolidated farms, the number of farm units on the Lower Yellowstone Project 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.

Intake Diversion Dam
This 700-feet long dam is a 12-foot high, timber, stone-filled structure that spans the Yellowstone River and diverts water into the headworks of the Lower Yellowstone Project's main canal. The crest of the dam lies about 5 feet above the natural low water mark of the river and 9 feet above the riverbed. A cableway system is used to replace rock at the dam as needed to maintain sufficient elevation for diversion into the main canal headworks.

Headworks
The Intake Diversion Dam diverts water from the Yellowstone River through the canal headworks structure into the main canal for distribution to the lateral system. Ample flow in the Yellowstone River precludes the need for a water storage reservoir. Irrigation waters are distributed primarily through a gravity flow system, but three pumping plants on the main canal supply water for a small area not reached by the gravity system. The headworks and fish screens, constructed in Phase I of the project, contain 12 intakes and fish screens controlled at the inlet by metal slide gates. When a gate is open, water above the diversion dam flows through the headworks conduits and into the main canal. Up to 1,374 cfs can be diverted through the headworks into the main canal.

Future Without-Project Conditions

Pallid Sturgeon
The pallid sturgeon recovery plan projects that the remaining wild population of pallid sturgeon in the reach from Ft. Peck Dam to the headwaters of Lake Sakakawea (including the lower Yellowstone River) will become locally extinct (extirpate) by the year 2018. The prospect for making flow and temperature modifications at Fort Peck Dam to benefit pallid sturgeon is unknown due to feasibility concerns, high cost, schedule for design and implementation, and uncertainty in lake elevations which could preclude release of water through the spillway as a means to implement those measures.

Reclamation has been in Section 7 consultation with the Service on the potential effects of current and future operations of the lower Yellowstone Project since Intake Dam was cited as an impediment to pallid sturgeon recovery in the 1993 Pallid Sturgeon Recovery Plan. The pallid sturgeon in the Fort Peck Dam to Lake Sakakawea reach are genetically distinct from other parts of the species range (Heist et. al., 2009), meaning preserving their genetics is essential to the overall extinction vulnerability of the pallid sturgeon population. The Service has already noted that the upper basin sturgeon, as well as the entire population, is vulnerable to extinction (Service, 2007).

Existing Dam and Facilities
The existing dam and new headworks are likely to continue to provide reliable water delivery to the main canal and irrigation districts into the future with on-going maintenance. The existing dam is over 100 years old and periodically requires major repairs to replace deteriorated and/or damaged timbers. The last major repair was performed in the late 1970s, so another round of repairs is likely sometime in the next 10 to 20 years. The existing dam would continue to impede upstream fish passage of native fish and continue to completely block migration of pallid sturgeon. In addition, Reclamation would continue consulting with the Service under Section

7(a)(2) of the ESA. Based on Reclamation's experience with Section 7 consultation and ESA compliance on other projects and facilities, the Service would likely issue a BiOp requiring that the facilities be modified to provide improved fish passage by some specific date in the future in order to comply with the ESA. If Reclamation were to fail to comply with the BiOp RPAs, it could result in curtailment of project water deliveries over the long term.

Formulation of Alternative Plans

History of Alternative Development

Since the late 1990s Reclamation has been addressing endangered species issues associated with operation and maintenance of its Lower Yellowstone Project. The Corps has been working concurrently to restore habitat and recover endangered pallid sturgeon in the Missouri River Basin. Because of overlapping activities, Reclamation and the Corps have collaborated periodically on technical studies, data collection, and planning for the Lower Yellowstone Project. In 2005, Reclamation and the Corps, along with the Service, the state of Montana, and The Nature Conservancy, signed a Memorandum of Understanding (MOU) to collaboratively address Lower Yellowstone Project pallid sturgeon issues. Since 2005 Reclamation and the Corps, in consultation with the Service, have been partners in pallid sturgeon habitat restoration and recovery.

The original EA was completed in April, 2010. Entrainment protection was addressed with construction of a new headworks structure that included mechanical fish screens. The headworks structure and screens were constructed and in operation for the 2012 irrigation season. However, due to concerns by the lead agencies about rock ramp maintenance, constructability and costs, construction of this component was not implemented. At this time, the lead agencies re-evaluated fish passage options and identified a bypass channel for detailed analysis. Cooperating agencies and stakeholders expressed uncertainty about the bypass channel alternative. In response, Reclamation and the Corps initiated a new planning study effort in June 2013. The goal was to bring the original cooperating entities back to the table to revisit all the alternatives that had been previously identified along with potential new alternatives for achieving fish passage at Intake. This review was completed in early September 2013 and six alternative themes for achieving the goals were developed to an appraisal level of consideration. The themes included an open river channel with pumping, three rock ramp variations, a bypass channel, and conveying water through a new diversion canal. This new collaborative planning effort identified the original Bypass Channel Design, with modification, as the acceptable and implementable fish passage alternative to advance.

This supplement to the 2010 EA was prepared jointly by the Corps and Reclamation to inform decision-makers and the public of the changes to the proposed action, reasonable alternatives, and their environmental impacts.

Development of alternatives began in 1997 during early informal ESA consultation, and it has progressed through various stages. The following documents were developed to help formulate and evaluate alternatives. See the "Literature Cited" section at the end of the 2010 EA for full citations:

- Lower Yellowstone River Fish Passage and Protection Study (Reclamation & Montana Fish Wildlife & Parks, 1997)
- Concept I Report (Mefford et al., 2000)
- Fish Entrainment Study (Hiebert et al., 2000)
- Assessment of Sturgeon Behavior and Swimming Ability for Design of Fish Passage Devices (White & Mefford, 2002)
- 2002 Alternatives Report (Corps, 2002)
- 2002 Value Engineering Study (Reclamation, 2002)
- Test Results of Intralox Traveling Screen Material (Reclamation, 2003)
- Concept II Report (Glickman et al., 2004)
- Value Planning Study (Reclamation, 2005)
- Technical Team Recommendations (Technical Team, 2005)
- Biological Review Team Comments (Jordan, 2006)
- *Lower Yellowstone River Intake Dam Fish Passage and Screening Preliminary Design Report* (Corps, 2006)
- Biological Review Team Comments (Jordan, 2008)
- *Intake Diversion Dam, Trashrack Appraisal Study for Intake Headworks*, Lower Yellowstone Project – Montana-North Dakota (Cha et al., 2008)
- *Intake Diversion Dam, Assessment of High Elevation Intake Gates*, Lower Yellowstone Project – Montana-North Dakota (Mefford et al., 2008)
- L*ower Yellowstone Project Fish Screening and Sediment Sluicing Preliminary Design Report* (Corps, 2008)
- *Final Environmental Assessment (Corps & Reclamation, April 2010)*
- *Intake Diversion Dam Modification Project Summary of Fish Passage Concepts (Corps, April 2011)*
- *Final Value Engineering Study Report (VMS / Corps, April 2013)*

As a result of informal ESA consultations, various fish passage alternatives and screening options were identified, and the agencies focused on these. The 2002 Alternatives Report, which was a joint effort between Reclamation and the Corps, evaluated an array of different fish passage alternatives and also included various swim studies focused on collecting more information on the swimming abilities of pallid sturgeon and their likelihood to successfully navigate through various fish passage structures (fish ladders, rock fishways, etc.).

Value Engineering Study

In July 2002 Reclamation sponsored a Value Engineering Study to identify alternatives that would satisfy essential functions at the highest value (Reclamation, 2002). The study team included biologists, engineers, and maintenance experts from Reclamation, the irrigation district manager, the Service's Pallid Sturgeon Recovery team leader, and a fisheries professor representing FWP. The team used the Concept I Report (Mefford et al., 2000) as a baseline proposal for the study.

The team defined critical functions, criteria for those functions, and associated costs of various options. Using brainstorming techniques, they suggested alternative ideas to perform those functions at a lower cost or an increase in long-term value. The team evaluated, analyzed, and prioritized these ideas to develop the best for comparison. The results were summarized in the 2002 Value Engineering Study (Reclamation, 2002). During the next step, decision-makers from Reclamation's Montana Area Office and the Reclamation's Technical Service Center examined each of the proposals in the 2002 Value Engineering Study and identified alternatives for further evaluation (Reclamation, 2004).

Value Planning Study

After execution of the MOU in 2005, the MOU partner agencies, along with the irrigation districts, conducted a Value Planning Study to explore various ways to improve fish passage for the Intake Project. The Value Planning Study used the Value Method to compare and contrast these ideas to identify the options with the highest value (Reclamation, 2005).

Value Method - a decision making process to creatively develop alternatives that satisfy essential functions at the highest value. It has many applications but is most often used as a management or problem-solving tool.

The Value Planning Study process followed a structured approach critically examining Reclamation's originally proposed rock fishway alternative to understand features, costs, and performance characteristics. It also identified desirable functions to compare with other alternatives. The value planning study group brainstormed techniques to creatively identify alternative solutions that would perform these functions at a lower cost or with an increase in long-term value. Brainstorming produced 110 ideas that initially were screened to remove duplicative or technically infeasible alternatives, as well as those beyond the scope of value planning.

The remaining ideas were then evaluated, analyzed, and prioritized using the ratings criteria shown in Table A.1.1. Once rated and prioritized, the best ideas were developed to a conceptual level and compared using a more rigorous "choosing by advantages" (CBA) decision making system (Suhr, 1999). The baseline alternative for comparative purposes was the rock fishway originally proposed by Reclamation. Normally, any idea rated as a 1 or 2 would be considered an improvement over the baseline and, thus, would be a candidate for further development. However, based upon professional experience, it was decided that the baseline would likely underperform despite its relatively low cost. Therefore, all ideas recommended for further evaluation were required to have a score of 3 above the baseline score.

Table A.1.1 - Ratings Criteria for Value Planning Study Alternatives Screening

Score	Rating Definition
1	Likely to lower costs and improve performance
2	Likely to leave costs unchanged and improve performance OR likely to lower costs and leave performance unchanged
3	Likely to increase both costs and performance OR likely to have no impact on costs or performance OR likely to decrease both costs and performance
4	Likely to increase costs and leave performance unchanged OR likely to leave costs unchanged and lower performance
5	Likely to increase costs and lower performance

The final step was to combine similar ideas into the final list of alternatives to be evaluated. Table A.1.2 lists the original 110 ideas that were evaluated and their initial screening values.

Table A.1.2 - Value Planning Study Ideas Considered and Their Disposition

Idea	Disposition
1. Remove dam	Combined with 43
2. Use elevators	Combine with 104
3. Catch and truck fish upstream	Infeasible
4. Use Lenny's "ooze gallery"	Duplicate of 110
5. Use side channel	Duplicate
6. Archimedes screw	Infeasible, adult fish too large
7. Return to dry land farming	Infeasible
8. Provide pumping facilities	Duplicate
9. Provide trust fund (equal to project cost) to subsidize farmers	Beyond study scope
10. Change dam angle to block only half channel	Infeasible
11. Use L-shape dam	Rated 3A – develop
12. Decrease slope of dam	Infeasible
13. Build island	Rated 3A – develop
14. Improve head with upstream Reclamation dam	Infeasible
15. Plant fish	Infeasible
16. Provide infiltration gallery	Infeasible
17. Use trust fund interest to subsidize pumping costs	Combine with 43 and 107
18. Fish lock	Infeasible
19. Wind farm to subsidize pumping costs	Combine with 43
20. Use irrigation wells	Infeasible
21. Well field next to Yellowstone	Infeasible
22. Off channel detention storage	Infeasible
23. Remove main stem dams	Infeasible
24. Partial removal of dams	Infeasible
25. Use pipelines from other (unnamed) source	Infeasible
26. Rehab irrigation project – water conservation	Combine with 43 and 107
27. Tie in rural water systems	Infeasible
28. Methane well discharges	Infeasible
29. Build new dam to catch spring flows	Infeasible
30. Build several new reservoirs on lower Yellowstone	Infeasible
31. Pipe from Fort Peck or other upstream sources	Infeasible
32. Reduce Lake Sakakawea water level to increase larval drift time before reservoir	Infeasible
33. Add meander & side channels, reduce slope, lengthen channel for longer drift times	Infeasible
34. Add instream structures to guide larval fish to lengthen channel	Infeasible
35. Construct regional sewage plant; use effluent in irrigation system	Infeasible
36. Pipe from Cartersville Dam	Infeasible
37. Use in-channel infiltration pipes	Rated 5
38. Guide fish with louver system	Infeasible
39. Make hydro facility including larger concrete fishway	Infeasible
40. Pipe municipal water returns from Glendive	Infeasible
41. Pay Glendive for water returns to mitigate caviar loss	Infeasible; beyond study scope
42. Attract fish with light, sounds, or whatever they really like	Infeasible
43. Remove dam, build pumps & wind farm with Pick-Sloan & create trust	Rated 3A – develop
44. Remove dam; move point of diversion upstream	Combine with 110
45. Diversion without dam; with pumping backup	Combine with 43
46. Remove part of dam and convert rest to infiltration gallery	Infeasible
47. Pump to reservoir in winter	Infeasible

Idea	Disposition
48. Widen fishway alternative 1A	Rated 3A – develop
49. Obtain Montana grant to develop pumping power	Combine with 43
50. Establish lots of paddle wheel pumps	Infeasible
51. Use fish ladders	Duplicate
52. Use collapsible dam	Duplicate
53. Floating diversion dam	Duplicate
54. Seasonal push-up dam	Infeasible
55. Remove dam; irrigate only when water high enough to supply head	Infeasible
56. Down canal impoundment to store water with high flows – only divert when high enough to supply head	Infeasible
57. Develop strain of beets requiring no water	Infeasible
58. Use multiple diversions	Rated 5
59. Use Agricultural Department farm bill monies to rehab irrigation system	Infeasible
60. Buy out irrigators to reduce demand	Outside of study scope
61. Use windfarm to pay irrigators to switch to dry land farming	Infeasible
62. Explore drip irrigation	Water conservation issue
63. Explore sealing canal delivery system to reduce/eliminate seepage	Water conservation issue
64. Use pipe system to reduce evaporation in delivery system	Water conservation issue
65. Fish ramp	Duplicate
66. Fish tunnel	Infeasible
67. High and low water passage designed into dam	Infeasible
68. 21G to 2AG fish channel	Rated 4
69. Upstream passage designed into bypass screen structure	Infeasible
70. Pump fishway design – false weir	Infeasible
71. Use German retractable dam	Combined with 105
72. Fish catapult	Infeasible
73. Pay fisherman to put fish upstream of dam	Infeasible
74. Rewards for pallid sturgeon caught by paddle fish fishermen	Infeasible
75. Use bascule gate	Duplication
76. Make whitewater river course through project area	Infeasible
77. In-channel turbine to provide power for pumps	Infeasible
78. Build habitat to attract fish	Combine with 94
79. Remove rocks washed downstream; reuse rocks; sell rocks to landscapers on east coast	Infeasible
80. Use fish herding black Labrador retrievers	Infeasible
81. Use rock dikes to let water into canal – but not fish - into canal	Infeasible
82. Use multiple small pump plants close to demand	Rated 3A – develop
83. Use differential gates such as Obermeyer to move thalwag	Duplication
84. Clean up rock debris and breech center of existing dam	Infeasible
85. Reroute Yellowstone to current backchannel to maintain irrigation	Infeasible
86. Use solar power pumps	Infeasible
87. Use sounds and lights to reduce entrainment	Duplication
88. Spawning habitat in canal	Infeasible
89. Add new screens at wastewater sites	Infeasible
90. Raise bed of Yellowstone	Infeasible
91. Install twenty sills (6” to 8” high) to get head	Rated 5
92. Low head hydro plant for supplemental power	Infeasible
93. Increase funding level for pallid sturgeon efforts elsewhere	Infeasible
94. Modify dams to enhance attracting fish	Combine with 48
95. Crossbreed sturgeon with steelhead	Infeasible
96. Do nothing	Rated 3C – develop; rejected during development
97. Concept II, Alternative 1A – riprap fishway around fishway	Rated 4

Idea	Disposition
98. 1B through dam	Rated 4
99. 1B grouted	Rated 4
100. 1C with earthen wall	Rated 4
101. Flume and baffle fishway	Rated 4
102. Denil fish ladder	Rated 5
103. Long low gradient channel	Rated 3A
104. Fish elevators + music	Rated 4
105. Collapsible gates with rock fishway	Rated 3A
106. Provide infiltration gallery	Questionable feasibility
107. Conventional pump plants on Yellowstone	Combine with 43
108. Rock ramp fish passage	Rated 3A
109. Infiltration ponds	Infeasible
110. Upstream diversion point without pumps	Rated 3A

The initial screening identified ten alternatives for conceptual development and evaluation (Table A.1.3).

Table A.1.3 - Summary of Value Planning Ideas Recommended for Evaluation

ID #	Priority 1	ID #	Priority 2
43	Remove dam, build pumps & wind farm with Pick-Sloan preference power & create trust	11	Use L-shape dam[1]
48	Widen fishway alternative 1A	13	Build island
103	Long low gradient channel	82	Use multiple small pump plants close to demand
105	Collapsible gates with rock fishway	96	Do nothing[2]
108	Rock ramp fish passage	110	Upstream diversion point without pumps

[1] The L-shape dam concept was subsequently subdivided into two versions (Alternative 1A and 1B) that extended upstream 6,600 and 20,000 ft, respectively. [2] The "Do Nothing" alternative was dropped from further consideration, as the team did not feel it met the purpose of providing fish passage and was not useful for comparative purposes.

After conceptual development of each of the ten remaining alternatives, the team applied the CBA system to evaluate and compare those alternatives. Table A.1.4 presents the final scoring of the CBA matrix for the various alternatives. The three alternatives with the lowest scores were eliminated. A matrix of factors and sub-factors was used to organize the analysis. The CBA analysis resulted in three tiers of alternatives:

- **Tier One -** the top four alternatives that scored relatively high in the importance of their advantages;
- **Tier Two -** the next three alternatives whose total scores are lower than the top group, but some individual team members ranked very high;
- **Tier Three -** the final three alternatives with the lowest overall scores.

The Value Planning Study (Reclamation, 2005) recommended that the Long, Low-Gradient Channel Alternative, Rock Ramp Alternative, Remove Dam and Build Single Pumping Plant Alternative and the Widen Fishway Alternative be carried forward for further consideration. The Remove Dam and Move Diversion Upstream Alternative, Multiple Pump Stations Alternative, and Collapsible Gates Alternative also were identified for further study. Finally, the study concluded that the Island, L-Shaped Dam 6,600 ft, and the L-Shaped Dam 20,000 ft alternatives be eliminated from further consideration, because these alternatives had the lowest scores.

Technical Team Recommendations

After completing the Value Planning Study, Reclamation invited representatives from the Lower Yellowstone Project, the state of Montana, The Nature Conservancy, the Corps, and the Service to a meeting (see Chapter 5 for a list of participants). The purpose of the meeting was to recommend alternatives that should be further evaluated to support the ESA consultation process. The multi-agency team met on November 28, 2005, and jointly identified a set of progressive filters to screen the Value Planning Study alternatives. The three filters were to be applied in consecutive order from first to third, so that if there was insufficient information to apply a filter to an alternative or the alternative did not meet the first filter, it would not be evaluated against the other two. The filters the team identified were:

1) **Biological Filter** - Probability of success in meeting ESA objectives;
2) **Water Delivery Filter** - Reliability in maintaining water delivery to the project; and
3) **Engineering and Construction Filter** - Engineering, design, and constructability factors.

Table A.1.4 - Compilation of CBA Scores and Rankings.

Alternative	L-Shaped Dam, 6,600'	L-Shaped Dam, 20,000'	Island	Widen Fishway	Multiple Pump Stations	Long, Low-Gradient Channel	Remove Dam and Move Diversion Upstream	Rock Ramp	Collapsible Gates	Remove Dam and Build Single Pumping Plant
Proposal #	**1A**	**1B**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Individual Team Member Scores	240	220	300	400	310	490	310	510	280	370
	321	249	395	469	421	573	436	554	391	497
	382	382	562	751	661	847	663	755	644	757
	135	125	204	568	590	609	573	538	410	568
	239	214	244	270	315	420	330	395	260	370
	132	124	143	362	400	396	450	286	185	412
	443	353	523	611	629	801	621	720	537	711
	280	260	280	530	410	490	500	560	280	480
	310	260	377	419	452	529	398	493	287	520
	160	150	205	500	420	704	375	575	325	465
	170	160	180	480	350	610	420	670	350	420
	215	215	235	265	325	295	420	355	160	325
TOTAL SCORE	3027	2712	3648	5625	5283	6764	5496	6411	4109	5895
RANK	**9**	**10**	**8**	**4**	**6**	**1**	**5**	**2**	**7**	**3**

To further refine the Value Planning Study results and compare alternatives, the CBA matrix was revised to measure performance factors against the baseline. To apply this approach, the team defined a baseline for each factor and assessed whether deviations from the baseline were either positive or negative, as well as the degree of each deviation. Positive deviations were characterized as either “better” or “much better,” and negative deviations were either “less than good” or “poor.”

The negative deviations were of concern to decision makers. Fish passage alternatives that required fish to find an entrance to a passage structure were of special concern. Uncertainty about fish attraction to passage entrances raised a red flag for those alternatives that lacked passage across the full width of the river.

Table A.1.5 presents the refined Value Planning Study results matrix using symbols and includes preliminary cost estimates. The technical team identified the Rock Ramp with an In-Canal Fish Screen as the alternative most likely to meet biological and ESA requirements, and most likely to be acceptable to interested parties. In addition, the team identified the Single Pumping Plant and the Move Diversion Upstream Alternatives as also viable to provide the desired fish passage.

Reclamation and the Corps proceeded with further preliminary design and evaluation of these three alternatives from 2005 through 2009. Preliminary design information was developed in anticipation of the need for better information for the Draft EA and to prepare preliminary cost estimates.

Biological Review Team

After the Corps (2006) report was completed, the Service formed a team of pallid sturgeon experts, called the Biological Review Team (BRT) (see Chapter 5 for a list of team members). The team held an initial meeting on August 17 and 18, 2006, to review the preliminary alternatives. The BRT recommended specific design considerations to improve the probability of successful pallid sturgeon passage and entrainment protection at Intake (Jordan, 2006). These recommendations included:

- An improved trashrack
- Increasing the elevation of intakes
- Applying National Marine Fisheries’ standards for salmonid screening to screen design
- Further study on larval impingement survival
- Non-step rock fishway design modeled after existing Yellowstone River riffles
- Model of 0.5%, 0.75% and 1.0% non-step ramps
- Development of a physical model to evaluate depths and velocities
- Ramp design to allow fish to avoid headworks
- Remove the Relocate Diversion Upstream Alternative

Table A.1.5 - Final Value Planning Alternative Screening Matrix (Reclamation, 2005)

ESA Modifications - Alternatives Evaluation Matrix

Alternative Name and (VP Study Number)	Rank from VP Study	Fish Screen - Field Construction Cost ($)	Fish Passage Field Construction Cost ($)	Total Field Construction Cost ($)	Total Project Cost ($)	Annual O&M Cost (Excluding Energy) ($)	Annual Energy Cost--Pick-Sloan rate of 10.76 mills/kWh ($)	Annual Replacement Cost ($)	Total Annual Operation, Maintenance and Replacement Cost ($)	Biological Monitoring Cost ($)	Biological Monitoring Duration (yrs)	Likelihood of ESA Success	Benefits to All Native Fisheries	Constructability	Water Delivery Reliability	Acceptability: Recreational Community	Acceptability: Environmental Community	Acceptability: Irrigation Project Water Users
Present Condition						$ 19,000												
Diversion Dam Alternatives																		
Widen Fishway (3)	4	$ 8,100,000	$ 7,200,000	$ 15,300,000	$ 20,961,000	$ 24,000		$ 160,000	$ 184,000	$ 3,189,000	10	▼[a]	◊[a]	●	▲	▲	▼[a]	○
Long Low Gradient Channel (5)	1	$ 8,100,000	$ 18,000,000	$ 26,100,000	$ 35,757,000	$ 39,000		$ 430,000	$ 469,000	$ 3,189,000	10	▼[a]	◊[a]	▲	○	▲	▼[a]	○
Rock Ramp (7)	2	$ 8,100,000	$ 22,000,000	$ 30,100,000	$ 41,237,000	$ 25,000		$ 378,000	$ 403,000	$ 1,703,000	6		▲	○	▲	○	○	○
Open River Alternatives																		
Single Pumping Plant (9)	3	$ 8,100,000	$ 27,000,000	$ 35,100,000	$ 48,087,000	$ 30,000	$ 108,000	$ 744,000	$ 882,000	$ 667,000	2	●	●	○	○	▼[b]	●	◙[c]
Move Diversion Up River (6)	5	$ 8,100,000	$ 31,000,000	$ 39,100,000	$ 53,567,000	$ 27,500		$ 614,000	$ 641,500	$ 667,000		●	●	◊[d]	▼[d]	▼[b]	●	▼[d]

Alternatives Considered But Eliminated		Reason for Elimination
L-Shaped Dam (1B)	9	This alternative was dropped from further consideration due to the significance of construction required to implement, high risk of potential failure from flood waters, ice jamming, erosion, and channel movement.
Collapsible Gates (8)	7	This alternative was eliminated due to concerns relative to operation and maintenance. This alternative would also remain a barrier to fish passage while in operation since the majority of the river would be blocked to provide sufficient head for delivery of water into the canal.
Island (2)	8	While this alternative would partially open the river channel, it was dropped from further consideration due to water risk, construction risk, ability to modify in the future and acceptability.
Multiple Pump Stations (4)	6	This alternative originally was dropped from further consideration because is a duplicate of the single pumping plant alternative, but it was included in the Draft EA in response to public scoping comments.
Do Nothing (10)		This alternative does not meet the requirements of the Endangered Species Act

Legend

Much Better	●	Red flag: less than good	▼
Better	▲	Poor	◙
Good	○	Unknown	◊

[a] *It is not known whether fish will be able to locate a fishway entrance, or if the unnatural conditions of a fishway would subject them to predation. This uncertainty results in a degree of risk that pallid sturgeon will not be able to find the off-channel structure and pass without unacceptable delay. The environmental community may find the uncertainty associated with these alternatives undesirable.*
[b] *There would no longer be a structure in the river to concentrate paddlefish at one location. There would probably still be a sport fishery, but it may be spread out along the river, which could negatively affect the associated economic benefit of caviar collection.*
[c] *The irrigation district is opposed to the pumping plant alternative due to the increased operation and maintenance concerns and associated cost.*
[d] *This is a relatively new concept of constructing a canal headworks structure in a major river without a diversion dam to divert water in low river flow conditions. There would be considerable risk related to long-term water delivery if the river channel migrated. The water users would be uncomfortable with these risks. Additional study would be required.*

The team convened again on February 12, 2008, to evaluate the fish screen options being developed for the proposed Intake Project. The team recommended the following (Jordan, 2008):

- Screen design should include approach velocities of 0.4 feet per second (fps) based on White and Mefford (2002);
- In-canal screen with new trashrack (Cha et al., 2008) has potential;
- In-channel screen would be preferable over an in-canal screen; and
- Sluiceway options require additional detailed study on sediment load and transport analysis to more accurately estimate the amount of water and size of sluiceway required to reduce sediment concerns.

A third meeting on February 17 – 18, 2009, reviewed the action alternatives and developed a method to score alternatives on a relative scale to incorporate biological input. The report (Jordan, 2009) offered recommendations for improvement of the alternatives, raised specific concerns, and asked questions about the alternatives.

NEPA Initial Screening

NEPA screening began by seeking public input on the No Action Alternative, four fish passage alternatives, and two fish screen options identified during previous Intake Project studies. Public scoping meetings were held during October 2008 to invite public comment on these alternatives, identify issues related to them, and collect ideas about other alternatives not previously investigated (Reclamation & Corps, 2009). A number of commenters suggested revisions to the alternatives as well as several new alternatives (Reclamation & Corps, 2009).

Public Meeting in Glendive, Montana

In response to public comment, all of the fish passage alternatives were revised and several were eliminated, as explained in this section. One previously eliminated alternative was identified as worthy of reconsideration, the Multiple Pumping Stations Alternative described in the next section. Table A.1.6 presents the eight alternatives under consideration prior to the initial NEPA screening process and their disposition after screening.

Table A.1.6 - Draft EA Alternatives and Their Disposition

Alternative	Disposition
1. No Action	Evaluated in detail as the **No Action Alternative**, as required by NEPA.
2. Rock Ramp	Evaluated in detail as the **Rock Ramp Alternative**.

3. Relocate Diversion Upstream	Eliminated from detailed study. Further hydraulic analysis determined that a diversion dam/weir with rock ramp would be required to provide sufficient head for reliable diversion of water under low flow.
4. Relocate Main Channel	Evaluated in detail as the **Relocate Main Channel Alternative**.
5. Single Pumping Plant	Eliminated from detailed study. Further hydraulic analysis determined that a diversion dam/weir with rock ramp would be required to provide sufficient head for reliable diversion of water under low flow.
6. Multiple Pumping Plants	Conceptual design developed in response to public scoping, but eliminated from detailed study because of reliability and entrainment concerns and construction and O&M costs.
7. Removable Rotating Cylindrical Screens	Evaluated in detail as **Removable Rotating Drum Screen Option**.
8. V-Shaped Screen	Eliminated from detailed study. Further evaluation required modification to include an in-river trashrack. This alternative is duplicative of the **Removable Rotating Drum Screen Option.** Both screen options would perform the same function, but the V-Shaped Screen with the trashrack would be more expensive to construct and maintain and would expose juvenile fish to an unnatural environment for a longer duration than the other screen option.

After the public scoping meetings, alternative screening criteria based upon Council on Environmental Quality guidelines, legal mandates, and previous Intake Project studies were developed to formulate alternatives for detailed study, and to identify alternatives (or features of alternatives) to be eliminated.

The screening criteria for alternatives were:

Alternatives Screening Criteria

- Provide upstream and downstream fish passage for adult pallid sturgeon and other native fish in the lower Yellowstone River;
- Minimize entrainment of pallid sturgeon and other native fish into the main canal;
- Continue effective operation of the Lower Yellowstone Project as authorized and in compliance with the Endangered Species Act;
    - Alternative does not adversely impact the ability of the Lower Yellowstone Project to meet crop irrigation requirements.
- Contribute to restoration of the Lower Yellowstone River ecosystem;
    - Reconnecting the Lower Yellowstone River from the confluence of the Missouri River, past the Intake Diversion Dam, upstream to the next barrier at Cartersville Dam near Forsyth, Montana, would allow free movement of aquatic species, including endangered pallid sturgeon and other native fish.
- Alternative not redundant or similar to other alternatives; and
- Alternative not prohibitively greater in cost or in environmental impacts than the other alternatives.

Alternatives Considered But Eliminated

According to NEPA, the responsible federal agency must "study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources (42 USC § 4332 Section 102(E)). Reasonable alternatives include those that are practical or feasible from the technical and economic standpoint and using common sense, rather than simply desirable from the standpoint of the applicant" [*Federal Register* 46(55)].

During the scoping process, the public commented on various alternatives and features. Table A.1.6 shows the disposition of the alternatives and screen options disclosed during the initial scoping in October 2008. After preliminary analysis some of these appraisal-level alternatives and features were eliminated from detailed study using screening criteria. This EA Addendum evaluates three alternatives from the earlier studies and six alternative themes from the recent 2013 planning studies. The following are the alternatives eliminated from detailed study after scoping and the reasons for eliminating them.

Alternatives Eliminated After Initial Scoping in 2008

Relocate Diversion Upstream Alternative

Removal of the existing Intake Diversion Dam and construction of a new canal and headworks structure upstream was eliminated from further consideration for three reasons: 1) it was duplicative of the rock ramp alternative, 2) required crossing of the Yellowstone Valley Railroad at two locations, and 3) mandated purchase of substantial real estate for implementation.

The Value Planning Study (Reclamation, 2005) originally recommended further evaluation of this alternative. Because this alternative removed the existing dam, which the BRT recommended for optimal fish passage, it was presented during public scoping.

The original concept was to move the point of diversion for the canal upstream far enough to allow diversions of water into the canal without a dam/weir. Although no dam would be needed, initial design features included several rock sills in the river channel to prevent head cutting after dam removal, as well as a rock dike field and revetment to stabilize the channel location at the point of diversion. This would reduce the risk of the channel migrating away from the new diversion site.

This alternative would require construction of a new headworks structure at the diversion site and excavation of approximately 12,500 feet of new canal to extend the existing canal upstream to the new diversion site. Topography along the new canal alignment is a relatively high hillside (60 feet above the river), and the railroad running through the site skirts along an excavated bench adjacent to the river channel. Figure A.1.1 shows an aerial photo and site layout for this alternative with a rock ramp shown in orange.

Hydraulic modeling revealed that this alternative would be technically infeasible without a dam/weir to raise and divert water during low flow. Three thousand cfs was set as the minimum flow in the river to evaluate the reliability of alternatives for diverting flow into the canal. Under minimum flow conditions a 5-6 foot high dam/weir would be required to provide sufficient head for diversion of 1,374 cfs flow into the canal (Figure A.1.1). The additional dam/weir would be a fish passage impediment much like the existing dam (although about 5 feet lower) that could be combined with a rock ramp to provide fish passage.

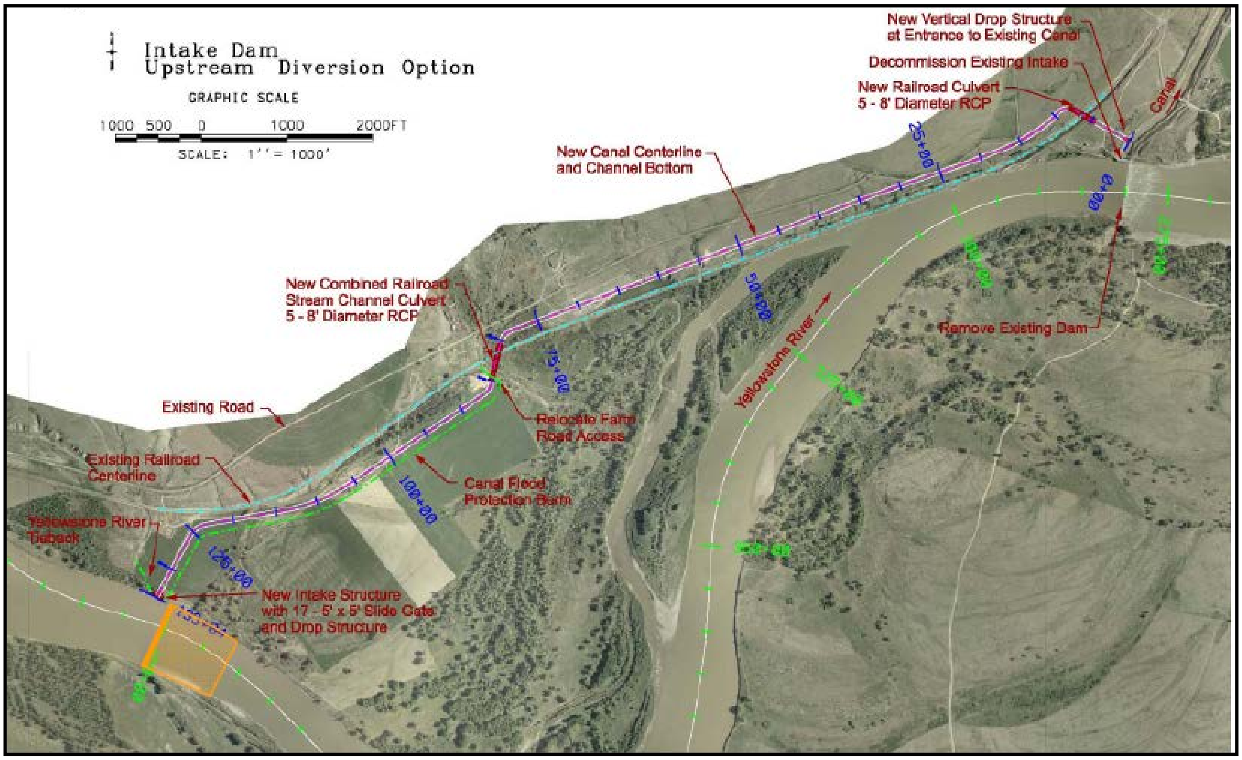

Figure A.1.1 - Relocate Diversion Upstream Alternative With Rock Ramp

Due to the proximity of the railroad to the river, the new canal alignment would run on the landward side of the railroad, requiring a 60-foot deep excavation for over half the length of the new canal. Using minimal slopes, a bottom width of 50 feet, and incorporating a mid-slope berm for slope stability, the overall top width of the excavation would be approximately 250-300 feet. The new canal alignment would cross the railroad at two locations through five 8-foot diameter culverts. The upstream end of the canal, where it runs along the left-bank floodplain, would feature tie-back levees extending from the new headworks structure to the floodplain limit. The levees would prevent the canal from damage or filling with sediment during Yellowstone River floods. These levees would be sized to protect against a 100-year ice-affected flood event.

Approximately 120 acres of private farmland would be acquired, and two center pivots likely would be affected. In addition, two rights-of-entry under the Yellowstone Valley Railroad would be needed. The deep canal excavation would remove approximately 3.7 million cubic yards of material, which would require another 100-115 acres for disposal. Although some material could be re-used by Montana Department of Transportation or other interests, temporary stockpiling would be necessary. The conceptual cost estimate of this alternative was $67 million.

Construction of a new facility, including excavation of the additional canal, acquisition of real estate, working with the railroad, and other issues in combination with a rock ramp redundant to the Rock Ramp Alternative eliminated this alternative from further consideration.

Single Pumping Plant Alternative

Removing Intake Diversion Dam and constructing a single pumping plant at the canal headworks site was eliminated from further consideration for five reasons: 1) it duplicated the Rock Ramp Alternative because a rock ramp is also needed in the Single Pumping Plant Alternative to ensure operation during low flows; 2) it was substantially higher in initial construction costs than any other alternative under consideration; 3) it required substantial real estate for implementation; 4) continued effective operation of the Lower Yellowstone Project could not continue because the irrigation districts probably could not afford to pay the O&M costs; and 5) power demands would be higher than any other alternative, would not be supported by the current power grid, and would not be reliable without a backup generator system, which was not included in preliminary cost estimates.

The Value Planning Study (Reclamation, 2005) originally recommended further evaluation of this alternative because the initial design of this alternative included removal of the existing dam and restoration of the river bed. The BRT recommended this for optimal fish passage; therefore it was presented during public scoping.

The original concept was to remove Intake Diversion Dam and construct a large pumping plant at the canal inlet that would pump water from the Yellowstone River into the canal without a dam/weir. Other design features included several rock sills in the riverbed to prevent head cutting, as well as a rock dike field and revetment to stabilize the channel at the pumping plant site. This would reduce the risk of the channel migrating away from the pumping plant.

A new pumping plant would be constructed upstream from the existing headworks structure with removable rotating drum screens. Topography at the proposed pumping plant is a relatively high hill bounded on the north and west by the railroad, on the south by the river, and on the east by the existing canal. Figure A.1.2 shows an aerial photo and site layout for this proposed alternative. The new pumping plant would discharge into a stilling basin and a new canal section would transition into the existing canal upstream from the existing county road bridge.

Hydraulic modeling revealed that this alternative, like the previous one, would be technically infeasible without a dam/weir to raise and divert water during low flow (Figure A.1.2). Under minimum flow conditions an 8-foot high dam/weir would be required to provide sufficient head to divert 1,374 cfs flow into the pumping plant. The new dam/weir would be lower than the existing Intake Diversion Dam, which ranges from 10-11 ft high. Because the new dam/weir would be a fish passage impediment similar to the existing dam, a rock ramp would be needed to provide fish passage over it, making this alternative redundant with the Rock Ramp Alternative.

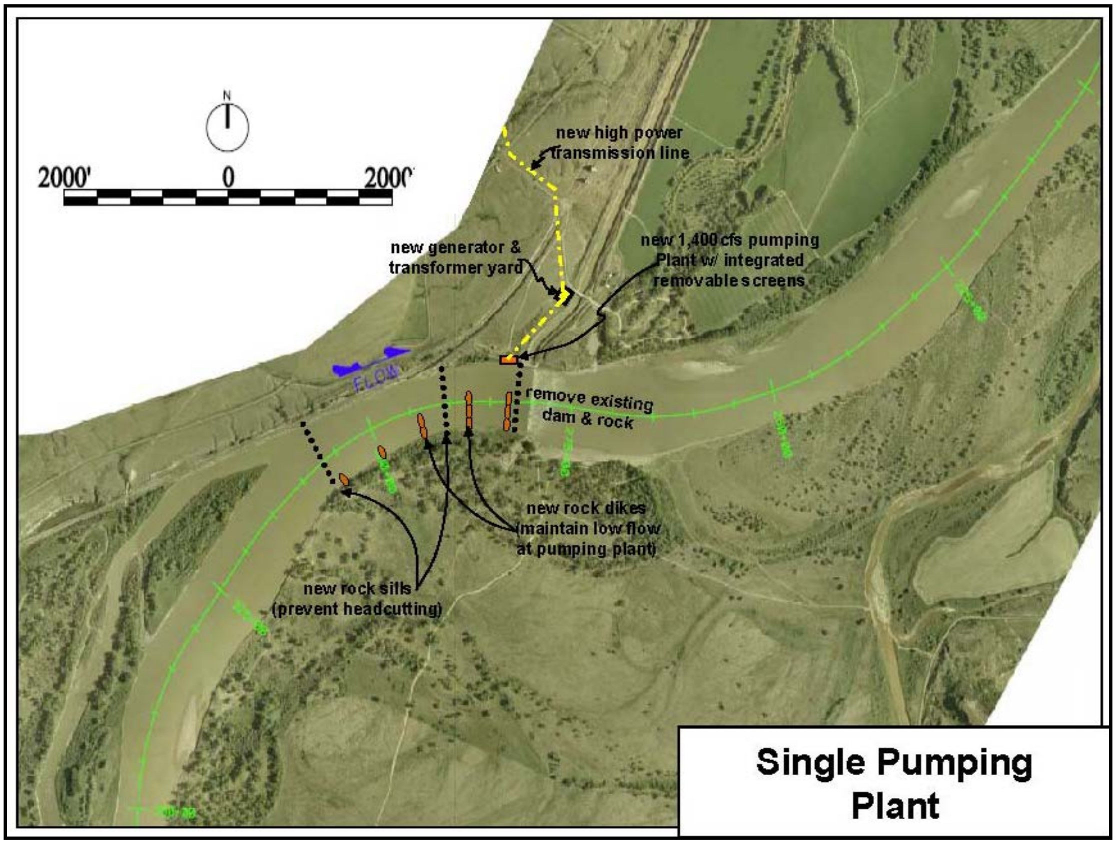

Figure A.1.2 – Single Pumping Plant Alternative Original Concept.

The preliminary estimated cost of constructing the plant was well over a $100 million. In addition to the construction costs, the total average annual energy required by such a pumping plant would be 7,000 megawatt-hours and would operate from April to the end of September (Cha & Zelenaka, 2008). The estimated annual O&M cost for power alone would be $315,000, which would be paid for by the irrigation districts. In addition, because of the frequent power outages in the area, a backup generator would be needed, which was not included in the initial cost estimate. Also of concern would be the load on the local power grid, which could not supply that level of power to the plant without substantial improvements.

Acquisition of approximately 24 acres of real estate would be required for construction and equipment staging. Much of that is private land. A temporary cofferdam extending approximately 100 ft out into the Yellowstone River channel would be needed during construction as well.

Therefore, redundancy with the Rock Ramp Alternative, construction of an expensive new facility, acquisition of real estate and additional O&M costs that would adversely affect the irrigation districts eliminated this alternative from further consideration.

Multiple Pumping Stations Alternative

Removing Intake Diversion Dam and constructing multiple river pumping stations was eliminated from further consideration for six reasons: 1) custom-designed fish screens have not been tested and the sediment auger could kill entrained fish ; 2) power demands would be higher than any other alternative, would not be supported by the current power grid, and would not be reliable without a backup generator system; 3) construction costs would be much higher than the other alternatives; 4) real estate issues would be greater than other alternatives; 5) effective operation of the Lower Yellowstone Project could not continue because the irrigation districts probably could not afford to pay the O&M costs; and 6) the construction footprint is the most widely distributed of all alternatives.

The Value Planning Study (Reclamation, 2005) originally recommended further evaluation of this alternative, because the initial design of this alternative would remove the existing dam to open fish passage. That recommendation changed after technical experts reviewed the Value Planning Study and recommended dropping the alternative from further consideration. They found that it was duplicative of the single pumping plant alternative and would be incompatible with the existing canal irrigation system. However, in response to public and agency comments during scoping, this alternative was reconsidered. After discussion with cooperating agencies, Reclamation and the Corps contracted with an engineering consulting firm to develop a conceptual level design of the alternative.

The conceptual design proposed removing Intake Diversion Dam, closing the existing headworks, and constructing seven pumping stations on the Yellowstone River to deliver water to the Lower Yellowstone Project (Figure A.1.3). The pumping plants would be constructed at various locations along the Lower Yellowstone Project. The pumps would be screened to minimize entrainment and would discharge into existing canals to supply the irrigation districts.

The conceptual design evaluated two possible configurations for each pumping plant station – floating or fixed pumping stations. The first concept, the floating pumping station, was originally conceived to allow unrestricted fish passage while delivering a reliable water supply to the irrigation districts without building permanent structures in the river. However, the floating pumping configuration was found to be infeasible because of the depth required for submergence of floating screens large enough to meet the water demand of the irrigation districts.

Sufficient, reliable, stable locations with sufficient depth and length for the screens could not be identified in the river with the best available information. The Yellowstone River with its large and small floating debris, ever-changing channel depth and location, and sediment deposition, all impact the feasibility of the floating pumping stations. Without permanent structures in the river, more extensive (longer and wider) fish screens would be needed, which at some locations would cover a large segment of the river channel and make installation in the spring and removal in the fall very difficult.

The complexity of this option affects reliability and O&M costs. Flexible pipelines extending from the pumping stations to the shore would be in constant danger of being snagged by and collecting floating debris. The size of the flexible pipelines would be a potential river hazard and barrier within the river and would be difficult to keep full of water.

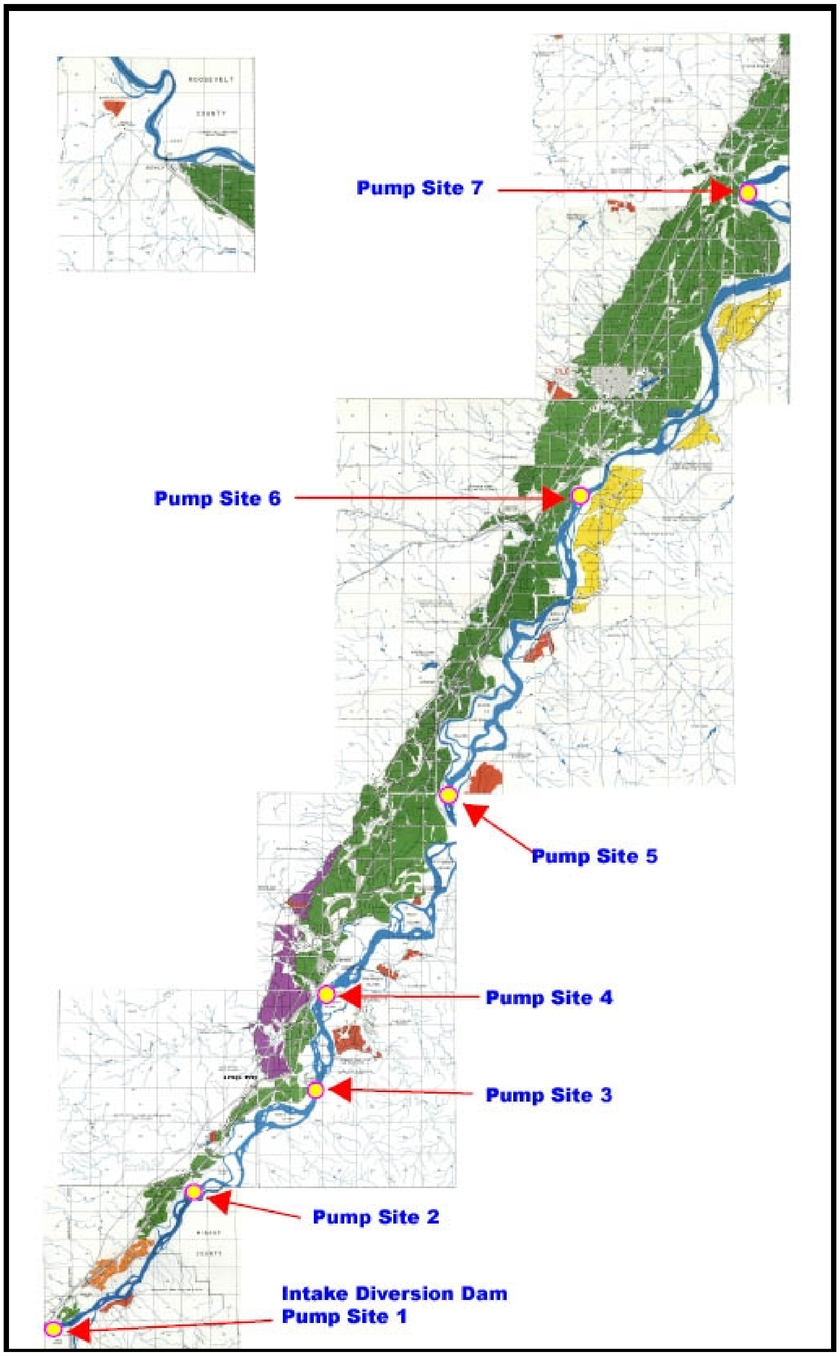

Figure A.1.3 - Proposed Locations of Pump Stations

The second concept was the fixed pumping station. It would have several engineering advantages over the floating stations, including improved protection from floating debris, less maintenance and labor, longer life expectancy, stabilized submergence requirements, pump design stability and reliability. A typical conceptual layout of the fixed pumping system is shown in Figure A.1.4.

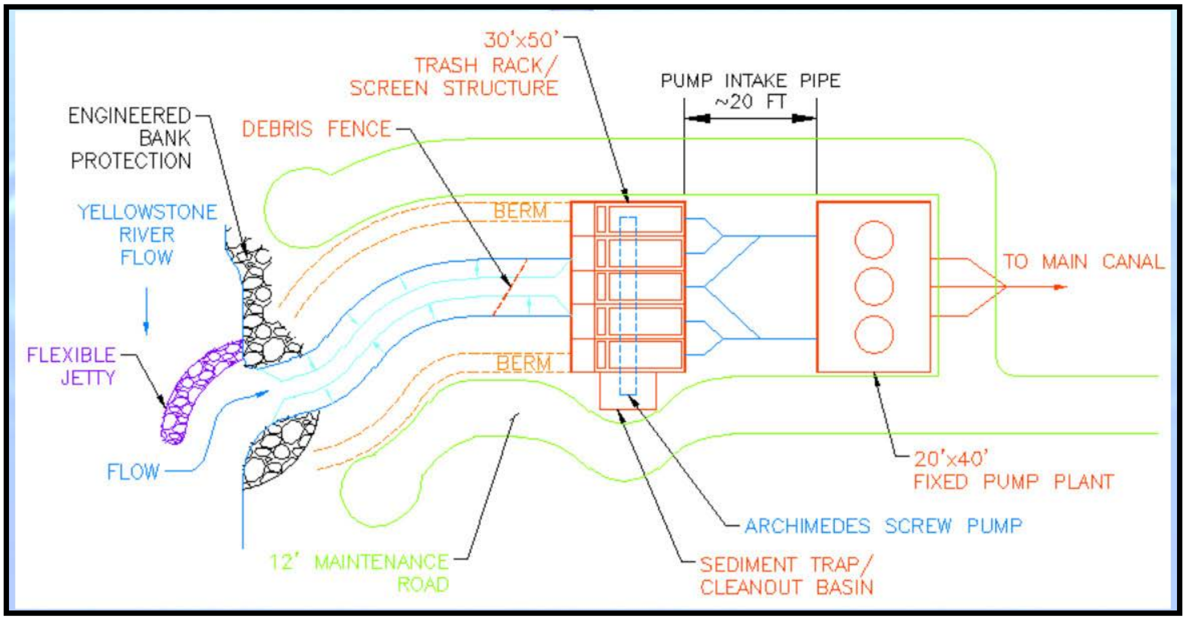

Figure A.1.4 – Conceptual Design of Fixed Pumping Station.

Each of the seven stations would include a building housing three pumps and pump motors and power lines, as well as improvements in the local power grid. The buildings would be constructed above the 100-year flood plain, and the size of the pumps and pump motors would be site-specific. A channel would be excavated from the Yellowstone River to each fixed pumping station to convey water. A structure to house trashracks and custom-designed fishscreens would be constructed in this channel with a sediment trap and an auger. A jetty would be constructed in the river channel to reduce silt accumulation in the inlet channel and some bank stabilization would be required along the entrance to each inlet channel.

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 Project canal system to accommodate a water supply from multiple points along the canal. It is estimated that 12 additional check structures would need to be constructed within the main canal to maintain the water depth and elevations required to deliver water to the lateral canals for distribution to the fields. Since the additional check structures would decrease the velocity of the water in the main canal, additional sediment deposition would be expected in the upper part of the system.

Preliminary construction costs and annual O&M costs were both estimated to be greater than the Single Pumping Plant Alternative. Annual O&M costs associated with this alternative would be a substantial increase over the cost of the current water delivery system and most likely beyond the capacity of the irrigation districts (see EA Chapter 4, “Social and Economic Conditions” section). The O&M of this alternative would exceed all the other alternatives, as it would have the additional requirements of maintaining and operating new check structures in the main canal, increased sediment removal in the main canal, maintaining access roads to each pump site, removing sediment in the inlet channels from the river to the pumping stations, as well as from the sediment traps, maintaining pumps and pump motors, maintaining rock jetties in the river, and paying power costs. Power costs would be expected to be much greater than the Single Pumping Plant Alternative, which was estimated to be $315,000 per year.

This alternative had the most widely distributed construction footprint of all the alternatives considered. Each station would require new roads or improvements to existing roads to access pump stations and construction of pipelines from each pumping station to the main canal. Building 2 miles of roads 16-feet wide would disturb about 4 acres. Building approximately 7 miles of 54-inch diameter pipelines would require open trench excavation about 25 feet wide, for a total disturbance area of 21 acres. Assuming a 100-foot inlet channel for each pumping station, construction of 7 stations would disturb about 2.5 acres. In all, approximately 27.5 acres would be directly impacted by construction. Acquisition of 26 easements and 6 railroad crossing permits would be needed for road and pipeline construction. Six of the 7 pumping stations would be constructed on private farmland.

Although this alternative would remove the impediment of Intake Diversion Dam, there are biological issues with this alternative. Juvenile pallid sturgeon could move along the jetty and turn into the pumping station channel through the debris fence, where they could be entrained in the sediment trap, which is cleaned by an auger (Archimedes screw pump) that could prove fatal to fish. The fish screens would be custom-designed for the pump stations, because no suitable commercial screens were identified. However, most of the biological issues could potentially be resolved with further refinement of the alternative, given sufficient time and money.

Infiltration Gallery Alternative

The Infiltration Gallery concept would use an infiltration gallery to divert water for irrigation. Infiltration galleries are long sections of screened pipe buried at a shallow depth under the river channel (Figure A.1.5). The screened pipes would collect water from below the river channel, and direct it into a system of collector pipes that would gravity-feed water into a pumping plant(s). The collector pipes and pumping plant(s) would be large structures sized to divert 1,374 cfs into a new outlet structure in the irrigation canal. The Intake Diversion Dam would be removed to allow pallid sturgeon and other native fish to migrate upstream.

This alternative would also have logistical, construction, and O&M issues. The current headworks location at Intake, Montana, may be suitable for an infiltration gallery, because the Yellowstone River channel is composed of coarse gravel and cobble; however, the large silt load and organic debris in the river would plug the gravel pack around the screened pipe and require frequent back-flushing. Because of the unknown stability of the riverbed without Intake Diversion Dam, there could be more deposition (covering the gallery with excessive material) or more degradation (uncovering or undermining the screened pipes). Screens buried deeper tend to seal and require more frequent back-flushing.

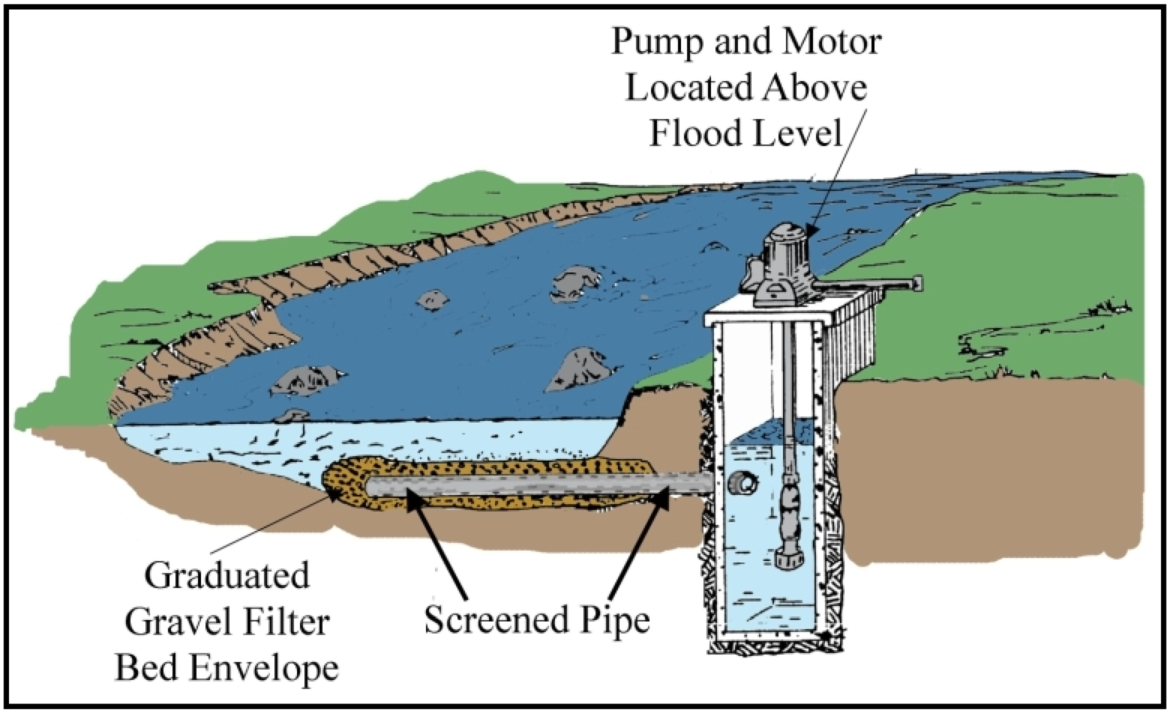

Figure A.1.5 – Conceptual Layout of an Infiltration Gallery.

Approximately 1,120 ft of screened pipes, up to 36 inches in diameter would be needed, based on calculations for the rotating removable drum screens; however, to allow for back-flushing the number of screened pipes would have to be increased by probably 25-50%. The pipes could be installed upstream of the existing headworks and run perpendicular to the bank. These would connect to a large collector pipe running into the pumping plant(s). Construction would disturb an area along the riverbank approximately 500 ft long. Because space is limited between the railway line and the existing headworks, an extensive riverbed area would be disturbed to install infiltration pipes.

Construction of an infiltration gallery in the river channel would require shallow excavation to bury screens and pipes and install a graduated gravel filter bed around each pipe to block sediment from passing into the pumping plant. During construction, river flows would be directed around the work area using temporary barriers, where possible. Construction would require complete dewatering of the riverbed and excavation to install infiltration gallery pipes probably extending 100 ft or more into the river. Excavating any open cut into a river bed is difficult and costly as the material continually sloughs into the trench. Excavated materials could be used to cover the collector pipes, with excess excavated fill shaped over the disturbed riverbank. The control station would have a control valve and back-flush plumbing, and the pump outlet would use a flow meter to regulate diversions. In the pumping plant(s), the inlet pipes likely would be routed into a wet-well chamber to equalize flow.

There are several relatively large risks and unanswered questions associated with the infiltration gallery concept:

1) How often would fine silt and organics clog the filters requiring back-flushing?

   - Back-flushing would require reversible pumps or additional pumps, automated back-flush instrumentation and valves, and an additional water source to back-flush the screens.
2) After removal of the existing dam, would the river channel degrade and scour, and if so, how could the pipes be protected from exposure?
   - The scour could require armoring of the bed over the pipes or construction of sills across the channel to prevent scour.
3) Would sufficient water be available during low flows?
   - The amount of water flowing into the screened pipes is directly affected by the depth of water over the pipe. Under low flow additional pipes might be needed to provide an adequate water supply.

Removing Intake Diversion Dam and constructing an infiltration gallery was suggested by EPA, but it was eliminated from further consideration, because this alternative would require at least one and most likely multiple pumping plants, which makes it redundant with the Single Pumping Plant Alternative. In addition, the same reasons for eliminating the Single Pumping Plant Alternative would apply to the Infiltration Gallery Alternative (see above). For example, power demand would be as high as or higher than the Single Pumping Plant Alternative, but unlike the Single Pumping Plant, back-flushing would also be required. Its only advantage over the Single Pumping Plant Alternative would be elimination of fish screens in a new headworks; however, excavation and construction of the infiltration gallery likely would be as costly and would disturb much more river channel than the Single Pumping Plant Alternative.

V-Shaped Screen Option

This option was originally identified during the 2002 Value Engineering Study (Reclamation, 2002). The original screening concept was a long flat plate screen constructed at an angle across the canal (Mefford et al., 2000). Due to concern over the duration of fish exposure to the screen it was revised to a v-shaped configuration by the Concept II Report (Glickman et al., 2004). Ice damage would be avoided by constructing the screen in the canal behind the existing headworks structure (Figure A.1.6).

This fish screen option would have two stainless steel flat plate screens, in a v-shaped configuration, to funnel fish to the downstream end where they would be carried in a 36-inch pipe back to the river. The screening structure would have a steel bar trash rack with 2-inch bar spacing at the upstream end to prevent large fish and large debris from entering the screening structure. At the downstream end a large adjustable gate would control water to provide sufficient head for the bypass pipe to gravity flow even when the Yellowstone River is high.

Originally this option lacked a trashrack, but on-going informal consultation with the Service resulted in a significant modification to this option prior to public scoping. The BRT was concerned that large, adult fish entering the canal would be blocked by the trashrack at the upstream end of the fish screen structure (Jordan, 2006) These fish would be trapped in an artificial canal environment indefinitely, potentially requiring capture and relocation each fall. In

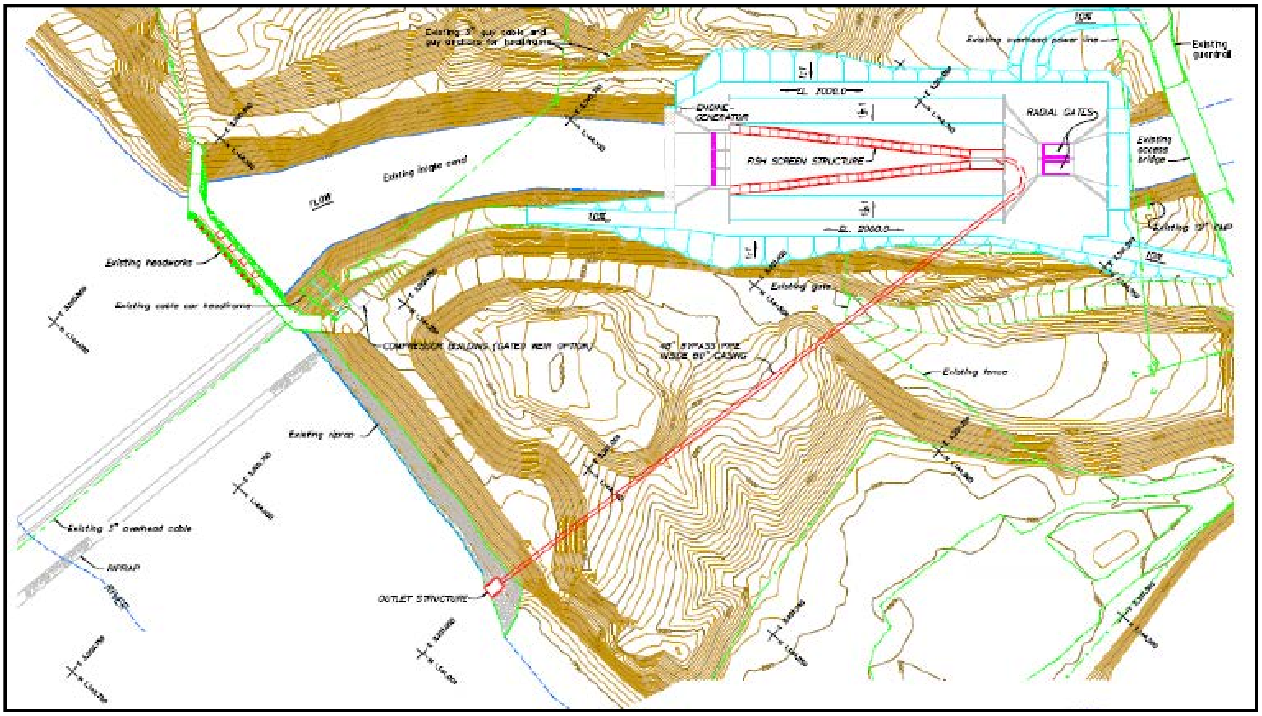

Figure A.1.6 – V-Shaped Fish Screen Option.

response to this concern, Reclamation designed a trashrack to be placed on the river side of the existing headworks to block adult fish and large debris from entering the canal. The trashrack would be a new concrete structure with panels that could be removed during the winter to avoid ice damage.

Construction of the v-shaped screen structure would likely occur during the winter to avoid and/or minimize impacts to canal operations. A cofferdam would be built approximately 100 feet out into the Yellowstone River channel to redirect river flow during trashrack construction.

After the V-Shaped Screen Option was redesigned to include the trashrack, it was determined that this option was redundant with the Removable Rotating Drum Screen Option. Both options were designed to meet National Marine Fisheries and Service fishery criteria. However, the V-Shaped Screen Option would require an additional trashrack structure to keep the adult fish out of the canal environment. Having two mechanical systems would increase O&M costs. Construction of the trashrack would increase the cost of this option by approximately 53% as compared to the Removable Rotating Drum Screen Option.

Construction of a v-shaped flat panel screen within the upstream reach of the canal was eliminated from further consideration for three reasons: 1) it was duplicative of the Removable Rotating Drum Screen Option, 2) would expose juvenile pallid sturgeon and other native fish to an unnatural environment for longer duration than the drum screens, and 3) initial construction costs would be substantially higher than the drum screens.

Relocate Main Channel

This alternative would move the main channel of the Yellowstone River from its current location to bypass the existing Intake Diversion Dam. The relocated channel would have a steeper slope than the natural riverbed in order to reliably divert flow into the main canal without pumping. This newly excavated channel would provide relatively unimpeded fish passage, although there would be some erosion-control features. The relocated channel would be paired with new headworks and removable rotating drum screens or other screens that meet the screening criteria to prevent entrainment of fish into the main canal. It also would allow regulation of diversion flows into the Lower Yellowstone Project.

The main channel relocation alternative would have the following features:

- Excavated main channel
- Concrete control structure
- In-channel grade control structures (sills and rock riprap revetment)
- Irrigation canal extension
- New headworks with screens and
- Tieback levees

<u>Excavated Main Channel Feature</u>

The primary component of this alternative is excavation of a new 12,500-foot (2.4-mile) long channel segment to provide fish passage. The existing channel would be partially filled and the existing Intake Diversion Dam buried. The new channel would diverge from the natural channel of the Yellowstone River approximately 8,000 ft upstream from the Intake Diversion Dam and would reconnect to the natural channel approximately 5,000 ft downstream. The longitudinal slope of the new channel would be approximately .085%, which is slightly steeper than the natural channel. For comparison purposes the natural slope of the Lower Yellowstone River is variable, but typically ranges from between .05% - .065%.

The new channel would simulate a natural channel with a compound cross-section and the banks would tie into existing ground. All channel sides would have a 4 to 1 slope. The new channel would have three components:

1) Low flow channel 50-feet wide by 2-feet deep,
2) Normal flow channel 600-feet wide by 6-feet deep, and
3) High flow channel 1,250-feet wide.

Fish would use the low-flow channel during low flows, while the wide, high-flow bench would minimize flood impacts that could result from a channel with a higher slope than the existing channel. The 100-year flood elevation at the upstream end of the proposed channel would be equal to or less than the existing 100-year flood elevation.

Approximately 6.1 million cubic yards of soil would be excavated to construct the channel. To minimize flood flow impacts, the entire channel probably would be constructed using either mechanical excavation or hydraulic dredging, as opposed to partially constructing the channel and allowing natural flows to finish it by eroding out the remaining material. Under both the mechanical excavation and hydraulic dredging scenarios, approximately 3.4 million cubic yards of material excavated from the new channel would be used to fill the existing channel of the river. The existing Intake Diversion Dam would be buried in place. In addition approximately 150,000 cubic yards of the excavated fill would be used to construct tieback levees. The remaining 2.5 million cubic yards of material would be hauled to an upland disposal site.

Concrete Control Structure

Upstream from Intake, a concrete control structure would stabilize the inlet to the new channel at an elevation high enough to divert 1,374 cfs into a new canal headworks. The concrete control structure would hold the upstream end of the new main channel in place and protect it from ice gouging and erosion. This control structure would resemble a 600-foot wide concrete weir with a 10-foot crest width and a 2 to 1 slope on the front face. However, unlike a weir, the downstream side would tie directly into the bottom of the excavated main channel providing a seamless transition and unimpeded fish passage rather than sloping down to the riverbed like a typical weir. The concrete control structure would incorporate a 50-foot wide by 2-foot deep low flow channel to match the new low flow river channel. The crest elevation of the control structure would rise approximately 5 - 6 feet above the natural channel bottom.

Real Estate Requirements

The Relocate Main Channel Alternative features would be located primarily on Joe’s Island, which is in the Yellowstone River floodplain. Some of this property was acquired by Reclamation during construction of the original Lower Yellowstone Project and is still administered by the agency. Other lands on Joe’s Island are Montana State Trust lands or part of the old river channel. The ownership status of the old river channel has not been determined. Additional real estate interest (title or easement) would be acquired on approximately 33 acres for disposal of excess excavated material. In addition, temporary rights-of-entry and/or easements might be necessary for construction staging areas. A pre-construction survey to determine land boundaries and subdivisions would be conducted to clarify ownership status so that real estate interests could be obtained.

Construction Considerations

This would be a fairly large construction project, considering the volume of material to be excavated to construct a new channel. Because the Yellowstone River is large, construction access to either side would follow separate routes, since a temporary bridge would be infeasible. Access from the left bank would be used to construct the headworks and screening structure, canal extension, and tieback levees. Access from the right bank would be used to construct the concrete control structure, excavate the new channel, and construct sills and the upstream revetment. In addition, designated staging and stockpiling areas would be necessary to accommodate equipment, materials, and work crews during construction.

Construction of this alternative likely would take 3 years, if sufficient funding were available. It would begin with installation of a cofferdam around the site of the new headworks. By using a cofferdam, flow in the existing river channel could be maintained allowing uninterrupted operation of the Lower Yellowstone Project irrigation facilities. Concurrently, excavation of the new channel would proceed from the center of the channel outwards upstream and downstream.

After the headworks and canal extension were completed, flows would be diverted through the new headworks, while finishing excavation of the channel and building the tie-back levees. Operation of the screens could be supplied by the existing local power grid.

Relocating the main channel was an alternative considered in detail in the 2010 EA. The cost estimate for this alternative was $50 million, however many of the cost increases that were found in the earlier rock ramp alternative would apply here as well, therefore the cost estimate would be considerably higher. Due to logistical incompatibility with Phase I of the project, which has already been constructed, this alternative has been eliminated from further detailed consideration and an updated cost estimate was not conducted.

Alternatives Considered During Planning Studies in 2013

A rock ramp was originally proposed in the 2010 EA as a fish passage alternative. This alternative was favored by cooperating entities as the most likely option considered to improve fish passage at Intake. However, due to constructability, maintenance, and cost concerns, the lead agencies believed it was necessary to re-consider other options, and preliminary design work was started on a bypass channel alternative – an alternative considered but not analyzed in detail in the 2010 EA. The bypass channel alternative included a river-wide concrete weir designed to provide adequate water surface elevations for both diversion of water into the proposed bypass channel and delivery of irrigation water through the newly completed headworks. Construction of a new concrete weir would eliminate the need to repeatedly place rock along the crest of the existing diversion structure to maintain necessary head requirements for both the bypass channel and the new headworks. The preliminary cost estimate of the bypass channel alternative was about $59 million.

Due to concerns raised by stakeholders and cooperating entities about the bypass channel, a new planning effort was initiated that brought the original cooperating entities (the Corps; Service; the State; the Irrigation Districts) together to revisit the alternatives that had been previously identified along with potential new alternatives for fish passage at Intake. The planning effort started with a meeting on June 20, 2013 and continued into September 2013. The objective of the meetings was to get involved parties to identify acceptable and implementable alternatives that would merit more detailed review.

Reclamation facilitated seven cooperating agency collaborative meetings between June 20, 2013 and September 13, 2013 to re-initiate efforts to identify viable fish passage alternatives at Intake. The goal was to identify preliminary alternatives that could provide fish passage while maintaining the viability of the Project including the ability to divert irrigation water without an unbearable increase in Project O&M costs. The specific meeting objectives were to identify fish passage alternatives and apply screening criteria to narrow the list. Reclamation and the Corps also conducted preliminary cost and feasibility (design, constructability, and biological) analyses of these alternatives. The cost and feasibility information was shared with the group to continue to refine alternatives and identify a final range of alternatives. Since not all alternatives or all elements of the alternatives were supported by all cooperating entities the group continued investigating measures that could be used to overcome cooperating entity design and O&M concerns. This review was completed in early September 2013, and six alternative themes for achieving the goals were developed to an appraisal level of consideration. The themes included an open river channel with pumping, three rock ramp variations, a bypass channel, and conveying water through a new diversion canal called the Island Alternative. In addition, conservation measures were evaluated for the potential to reduce water demand under most of the alternatives. The alternative themes considered in this new planning study are presented below.

1. Theme A-Open Channel with Multiple Ranney Wells
2. Theme B-Original Rock Ramp
3. Theme C-Rock Ramp with Reduced Weir Elevation
4. Theme D-Combination Rock Ramp and Weir
5. Theme E-Realigned Bypass Channel w/ Modified Weir
6. Theme F-Island

This collaborative planning effort identified the current Bypass Channel Design as the acceptable and potentially implementable fish passage alternative to pursue if changes and issues identified under Alternative Theme E were addressed and incorporated, if proven beneficial, into the current Bypass Channel design. Table A.1.7 reflects the ranking determined for each alternative theme evaluated by the planning team.

Table A.1.7. ESA modifications – alternatives evaluation matrix for Intake Diversion Dam

Lower Yellowstone - Intake Diversion Dam
ESA Modifications - Alternatives Evaluation Matrix

Alternatives	Head Works Cost ($M)	Field Construction Cost ($M)	Conservation Measures Cost ($M)	Total Project Cost ($M)	Annual O&M Cost (Excluding Energy) ($M)	Annual Energy Cost ($M)	Annual Replacement Cost ($M)	Total Annual Operation, Maintenance and Replacement Cost ($M)	Likelihood of ESA Success	Water Delivery Reliability	Constructability	Acceptability: State Acceptability	Acceptability: District Acceptability	Acceptability: BOR Acceptability
Original Rock Ramp (w/conservation measures, and potential lower elevation) - Evaluate if a lower weir and ramp elevation improves fish passage - If lower elevation does improve fish passage potential is there efficiencies within the district to help reduce weir and ramp elevation - Evaluate what these efficiencies can be and cost of these measures	$28	$91.6	$0	$119.6				$0	3	5	2.5	3	5	4
30% Design Bypass Channel(w/modifications and Federal Assurances) - Evaluate options to move the current bypass channel alignment out of the existing high flow channel - Physical modeling of bypass channel entrance and exit - Federal Assurances in writing - Modified weir design, reduce weir crest width from 25' to 6'	$28	$59.9	$0	$87.9	$0.14			$0	3	5	3.5	2	3	3
Alternatives Considered But Dropped														
Open Channel w/ Multiple Ranney Wells	$28	$215.6	$0	$243.6		$2.7		$2.7	5	3	3.5	5	1	3
Rock Ramp w/ Reduced Elevation (1989')	$28	$69.4	$10	$107.4				$0	Did Not Receive A Ranking					
Combination Rock Ramp and Weir	$28	$91.0	$0	$119.0				$0	2	5	2.5	2	4	2
Realigned By-pass Channel w/ Modified Weir	$28	$59.0	$0	$87.0	$0.14			$0	Did Not Receive A Ranking					
Island	$28	$37.0	$0	$65.0				$0	4	2	2.5	4	1	3

Alternative Theme A. Open Channel with Multiple Ranney Wells

Alternative Description:
This proposal consists of four main components: the existing headworks would continue to be used to divert irrigation water when river flows are sufficient to do so; replacing the existing diversion dam with multiple pumping stations along the river downstream from existing weir; implementation of water conservation measures throughout the irrigation delivery system to reduce the amount of water needed for the project (see Conservation Measures supplemental alternative description); and installing renewable energy sources to supplement power demand for the pump system. Due to time constraints, the renewable energy options were not investigated as part of this proposal.

Proposed Pump Systems:
The multiple pumping stations option consists of numerous radial collector wells installed at seven locations adjacent to the Yellowstone River to supply irrigation water to the main canal. Water would be carried from the pumps to the main canal by several buried pipelines. Using radial collector well type systems with fixed pumps would eliminate the need to construct permanent structures within the Yellowstone River.

Radial collector wells, one type being a Ranney® collector well, are generally comprised of a vertical reinforced concrete shaft (caisson)—typically 16 feet in diameter—excavated to a target depth at which well screens project laterally outward in a radial pattern. In a practice referred to as riverbank filtration, the wells are designed to induce infiltration from a nearby surface water source, combining the desirable features of groundwater and surface water supplies.

Where alluvial deposits form aquifers that are hydraulically connected with surface water sources, water supply systems can be installed to induce infiltration to recharge the water being pumped from the aquifer, providing water that is naturally filtered to provide very uniform water quality and temperature. As water is pumped from the well, the water table lowers, reversing the hydraulic gradients within the aquifer, which induces recharge to filter through riverbed and riverbank deposits providing a sustained flow of naturally filtered water to the well or infiltration system.

Ranney® collector wells are the preferred method for developing moderate to very high capacity riverbank filtration (RBF) supplies. RBF collector wells will be installed adjacent to the Yellowstone River (surface water source) at seven sites indicated on the map with their lateral well screens projected beneath the riverbed to optimize induced infiltration supplies. These wells can be installed with designated setback distances to increase the degree of filtration achieved. The result is an abundant, dependable supply of high-quality water with a constant temperature and low turbidity.

Ranney wells have been designed with capacities up to 123cfs. In this alternative, each well site must produce approximately 200cfs. Two collector wells will be needed at each site. In the right location, a Ranney well will produce the same volume of water as several vertical wells while using less area than a conventional well field. Additionally, a properly designed Ranney well has enough screens to minimize the entrance velocity of groundwater, reducing the frequency of required maintenance (see Figure A.1.8).

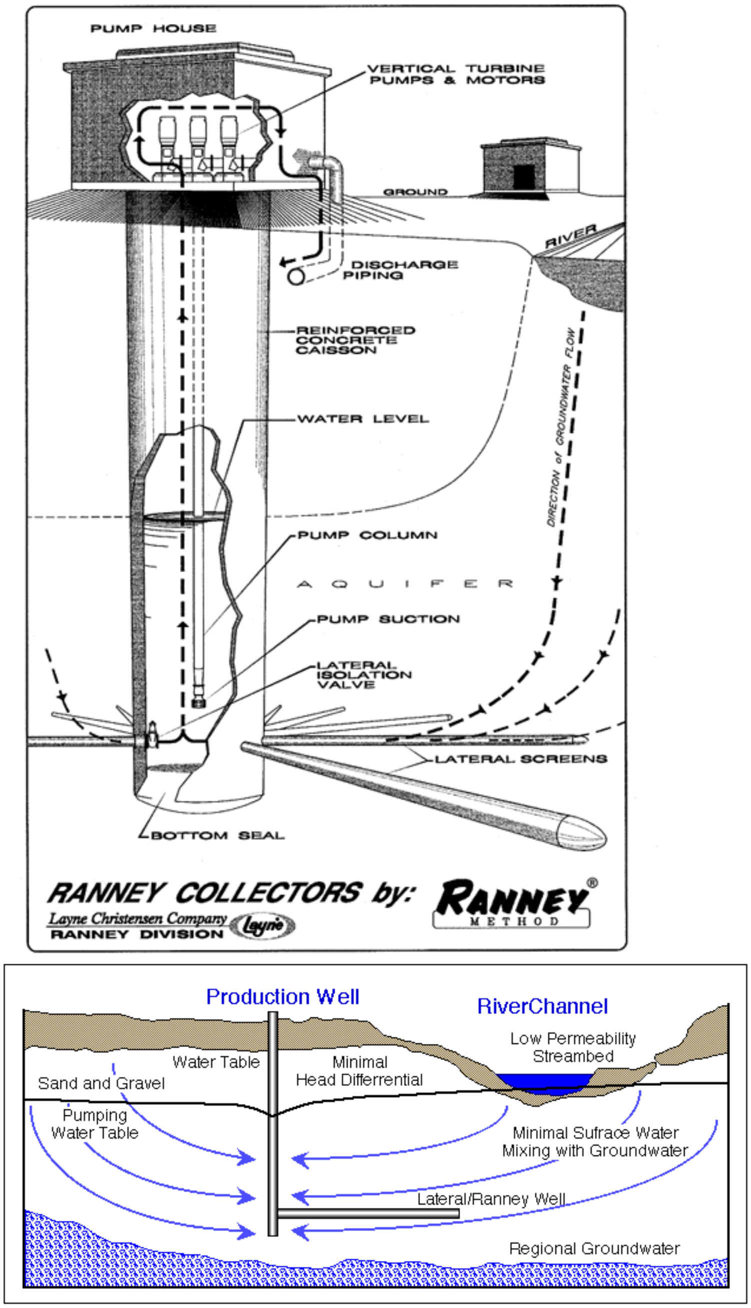

Figure A.1.8. Example Collector Well

Existing Irrigation Canal Operation:
The existing canal consists of about 72.5 miles of unlined canal and the flow into the canal is diverted from the Yellowstone River when flows are high enough to allow diversion. The canal currently functions as a conveyance system and is controlled by a downstream operational

concept where the water demand or scheduled deliveries determine the flow into the canal. In a report by Henry T. Falvey & Associates dated April 9, 2009 critiquing the use of multiple pumps to supply water to this system, it was identified that about 80% of the flow is distributed in the downstream third of the canal. This report stated that the upper reaches are considered to be a connector system and lower reaches a delivery system.

Ditchriders patrol the canal to maintain the required flows at each irrigation turnout. As reported in the referenced report, the time for water entering the canal to traverse to the end of the canal is approximately 1 ½ days with a mean velocity in the canal of 2.5 feet/second. Mismatches in the inlet and the delivery flows can be anticipated because delivery orders are taken one day in advance of need.

Modified Irrigation Canal Operation:
The design of the canal with the pumping system is exactly opposite to that of the existing gravity system. A canal that is supplied with pumps is commonly called a collector system and is a supply-oriented system. A supply-oriented system is operated differently than a demand-oriented system, and this difference must be recognized in planning and design of modification to the canal system such as requiring the installation of more check structures in the upper reaches to ensure that water can be diverted into the existing turnouts.

Learning how to operate the new system will require retraining of both the water master and the ditchriders. The response time of the system can be reduced; however, more emphasis will be placed on leakage and wasting. With this system, the amount of water that is lost will be decreased.

Overall System:
The new headworks at Intake would continue to allow gravity diversion from the Yellowstone River when flows are high enough to supply the head necessary for the system; however, the system would utilize the multiple Ranney Well pump systems at times of lower river flows to supplement the system.

The total power load for the pumping stations would be approximately 17 megawatts. Power could be supplied from existing power supplies and potentially could be supplemented by project-specific sources such as a wind farm or solar generation, but these options were not investigated due to time constraints. Implementation of the proposed pumping plant would include the following elements: (1) removal/disposal of the existing diversion dam and restoration of dam site; (2) construct new pumping plants with site work for roads, parking, and infrastructure; and (3) construct new high power transmission line to route power to the pumping stations and auxiliary/backup power generation capability in the event of power outages.

Conclusion
This alternative was dropped because of the high cost to install the Ranney Well System and the high energy costs that would be placed upon the district. Concerns with service reliability, brownouts, and power outages were also discussed. These issues could cause disruption in canal flows and affect operation of the whole system. It was determined that there were cheaper, potentially more effective alternatives remaining.

Alternative Theme B. Original Rock Ramp

Alternative Description:
This alternative would replace the existing rock and timber structure with a new concrete diversion dam along with a shallow-sloped, ungrouted boulder and cobble rock ramp. The ramp would be designed to mimic a natural river riffle that would reduce the river elevation from the top of the weir crest to the toe of the rock ramp over a 2,000-foot length, creating the necessary 0.5% slope considered favorable for pallid sturgeon passage. The ramp crest elevation would be set at 1990.5 feet to provide 1,374 cfs to the LYIP at flows above 3,000 cfs.

Weir
A replacement concrete weir would be located downstream of the new headworks to elevation 1,990.5 ft which would create sufficient water height to divert 1,374 cfs into the main canal. The new concrete weir would replace the existing timber and rock-filled dam providing for long-term durability which is currently lacking in the existing structure. The weir would be constructed as a cast-in-place reinforced concrete wedge spanning the entire width of the Yellowstone River channel. The upstream face of the dam would be designed to withstand damage from blocks of ice moving up and over the dam in the spring of the year.

The weir crest would vary in elevation, including at least one low flow channel for fish passage during the low flow times of year. The variable crest would offer an array of depth/velocities across the weir to provide different passage options. Channels in the weir crest would be designed to provide fish passage during late summer and early fall low flows and would be approximately 1-2 feet in depth. The downstream side of the weir would tie directly into the rock ramp to provide a seamless transition and unimpeded fish passage as fish migrate upstream.

As an option and for a potential cost savings over the weir described above, the diversion weir could consist of a cantilevered structural wall consisting of “drilled” shafts with a concrete cap. Because of water levels, the shafts would be cased (pipe piles cleaned out and filled with reinforced concrete). The shafts would be spaced such that there would be gaps between them below the cap, but the backfill would be completely around the shafts (and for purposes of retaining wall design, bridge between the shafts). The top of the structure would be a concrete “cap” to protect the top of the structure and provide a smooth surface for ice to pass over. The crest of the new weir would be irregular in elevation to provide a variety of flow volume and velocity.

Rock Ramp
A rock ramp would be constructed downstream of the replacement weir by placing rock and fill material in the river channel to shape the ramp without grout, and then it would be covered with rock riprap. The ramp would be at a .5% slope that would provide flow characteristics that are thought to meet the swimming abilities of pallid sturgeon.

Because pallid sturgeon are sensitive to flow velocities and turbulence, the rock ramp would be constructed to be relatively flat over much of its width to keep flow velocities as low as possible with the idea of full river passage.

The new rock ramp would be constructed over the site of the existing Intake Diversion Dam, preserving most of the historic dam in place. The ramp would include at least one low flow channel in conjunction with the low flow channel on the crest of the weir. This would allow fish migration during low flow times of the year. The rocks in the ramp would be sized to withstand high flows and ice jams and range from 1 – 4 feet in diameter. The largest rocks would be placed near the crest to resist ice forces. Approximately 390,000 tons of rock riprap for the ramp, 40,000 tons of spalls/gravel, and another 60,000 tons of riprap for the toe of the ramp (for energy dissipation) would be needed for construction of the ramp.

Flood Plain Control

To help with depths and velocities over the crest of the weir, this alternative would incorporate a flood plain control structure. This flood plain control feature was envisioned to be a partial removal of the south (right) bank adjacent to Joe's Island. This bank removal is proposed in a stair-stepped configuration so that the river can experience more "out-of-bank" area as the river flow increases. The number of steps and area exposed at each step needs to be designed; however, the concept is to allow the river flow to spread out at each step in an attempt to reduce the effective depth above the rock weir for a given flow.

This structure would continue to concentrate flows over the rock ramp during low flows but at the same time help disperse high flows over the natural flood plain/riparian area with the idea being that as flows increase within the Yellowstone River, velocities over the crest of the dam would increase as well. When the higher flows are spread out into the flood plain, the amount of water being forced over the weir would be reduced which would help keep velocities down. Also by spreading flows into the riparian/flood plain area, this could act as another potential passage route for both pallid sturgeon and other native fish species.

The large eddy that currently forms on the south side of the existing dam is being eliminated by the design of the rock ramp where the feature causing the eddy is filled in with rock.

Alternative Theme C: Rock Ramp with Reduced Weir Elevation

Alternative Description:
This alternative would replace the existing rock and timber structure with a new concrete diversion dam along with a shallow-sloped, ungrouted boulder and cobble rock ramp. The ramp would be designed to mimic a natural river riffle that would reduce the river elevation from the top of the weir crest to the toe of the rock ramp over a 1,500-foot length, creating the necessary 0.5% slope thought to be favorable for pallid sturgeon passage. The ramp crest elevation would be set at the reduced height of 1989 ft to provide 1,150 cfs to the irrigation districts at a flow of 3,000 cfs (see Figure A.1.9). The remaining water right would be supplemented through pumping and project efficiencies such as center pivots and canal/lateral linings. The system was designed to run at full capacity so checking structures would need to be incorporated into this alternative to maintain sufficient water height within the main canal.

Weir
A replacement concrete weir would be located downstream of the new headworks to elevation 1,989 feet which is approximately 1.5 feet lower than what is needed to divert the full water right at 3,000 cfs. At flows of 6,100 cfs and above, the irrigation districts could divert their entire water right and supplemental pumping would not be needed.

The new concrete weir would replace the existing timber and rock-filled dam providing for long-term durability which is currently lacking in the existing structure. The weir would be constructed as a cast-in-place reinforced concrete wedge spanning the entire width of the Yellowstone River channel. The upstream face of the dam would be designed to withstand damage from blocks of ice moving up and over the dam during the spring.

The weir crest would vary in elevation, including at least one low flow channel for fish passage during the low flow times of year. The variable crest would offer an array of depth/velocities across the weir to provide different passage options. Channels in the weir crest would be designed to provide fish passage during late summer and early fall low flows and would be approximately 1-2 feet in depth. The downstream side of the weir would tie directly into the rock ramp to provide a seamless transition and unimpeded fish passage as fish migrate upstream.

As an option for a potential cost savings over the weir described above, the diversion weir could consist of a cantilevered structural wall consisting of “drilled” shafts with a concrete cap. Because of water levels, the shafts would be cased (pipe piles cleaned out and filled with reinforced concrete). The shafts would be spaced such that there would be gaps between them below the cap, but the backfill would be completely around the shafts (and for purposes of retaining wall design, bridge between the shafts). The top of the structure would be a concrete “cap” to protect the top of the structure and provide a smooth surface for ice to pass over. The crest of the new weir would be irregular in elevation to provide a variety of flow volume and velocity.

Rock Ramp
A rock ramp would be constructed downstream of the replacement weir by placing rock and fill material in the river channel to shape the ramp without grout, and then it would be covered with

rock riprap. The ramp would be at a .5% slope that would provide flow characteristics that are thought to meet the swimming abilities of pallid sturgeon.

Because pallid sturgeon are sensitive to flow velocities and turbulence, the rock ramp would be constructed to be relatively flat over much of its width to keep flow velocities as low as possible with the idea of full river passage.

The new rock ramp would be constructed over the site of the existing Intake Diversion Dam, preserving most of the historic dam in place. The ramp would include at least one low flow channel in conjunction with the low flow channel on the crest of the weir. This would allow fish migration during low flow times of the year. The rocks in the ramp would be sized to withstand high flows and ice jams and range from 1 – 4 feet in diameter. The largest rocks would be placed near the crest to resist ice forces.

Flood Plain Control
To help with depths and velocities over the crest of the weir this alternative would incorporate a flood plain control structure. This flood plain control feature was envisioned to be a partial removal of the south (right) bank adjacent to Joe's Island. This bank removal is proposed in a stair-stepped configuration so that the river can experience more "out-of-bank" area as the river flow increases. The number of steps and area exposed at each step needs to be designed; however, the concept is to allow the river flow to spread out at each step in an attempt to reduce the effective depth above the rock weir for a given flow.

This structure would continue to concentrate flows over the rock ramp during low flows but at the same time help disperse high flows over the natural flood plain/riparian area with the idea being that as flows increase within the Yellowstone River velocities over the crest of the dam would increase as well. When the higher flows are spread out into the flood plain, the amount of water being forced over the weir would be reduced which would help keep velocities down. Also by spreading flows into the riparian/flood plain area, this could act as another potential passage route for both pallid sturgeon and native fish species.

Efficiencies/Weir Height Reduction
This proposal looks at the opportunity to reduce the height of the rock ramp proposed in Alternative Theme B by reducing the peak demand required by the Irrigation District. The rock ramp in Alternative Theme B is designed to convey the full water right of 1,374 cfs at a minimum river flow of 3,000 cfs. This alternative will combine several levels of improved water management and supply augmentation, with the corresponding reduction of rock ramp height to attempt to identify the most advantageous combination of this hybrid proposal.

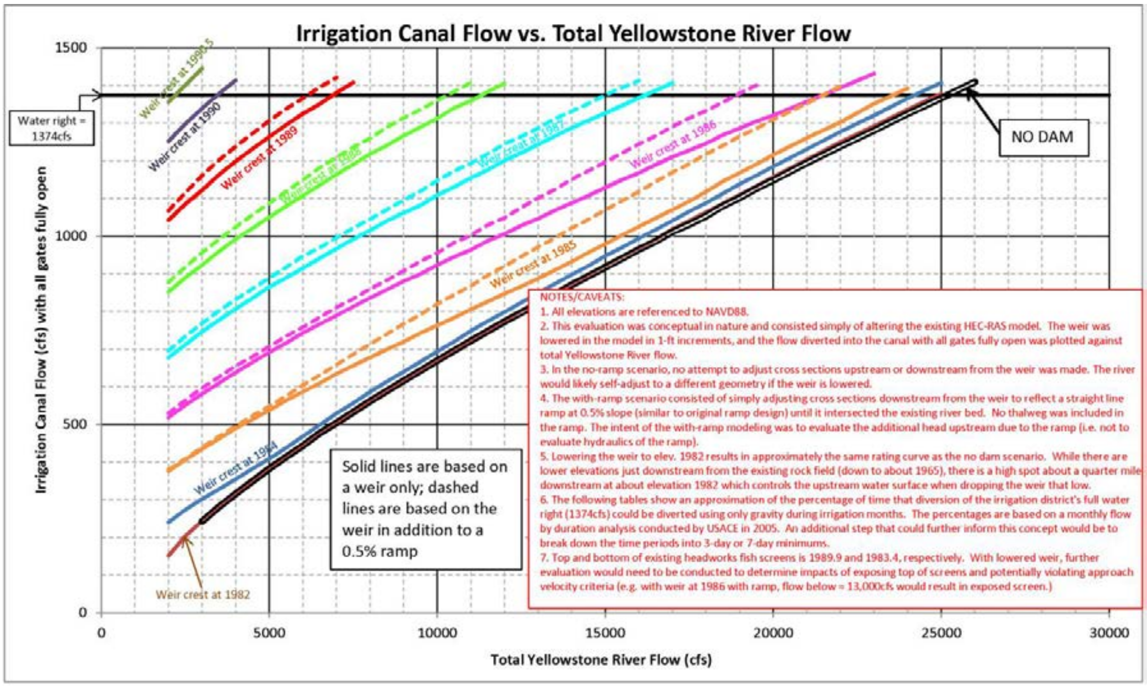

Figure A.1.9. Flow Splits Between River and Irrigation Canal at Different Weir Crests

Conclusion

This alternative was dropped but important components were combined with the original rock ramp alternative. The thought behind the lower ramp elevation was to help improve fish passage success at the same time reducing the cost of construction. Analysis was conducted at such a preliminary level, engineers could not confidently say what impacts a lower rock ramp and weir elevation would have on fish passage as it pertained to velocities. Significant cost savings were not achieved in the preliminary estimate for this alternative.

Alternative Theme D: Combination Rock Ramp and Weir

Alternative Description:
This alternative would replace the existing rock and timber structure with a new concrete diversion dam along with a shallow-sloped, ungrouted boulder and cobble rock ramp on approximately half of the river. The ramp would be designed to mimic a natural river riffle that would reduce the river elevation from the top of the weir crest to the toe of the rock ramp over a 2,000-foot length, creating the necessary 0.5% slope thought to be favorable for pallid sturgeon passage. The ramp crest elevation would be set at a height of 1990.5 feet to provide 1,374 cfs to the irrigation districts at a flow of 3,000 cfs and higher.

Weir

A replacement concrete weir would be located downstream of the new headworks to elevation 1990.5 ft which is needed to divert the full water right at 3,000 cfs. The new concrete weir would replace the existing timber and rock-filled dam providing for long-term durability, which is currently lacking in the existing structure. The weir would be constructed as a cast-in-place reinforced concrete wedge spanning the entire width of the Yellowstone River channel. The upstream face of the dam would be designed to withstand damage from blocks of ice moving up and over the dam during the spring.

The weir crest would vary in elevation, including at least one, low flow channel for fish passage during the low flow times of year. The variable crest would offer an array of depth/velocities across the weir to provide different passage options. Channels in the weir crest would be designed to provide fish passage during late summer and early fall low flows and would be approximately 1-2 feet in depth. The downstream side of the weir would tie directly into the rock ramp to provide a seamless transition and unimpeded fish passage as fish migrate upstream.

As an option for a potential cost savings over the weir described above, the diversion weir could consist of a cantilevered structural wall consisting of “drilled” shafts with a concrete cap. Because of water levels, the shafts would be cased (pipe piles cleaned out and filled with reinforced concrete). The shafts would be spaced such that there would be gaps between them below the cap, but the backfill would be completely around the shafts (and for purposes of retaining wall design, bridge between the shafts). The top of the structure would be a concrete “cap” to protect the top of the structure and provide a smooth surface for ice to pass over. The crest of the new weir would be irregular in elevation to provide a variety of flow volume and velocity.

Rock Ramp

A rock ramp would be constructed downstream of the replacement weir on approximately half of the river. The ramp would be built by placing rock and fill material in the river channel to shape the ramp without grout, and then it would be covered with rock riprap. The ramp would be at a .5% slope that would provide flow characteristics that are thought to meet the swimming abilities of pallid sturgeon.

Because pallid sturgeon are sensitive to flow velocities and turbulence, the rock ramp would be constructed to be relatively flat over much of its width to keep flow velocities as low as possible with the idea of full river passage.

The new rock ramp would be constructed over the site of the existing Intake Diversion Dam, preserving most of the historic dam in place. The ramp would include at least one low-flow channel in conjunction with the low-flow channel on the crest of the weir. This would allow fish migration during low flow times of the year. The rocks in the ramp would be sized to withstand high flows and ice jams and range from 1 – 4 feet in diameter. The largest rocks would be placed near the crest to resist ice forces. Approximately 172,000 tons of rock riprap for the ramp, 20,000 tons of spalls/gravel, and another 30,000 tons of riprap for the toe of the ramp (for energy dissipation) would be needed for construction of the ramp.

Flood Plain Control

To help with depths and velocities over the crest of the weir this alternative would incorporate a flood plain control structure. This flood plain control feature was envisioned to be a partial removal of the south (right) bank adjacent to Joe's Island. This bank removal is proposed in a stair-stepped configuration so that the river can experience more "out-of-bank" area as the river flow increases. The number of steps and area exposed at each step needs to be designed; however, the concept is to allow the river flow to spread out at each step in an attempt to reduce the effective depth above the rock weir for a given flow.

This structure would continue to concentrate flows over the rock ramp during low flows but at the same time help disperse high flows over the natural flood plain/riparian area. The idea being that as flows increase within the Yellowstone River velocities over the crest of the dam would increase as well. When the higher flows are spread out into the flood plain the amount of water being forced over the weir would be reduced which would help keep velocities down. Also by spreading flows into the riparian/flood plain area, this could act as another potential passage route for both pallid sturgeon and native fish species.

Conclusion

This alternative was dropped because it was comparable in cost to the original rock ramp but only provided half the river passage. The thought for considering this alternative was if the ramp width is cut in half, the costs could potentially be cut by half. Estimates from preliminary cost analysis did not validate the original assumption. A primary factor in why this alternative did not prove to be cheaper was that to keep the water on the half rock ramp, a very large retaining wall would need to be constructed from the weir crest to the toe of the ramp and upstream. This increased costs to the cost levels estimated for the original rock ramp design.

Alternative Theme E. Realigned Bypass Channel with Modified Weir

Alternative Description

The Corps has designed a bypass channel around the existing point of diversion that is currently at the 30% design stage. This alternative modifies the Corps' current design by:

- relocating the bypass channel to maintain the integrity of the existing high flow channel,
- reducing the width of the weir crest from 25 feet to approximately 6 feet, and
- providing variable flow velocities on the weir crest and downstream slope through slight undulations in crest height.

A primary feature of this alternative would be the construction of a bypass channel to divert approximately 15% of total river flow into the bypass under all flow scenarios above 3,000 cfs. The original By-pass channel was designed to typically divert 15% of the total flow during typical spring and summer discharges and diversion percentages varied from 10% at extreme low flows to 17% at extreme high flows. Under this alternative with existing high flow channel still active, either the bypass channel would not take the same percentage of flow at high flows (during migration) or the weir would need to be raised to account for flow into the existing high flow channel.

The proposed bypass channel alignment would be modified from the existing alignment to isolate it completely from the existing high flow channel along the south side of Joe's Island. This would be accomplished primarily by relocating the river entrance to the bypass downstream to avoid the mouth of the high flow channel. The current alignment is approximately 15,500-feet long with a slope of approximately 0.0006 feet/feet (natural Yellowstone River slope is approximately 0.0004feet/feet to 0.0007 feet/feet). It is expected the re-aligned bypass channel would comply with the BRT's recommendations regarding flow velocity and depth and would likely approximate the "original" dimensions. The bypass channel cross-section would be 40' wide at the bottom with side slopes varying from 1V:12H to 1V:3H. The original bypass channel design requires excavating approximately 1.2 million cubic yards of material from Joe's Island; however, this would increase considerably if the upstream end of the existing chute was not used.

A structure designed to control flow into the bypass would be constructed at the upstream river entrance to the bypass channel. The structure would likely be composed of riprap with a concrete sill and would be backfilled with natural river rock to give the appearance of a seamless channel invert.

Two vertical control structures (riprap sills) would be constructed to maintain channel slope and provide for early identification of channel migration. These structures would be constructed by over-excavating and backfilling the excavation with river rock to appear as a seamless channel invert while providing stability. A riprap sill would also be constructed at the downstream fish entrance to the bypass to maintain channel elevations. Additionally, riprap would be installed on at least two outside bends with higher potential for failure. Additional protection may be required in the future if, through adaptive management, assumptions about channel stability are proven incorrect and channel migration or degradation begins to impact passage efficacy.

A new concrete weir would be constructed approximately 40 feet upstream of the existing rock structure to provide sufficient water surface elevations to divert the appropriate flows through the bypass channel and headworks. The existing rock structure would be integrated into the new concrete structure by placing fill between the new and old structures. The new diversion weir would consist of a cantilevered structural wall consisting of "drilled" shafts with a concrete cap. Because of water levels, the shafts would be cased (pipe piles cleaned out and filled with reinforced concrete). The shafts would be spaced such that there would be gaps between them below the cap, but the backfill would be completely around the shafts (and for purposes of retaining wall design, bridge between the shafts).

The area between the new weir and existing structure and the area immediately upstream of the new concrete weir would be filled with sands and gravels excavated from the bypass channel and capped with riprap to provide a seamless transition between the old and new structures. The top of the structure would be a concrete "cap" to protect the top of the structure and provide a smooth surface for ice to pass over. The crest of the new weir would be irregular in elevation to provide a variety of flow volume and velocity.

Once pallid sturgeon migrate upstream past the weir using the bypass channel, they must also be able to migrate back downstream. The weir design would include a notched section that would produce sufficient depth of flow for downstream passage. Additionally, the existing rock weir and downstream rock field would be modified to create a thalweg of sufficient depth to allow downstream fish passage.

An access road would be constructed along the north side of the river to allow access for heavy equipment during construction. Following completion, the road would be removed and the area would be restored to pre-construction conditions. Existing access roads to Joe's Island would be improved as needed to allow access.

Features of this alternative would be located primarily on Joe's Island. This land was acquired by Reclamation during construction of the original Intake project and is still administered by Reclamation. All construction, staging and disposal would occur on Reclamation lands.

Conclusion
This alternative was dropped; however, many of the changes proposed in this alternative are being evaluated and considered for incorporation into the current 30% design of the bypass channel.

Alternative Theme F. Island

Alternative Description:
This alternative includes utilizing the existing island in the Yellowstone River upstream of the headworks to split river flows between a proposed canal and the Yellowstone River (see Figure A.1.10). The proposed constructed canal section would convey flows to the newly constructed headworks. The majority (approximately 600 feet) of the existing Intake Dam would be removed and a new 100-foot section of dam would need to be constructed to direct water into the existing headworks. A 9,600-foot long canal would be created by constructing a 3,400-foot long by 10-foot wide (top width) dike that extends from the existing Intake Dam on the headworks side of the river to the upstream island. About 100 feet of Intake Dam from the headworks side would be replaced with a newly constructed concrete dam. The new 100 ft wide dam would need to include appurtenances to pass flood flows, sluice sediment, and return fish from the canal to the main channel.

The canal around the island would be approximately the same width as the existing side channel, 150-foot bottom width with 1:1 side slopes. The last 3,400 feet of canal created by the dike would have a 70-foot bottom width with 1:1 side slopes. Excavation along this canal would be required to lower the canal invert to allow for flow conveyance. The entrance to the canal would be at an elevation higher than the river inlet. A concrete sill would also be required to stabilize the canal entrance. The entrance would also need to be designed to reduce debris entrainment (i.e., trash rack) and minimize ice flow damage to the canal.

Hydraulic modeling revealed that this alternative would be technically infeasible without a dam/weir across the entire width of the Yellowstone River (near the new canal entrance) to raise river levels and allow water diversion during low flow. The weir across the Yellowstone River would be located just downstream of the new canal entrance. This weir would have an elevation between 1991 and 1993 feet. At this elevation, given the river bottom at this location, the weir will be between 5 to 7 feet higher than the natural river bottom. A fish passage structure will be required, (e.g. rock ramp or bypass channel).

The new 100-foot wide concrete dam next to the existing headworks screening structure would utilize two 10-foot wide radial gates to pass excess water that enters the canal but is not needed for irrigation diversion. These gates would also be used to pass floating debris. Four 8-foot wide by 6-foot tall vertical lift gates would be used to sluice deposited sediments away from the headworks structure. A fish bypass would also be built to return fish that enter into the canal back to the river.

The island would be protected by placing a 10-foot wide rock dike along the river-side perimeter of the existing island. Material dredged from the 9,600-foot long canal would be placed into the interior of the island's rock dike perimeter. The upstream side of the island and upstream floodplain would also require stabilization so that the canal would not get flanked during high flows. The 3,400-foot long dike would overtop during flood events with a frequency that has yet to be determined. The dike would need to be designed for overflow.

Design options include:

- Build dike with roller compacted concrete to increase stability and reduce maintence of the structure.
- Include vehicle passage on the dam and dike for maintenance of the canal and entrance.
- Use collapsible gates to divert water into canal instead of concrete weir. “Checking up” the water to obtain a full diversion is only needed for flows less than 7,000 cfs.

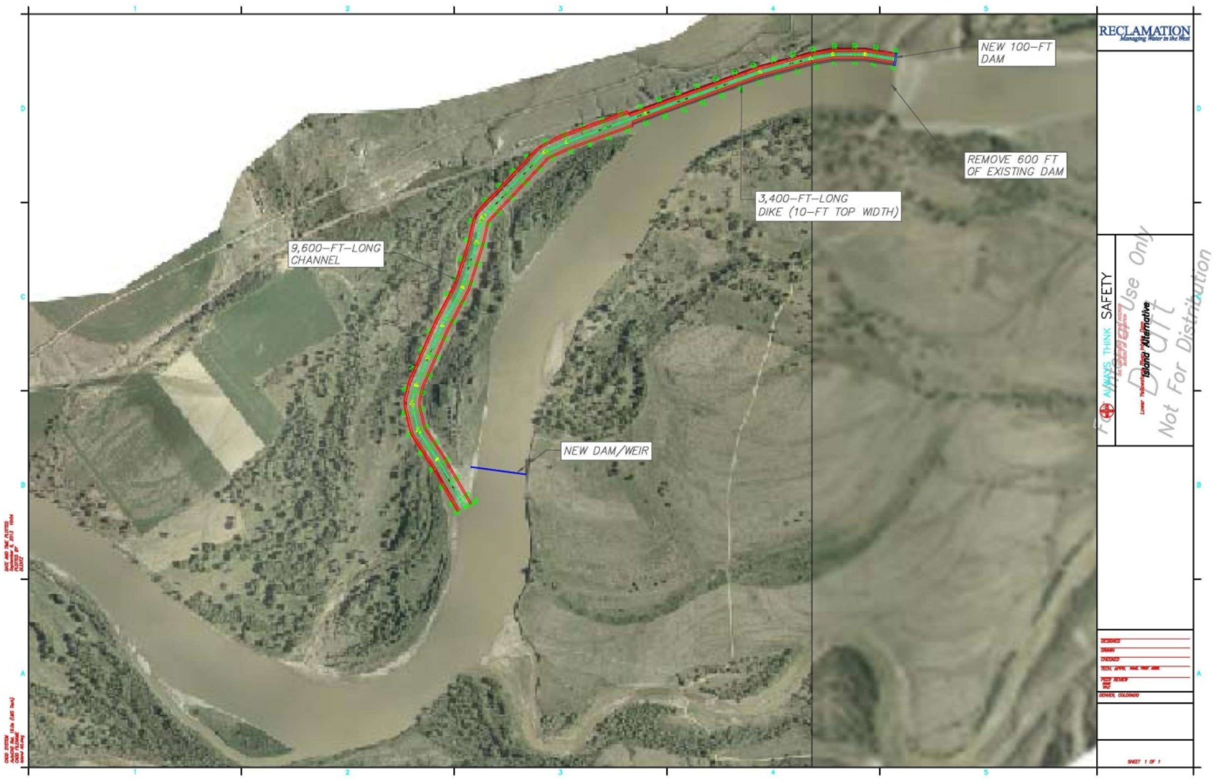

Figure A.1.10. Island Alternative

Conclusion

This alternative was dropped because of concerns regarding the river migrating away from the newly constructed headworks when the diversion dam was removed and the O&M cost will be considerable for the new dike system required on the outside bend of the river. It was also a concern that the hydraulics of this alternative would not allow the district to receive its full water right when the river flows dropped close to 3,000 cfs. Issues of sediment and fish entrainment were also discussed but not resolved. Concerns about stability and long term O&M costs were expressed. The main reason for not pursuing this alternative further was that it proved to be technically infeasible without constructing a weir/dam across the full width of the Yellowstone River.

Alternatives Identified for Further Study

Five fish passage alternatives and two fish screen options were initially identified for further analysis in the 2010 EA based on previous studies of the Lower Yellowstone Project. These were presented in the public scoping meetings held in October 2008. Using scoping input from cooperating agencies and the public, these alternatives were screened through criteria and modified into the three alternatives evaluated in the Final EA. During preparation of the Supplemental EA, input was gathered from the cooperating agencies on potential alternatives. All alternatives that were previously evaluated were reviewed and reconsidered. These alternatives were screened through the criteria and three alternatives are included in the Supplemental EA Addendum; No Action, Bypass Channel and Rock Ramp.

The Rock Ramp Alternative was considered in the 2010 EA and identified as the preferred alternative. Updated technical information and analysis of the rock ramp is documented in this supplemental EA. Due to maintenance, constructability, and cost concerns about the rock ramp design, a bypass channel alternative design was initiated. Due to concerns raised by some of the cooperating entities regarding uncertainty about the bypass channel, a new planning study effort was initiated to bring the original cooperating entities back to revisit all the alternatives that had been previously identified along with potential new alternatives for fish passage at Intake. The planning effort started with a meeting on June 20, 2013 and continued into September 2013 to get all parties working together to identify acceptable and potentially implementable alternatives that would merit more detailed review. As a result of these meetings, the Bypass Channel Alternative was identified for further analysis.

The alternatives evaluated in the EA Addendum are:

- **No Action (Continue Present Operation) -** Under this alternative, Reclamation would continue present operation of the dam and headworks to divert water from the Yellowstone River for irrigation purposes, as authorized. This means operating the irrigation project without any modifications to provide fish passage alternatives until Reclamation completes required ESA consultation activities with the Service and implements any ESA requirements regarding fish passage resulting from that consultation. The Corps has completed construction of a new headworks and fish screens for entrainment protection which is being operated by the Lower Yellowstone Irrigation District (LYID) during the 2012 irrigation season for the first time. Reclamation completed consultation with the Service on operation of the system in March 2012.

- **Bypass Channe**l – The primary feature of this alternative would be constructing a bypass channel from the inlet of the existing high flow chute to just downstream of the existing dam and rubble field. It would also replace Intake Diversion Dam with a concrete weir to raise the surface elevation of the river in front of the new headworks for diversion into the main canal. The bypass channel would improve fish passage and contribute to ecosystem restoration.

- **Rock Ramp** – The primary features of this alternative would be replacing Intake Diversion Dam with a concrete weir and boulder and cobble rock ramp. This would raise the surface elevation of the river upstream of the weir for diversion into the main canal, while improving fish passage and contributing to ecosystem restoration.

A more detailed description of each of the alternatives carried forward is presented in Chapter Two of the Supplemental EA as well as Appendix A.2 (Engineering).

Evaluation of Alternative Plans

For ecosystem restoration projects, benefits are typically non-monetized, but project outcomes can be quantified in terms of habitat units. The objective of the Intake Dam Modification Project is to provide fish passage and entrainment protection to endangered pallid sturgeon. Providing fish passage would reconnect access to up to 165 river miles of habitat for spawning and recruitment of pallid sturgeon which may assist in the recovery of a self-sustaining population.

To assist with evaluation of alternatives, the Service again called on the BRT to provide input to the process. According to the BRT, both action alternatives meet the objective of passage based on anticipated hydraulic performance compared against desirable depth and velocity criteria that meet the needs of pallid sturgeon. The Corps uses Cost Effectiveness/Incremental Cost Analysis (CE/ICA) to evaluate the effectiveness and efficiency of the alternatives at producing environmental outputs. A detailed analysis of CE/ICA is located in Appendix E. In summary, the Bypass Channel Alternative would provide 7,469 habitat units (HUs), for an incremental cost of approximately $319, while the Rock Ramp Alternative would provide 7,649 HUs for an incremental cost of approximately $8,597. Considering the steep increase in incremental cost to achieve a slightly higher level of HU outputs, the Bypass Channel is the preferred alternative, even if adaptive management measures are required.

Comparing Alternative Plans

Chapter 4 fully discloses the environmental impacts of the proposed alternatives, which are summarized below in Table A.1.8. The table identifies whether each alternative would have a long-term beneficial, long-term adverse, temporary effect, or minimal effect on a resource. The table takes into account implementation of the actions to minimize effects described in Chapter 4 of the 2010 EA, the supplemental EA and Appendix I.

Table A.1.8 – Summary of Environmental Impacts that Could Result from Construction and O&M of the Action Alternatives

Resource	Rock Ramp Alternative	Bypass Channel Alternative
B – Beneficial Effect **A** – Adverse Effect **M** – Minimal Effect **T** – Temporary Effect **N** – No Effect		
Climate	**N**	**N**
Air Quality	**T**	**T**
Hydrology	**N**	**N**
Geomorphology	**M**	**M**

Resource	Rock Ramp Alternative	Bypass Channel Alternative
B – Beneficial Effect **A** – Adverse Effect **M** – Minimal Effect **T** – Temporary Effect **N** – No Effect		
Surface Water Quality	T N	T M
Aquatic Communities - Fish	B	B
Aquatic Communities - Mussels	T M	T M
Aquatic Communities - Macroinvertebrates	T M	T M
Federally-Listed Species and State Species of Special Concern	B T M N	B T M N
Lower Yellowstone Project Irrigation Districts	T	T
Recreation	T M	T M
Social and Economic Conditions - Regional	T B	T B
Social and Economic Conditions - Irrigation Districts	M	M
Environmental Justice	N	N
Natural Resource Lands	T M	T M
Wildlife	T M	T M
Historic Properties	M	M
Indian Trust Assets	N	N

Selecting a Plan

Reclamation and the Corps have identified the Bypass Channel as the preferred alternative. Unlike the No Action Alternative, the Bypass Channel Alternative would meet the purpose and need of the proposed action. Compared to the rock ramp, it would provide a more natural passage route and would require much less fill to be placed within the main channel of the Yellowstone River. Because the construction footprint is larger, the bypass channel does create more temporary and permanent impacts to several natural resources, including riparian and wetlands, however these impacts are considered minor.

Fish Passage benefits modeling, while not all inclusive of all parameters that may affect fish passage, does indicate that the Rock Ramp option may be slightly better at providing passage to pallid sturgeon and other fish communities, but both alternatives would provide much greater benefits than the no action alternative. Based on results of CE/ICA, the Bypass Channel Alternative was identified as the preferable alternative in that it most efficiently provided habitat unit outputs (Appendix E).

Recommendations

In response to Section 3109 of WRDA 2007 (P.L. 110-114) and the October 2009 and March 2010 letters from the Service amending RPA elements from the 2003 Amended Biological Opinion, the Bypass Channel Alternative as presented in this Supplemental EA and Plan Formulation Appendix is recommended for implementation. This alternative will provide the opportunity for fish passage around the Intake Diversion Dam, restoring access to up to 165 river miles of historic critical habitat for the endangered pallid sturgeon and other native fish. Specific benefits include providing access to up to 165 river miles (280 river miles total upstream from

Lake Sakakawea) of high quality habitat deemed essential for successful natural spawning, recruitment, and rearing of pallid sturgeon which could contribute to establishment of a self-sustaining population in that segment of the Missouri River basin.