RECLAMATION
Managing Water in the West

Final Report

Lower Yellowstone Fish Passage Alternatives Value Planning Study

August 10, 2005

Conducted in Cooperation with State of Montana Fish Wildlife & Parks, the Nature Conservancy, Lower Yellowstone Irrigation Districts, U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, the Bureau of Reclamation Technical Service Center, and the Bureau of Reclamation Great Plains Regional Office and Montana Area Office

Montana Area Office

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Denver, Colorado

Table of Contents

Executive Summary

The Value Study Team met from June 27, to July 1 2005, for a 32-hour study of fish passage alternatives. The base line concept was a riprap channel fishway with boulder weirs at the right abutment. The baseline concept also included a screen structure in the Main Canal to address entrainment issues. Because some fish passage alternatives could affect the need for the fish screen, the fish screen is included in the baseline costs. The baseline fishway may not be adequate to meet fish passage needs due to questionable attraction to the fishway entrance. The estimated cost of this baseline concept is $8.7 million.[1] The Team developed nine proposals which are summarized (in random order) below.

The team pared down the idea list of 110 ideas first by identifying ideas that are duplicative, technically infeasible or beyond the scope of the study. The team next rated ideas as follows:

Ratings	Criteria Definition
1	Ideas which are likely to improve performance and lower cost,
2	Ideas which will likely improve performance with no cost impact or which will likely lower cost with no impact on performance,
3	A. Ideas which will likely increase both cost and performance, B. Ideas which will likely have no impact on either cost or performance, and C. Ideas which will likely decrease cost and performance,
4	Ideas which will likely increase cost and leave performance unchanged or ideas which will likely leave cost unchanged and will lower performance, and
5	Ideas which will likely increase cost and lower performance

Normally, ideas rated 1 or 2 would be candidates for development. In this study however, the team felt that the baseline (though apparently a relatively low cost solution) was not superior in performance to other available measures. As a result, all surviving ideas were rated 3.

Before proceeding to development, the team combined those ideas which lent themselves to a single write-up.

For purposes of development, the original ideas (see Disposition of Ideas) were preliminarily prioritized as follows:

Priority 1: Ideas 43, 48, 103, 105, and 108
Priority 2: Ideas 11, 13, 82, 96[2], and 110

Mutually Exclusive Proposals: The following proposals are mutually exclusive. The choice of any one precludes choice of another.

---

[1] The baseline was not evaluated along with other alternatives because the team felt that the baseline did not necessarily fully meet project purpose and need. However, in the future, the design team may choose to evaluate the baseline against any or all of the alternatives discussed in this study utilizing the same CBA approach used by the Value Team.

[2] This idea was discarded at the end of development because the team did not feel that it met project purposes and needs and was not useful for comparative purposes.

Proposal No. 1 (Ideas 11A and 11B): L-Shaped Dam

This proposal would replace the present diversion structure with an L-Shaped dam, allowing fish passage on the south side of the river with a continued diversion on the north side. The screen structure would remain the same as the baseline. The cost of this proposal is $17.1 and $29.5 million for Alternative A and B, respectively. The estimated avoidances of this proposal are -$8.3 to -$20.7 million before deducting any study and/or implementation costs.

Proposal No. 2 (Idea 13): Island

This proposal includes the construction of an island in the Yellowstone River to split the flow into a natural Yellowstone River channel to allow fish passage and a smaller channel conveying flows to the Lower Yellowstone Irrigation District diversion intake. The screen structure would remain the same as the baseline. The cost of this proposal is $15.5 million. The estimated avoidances of this proposal are -$6.8 million before deducting any study and/or implementation costs.

Proposal No. 3 (Idea 48): Widen Fishway

This proposal is intended to enhance attraction by widening the fishway channel and modification of the existing dam. The screen structure would remain the same as the baseline. The cost of this proposal is $11.6 million. The estimated avoidances of this proposal are -$2.9 million before deducting any study and/or implementation costs.

Proposal No. 4 (Idea 82): Multiple Pump Stations

Supply water to the irrigation district using multiple pumping plants distributed along the project. The inlet to each pumping plant would have fish screens. The cost of this proposal is $37.5 million. The estimated avoidances of this proposal are -$28.7 million before deducting any study and/or implementation costs.

Proposal No. 5 (Idea 103): Long Low Gradient Channel

This proposal would restore connectivity to an existing side channel to serve as a relatively natural fish bypass channel. The screen structure would remain the same as the baseline. The dam itself would remain intact. The cost of this proposal is $10.5 million. The estimated avoidances of this proposal are -$1.7 million before deducting any study and/ or implementation costs.

Proposal No. 6 (Idea110): Remove Dam and Move Diversion Upstream

This proposal would relocate the existing intake diversion structure approximately 2.5 miles upstream from the existing location to take advantage of the natural river gradient. The screen structure would be the same structure as in the baseline but at the proposed diversion location. The cost of this proposal is $41.1 million. The estimated avoidances of this proposal are -$32.3 million before deducting any study and/or implementation costs.

Proposal No. 7 (Idea 108): Rock Ramp

This proposal would construct a rock ramp fishway that incorporates a natural rock riffle design to provide adequate irrigation head and allow fish passage. The screen structure would remain the same as the baseline. The cost of this proposal is $16.7 million. The estimated avoidances of this proposal are -$7.9 million before deducting any study and/or implementation costs.

Proposal No. 8 (Ideas 105A and 105B): Collapsible Gate

This proposal would replace the existing dam with a collapsible gate system and rock fishway. The screen structure would remain the same as the baseline. The cost of this proposal is $21.7 million. The estimated avoidances of this proposal are -$12.9 million before deducting any study and/or implementation costs.

Proposal No. 9 (Idea 43): Remove Dam and Build Single Pumping Station

This proposal would replace the existing diversion dam with a single pumping station at the entrance to the canal. The cost of this proposal is $26.8 million. The estimated avoidance of this proposal is -$18.1 million. This proposal also explored ideas for water conservation measures throughout the irrigation delivery system to reduce the amount of water needed for the project and renewable energy sources to supplement power demand for the pump system. However, these costs were not included in the proposal.

Proposal No. 10 (Idea 96): Do Nothing

This proposal involves two possible scenarios (A) nothing would be done to improve fish passage at Intake Diversion dam on lower Yellowstone River, but the proposed fish screen would be installed in the Main Canal; (B) nothing would be done to improve fish passage or reduce fish entrainment. Under both scenarios, the irrigation Districts would continue to operate and maintain the Lower Yellowstone Irrigation Project.

The team then evaluated the proposals using Choosing By Advantages. This process showed that the proposals appeared to be readily separated into three tiers of alternatives.

First tier of alternatives that are recommended to be carried forward for further study and consideration are as follows:

- Proposal #5: Long, Low-Gradient Channel
- Proposal #7: Rock Ramp
- Proposal #9: Remove Dam and Build Single Pumping Plant
- Proposal #3: Widen Fishway

Second tier of alternatives that may be considered for further study are as follows:

- Proposal #6: Remove Dam and Move Diversion Upstream
- Proposal #4: Multiple Pump Stations
- Proposal #8: Collapsible gates

Third tier of alternatives that are not recommended to carry for any further consideration are as follows:

- Proposal #2: Island
- Proposal #1A: L-Shaped Dam 6,600'
- Proposal #1B: L-Shaped Dam 20,000'

Other Ideas: The Team identified no additional ideas for further consideration or development. All ideas are listed in the "Disposition of Ideas" table near the end of this report.

Value Study Team Members

Name/Title/Discipline	Address/Phone-Fax Numbers/E-mail
Michael Adams Value Study Team Leader Certified Value Specialist	Enlign Consultants 6309 Carmichael Street, Fort Collins, CO 80528-7071 Phone: 970-223-0702 Fax: 720-221-0771 E-mail: mike@enlignconsultants.com
Sue Camp Fisheries Biologist	Bureau of Reclamation, Montana Area Office P.O. Box 30137, Billings, MT 59107 Phone: 406-247-7668 Fax: 406-247-7338 E-mail: scamp@gp.usbr.gov
George Jordan Yellowstone River Coordinator Pallid Sturgeon Recovery Team Leader	U.S. Fish and Wildlife Service 2900 4th Avenue North, Room 301, Billings, MT Phone: 406-247-7365 Fax: 406-247-7364 E-mail: george_jordan@fws.gov
Dan Fritz Environmental Specialist	Bureau of Reclamation, Great Plains Regional Office PO Box 36900 Billings, MT 59107-6900 Phone: 406-247-7638 Fax: 406-247-7793 E-mail: dfritz@gp.usbr.gov
Brad Schmitz Fisheries Manager, R-7, MT FWP	Montana Department of Fish, Wildlife and Parks P.O. Box 1630 Industrial Site West Miles City, MT 59301 Phone: 406 234-0900 Fax: 406-234-4368 Email: brschmitz@mt.gov
Lyle Lallum Civil Engineer	Bureau of Reclamation, Great Plains Regional Office PO Box 36900 Billings, MT 59107-6900 Phone: 406-247-7644 Fax: 406-247-7793 E-mail: llallum@gp.usbr.gov
Lou Hanebury Wildlife Biologist USFWS-ES	U.S. Fish and Wildlife Service 2900 4th Avenue, N., Room 301, Billings, MT 59105 Phone: 406-247-7366 Fax: 406-247-7364 E-mail: lou_hanebury@fws.gov
Bob Dach Federal Activities Specialist USFWS-ES	U.S. Fish and Wildlife Service 134 Union Boulevard, Suite 645, Lakewood, CO 80228 Phone: 303-236-4264 Fax: 303-236-0027 E-mail: robert_dach@fws.gov
Larry Tandeski Engineering Technician	Bureau of Reclamation, Great Plains Regional Office PO Box 36900 Billings, MT 59107-6900 Phone: 406-247-7633 Fax: 406-247-7793 E-mail: ltandeski@gp.usbr.gov
Patrick Erger Hydraulic Engineer	Bureau of Reclamation, Montana Area Office P.O. Box 30137, Billings, MT 59107 Phone: 406-247-7313 Fax: 406-247-7359 E-mail: perger@gp.usbr.gov
Jerry Nypen Manager	Lower Yellowstone Irrigation Project Route 1 Box 2064, Sidney, MT 59270 Phone: 406-433-1306 Fax: 406-433-9188 E-mail: jnypen@midrivers.com

Value Study Team Members

Name/Title/Discipline	Address/Phone-Fax Numbers/E-mail
Burt Williams	Nature Conservancy 208 North Broadway, #402, Billings, MT 59101 Phone: 406-256-7512 Fax: 406-256-7526 E-mail: burt_williams@tnc.org
Brent Mefford Hydraulic Engineer	Bureau of Reclamation PO Box 25007(D-8560), Denver, CO 80225-0007 Phone: 303-445-2149 Fax: 720-544-0554 E-mail: bmefford@do.usbr.gov
Jeff McClenathan Hydraulic Engineer Chief Hydraulic Section	U.S. Army Corps of Engineers 106 S. 15th Street, Omaha, NE 69104 Phone: 402-221-4578 Fax: 402-221-3408 E-mail: jeffrey.t.mcclenathan@usace.army.mil
J. Greg Johnson Program Manager	U.S. Army Corps of Engineers 106 S. 15th Street, Omaha, NE 69104 Phone: 402-221-7258 Fax: 402-221-4890 E-mail: greg.johnson@usace.army.mil

Acknowledgement of Design Team and Consultation Assistance

The Value Study Team wishes to express their thanks and appreciation to the Design Team Leader, Mr. Brent Mefford, and the members of the design team, who fully and cordially provided all requested information and consultation on the conceptual design. The team would not have been as successful without the design team's cooperation and assistance.

The Value Study Team wishes also to express thanks and appreciation to those listed on the Consultation Record of this report. Their cooperation and help contributed significantly to the technical foundation and scope of the team's investigation and final proposals.

The goal of the value method is to achieve the most appropriate and highest value solution for the project. It is only through the efforts of a diverse, high-performing team, including all those involved, that this goal can be achieved. This study is the product of such an effort.

Value Method Process

The Value Method is a decision making process, originally developed in 1943 by Larry Miles, 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 study process follows a job plan that provides a reliable, structured approach to the conclusion. Initially, the team examined a single component of the project to define the critical functions (performed or desired), associated costs, and potential factors which will assist in determining the most important alternatives and priorities as required. Using creativity (brainstorming) techniques, the team suggested alternative ideas and solutions to perform those functions at a lower cost or with an increase in long-term value. The ideas were evaluated, analyzed, and prioritized, and the best ideas were developed to a level suitable for comparison decision making and adoption. Prior to completion of the development of the alternatives, Mr. Erger and Mr. Mefford heard informal presentations of each alternative to determine if any contained a fatal flaw and, if so, what could be done to remove the flaw. No alternatives were determined to be fatally flawed. Evaluation and prioritization of the completed alternatives was conducted in accordance with sound decisionmaking techniques described in The Choosing By Advantages Decisionmaking System, by Jim Suhr (i.e., chapter 22, the Tabular Method). Each team member has had the opportunity to read and discuss all alternatives with their respective authors.

This report is the result of a "formal" Value Study, by a team comprising people with the diversity, expertise, and independence needed to creatively attack the issues. The team members bring a depth of experience and understanding to the disciplines they represent and an open and independent enquiry of the issues under study, to creatively solve the problems at hand. Ideally, the team members have not been notably involved in the issues prior to the study. The team applied the Value Method to the issues and supporting information, and took a "fresh" look at the problems to create alternatives that fulfill the client's needs at the greatest value.

Current Description

The Intake Diversion dam and diversion headworks for the Lower Yellowstone Irrigation District's Main Canal are located on the Yellowstone River about 17 miles northeast of Glendive, Montana. See Figure 1. The Main Canal diverts water on the west side of the Yellowstone River and water is carried downstream in the Main Canal 71.6 miles until it returns to the Missouri River near the confluence of the Yellowstone and Missouri Rivers.

The Intake Diversion Dam is a rock filled timber crib weir with a structural height of about 12 feet, a hydraulic height of 4 feet, a crest length of 700 feet, and a crest elevation of about 1981.0 (original project datum; about 8 feet higher than NAV88 datum). See Figure 2. The dam was completed in 1909. The canal was originally designed with a 30 foot bottom width with a 1.5:1 side slope. The canal is designed to carry at full capacity about 1,400 cubic feet per second at a flow depth of about 10 feet. The canal operates from May 1 through the end of September each year.

Entrainment studies by Hiebert et al. (April, 2000) show significant numbers of fish are entrained with the diversion into the canal. Fish population studies by the Montana Fish Wildlife and Parks (Stewart, 1986, 1988, 1990, 1991) indicate that the dam is a partial barrier to many native species and likely a total barrier to some species. Among these species is the pallid sturgeon, listed as endangered under the Endangered Species Act. It is anticipated that if natural reproduction does not occur soon, pallid sturgeon will be extirpated by 2017.

Almost annually riprap is added to the dam via an overhead cable way to replace riprap lost from the dam due to high flows and/or ice flows. Major rehabilitation projects are conducted about every 30 years to repair accumulated damage to the wooden crest and other portions of the dam. The dam may be near or at the end of its service life. See Figures 3 and 4.

A Fish Protection and Passage Concept Study Report II for the Intake Diversion Dam (April, 2004) recommended a 440 ft. long, 10 ft. high, linear, flat-plate, stainless steel "V" fish screen located in the canal about 600 ft. downstream of the canal headworks with a 4 ft. diameter bypass pipe about 700 feet long to return fish to the river downstream of the diversion dam, at an estimated Field Cost of $8,100,000. See Figure 5. Also in the report a recommendation is made to construct a grouted riprap channel fishway on the south or right abutment with a 2 percent gradient, an 8 foot bottom width, 2.5 to 1 side slopes, 300 feet long with an estimated Field Cost of $640,000. See Figure 6.

Figure 1. Location Map

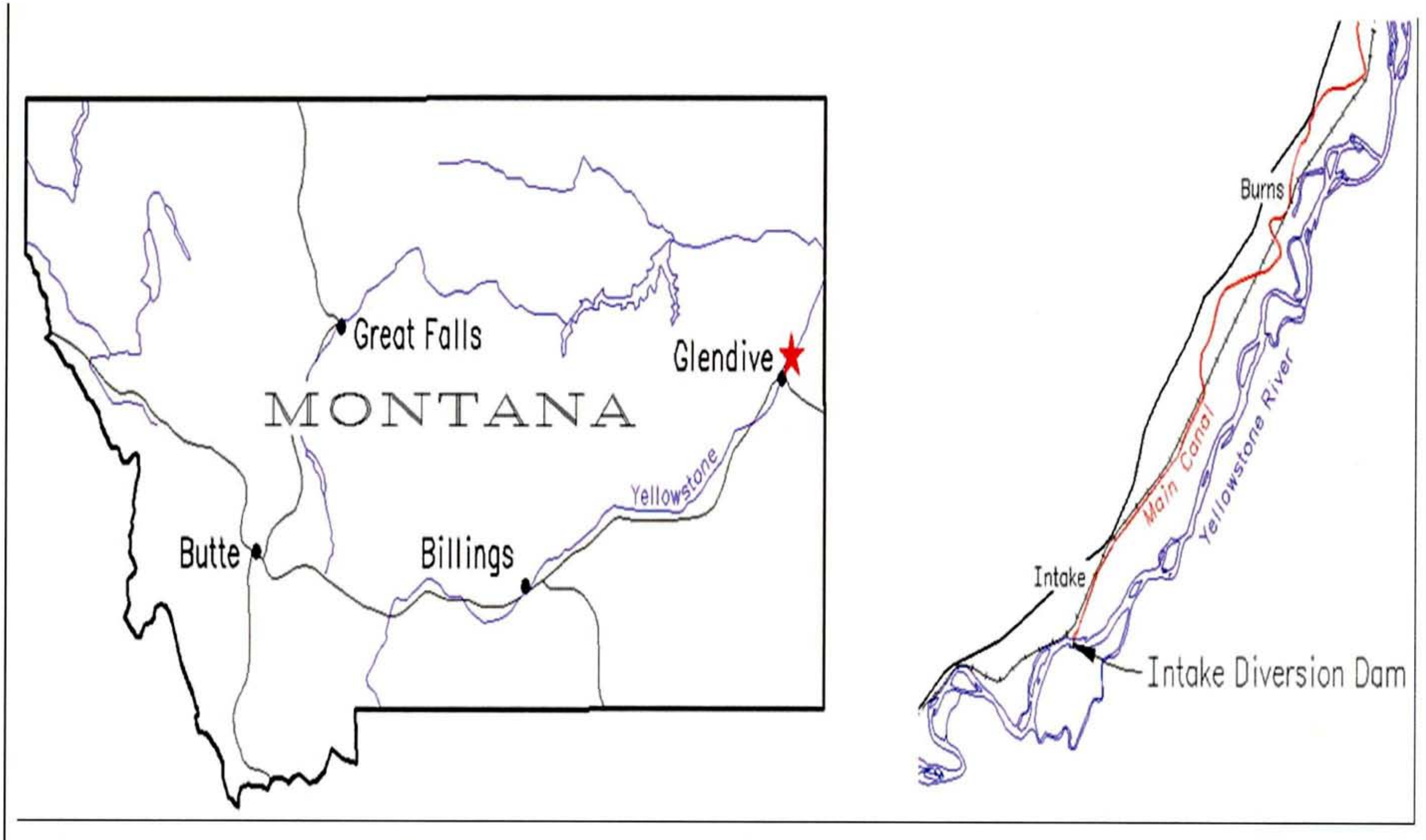
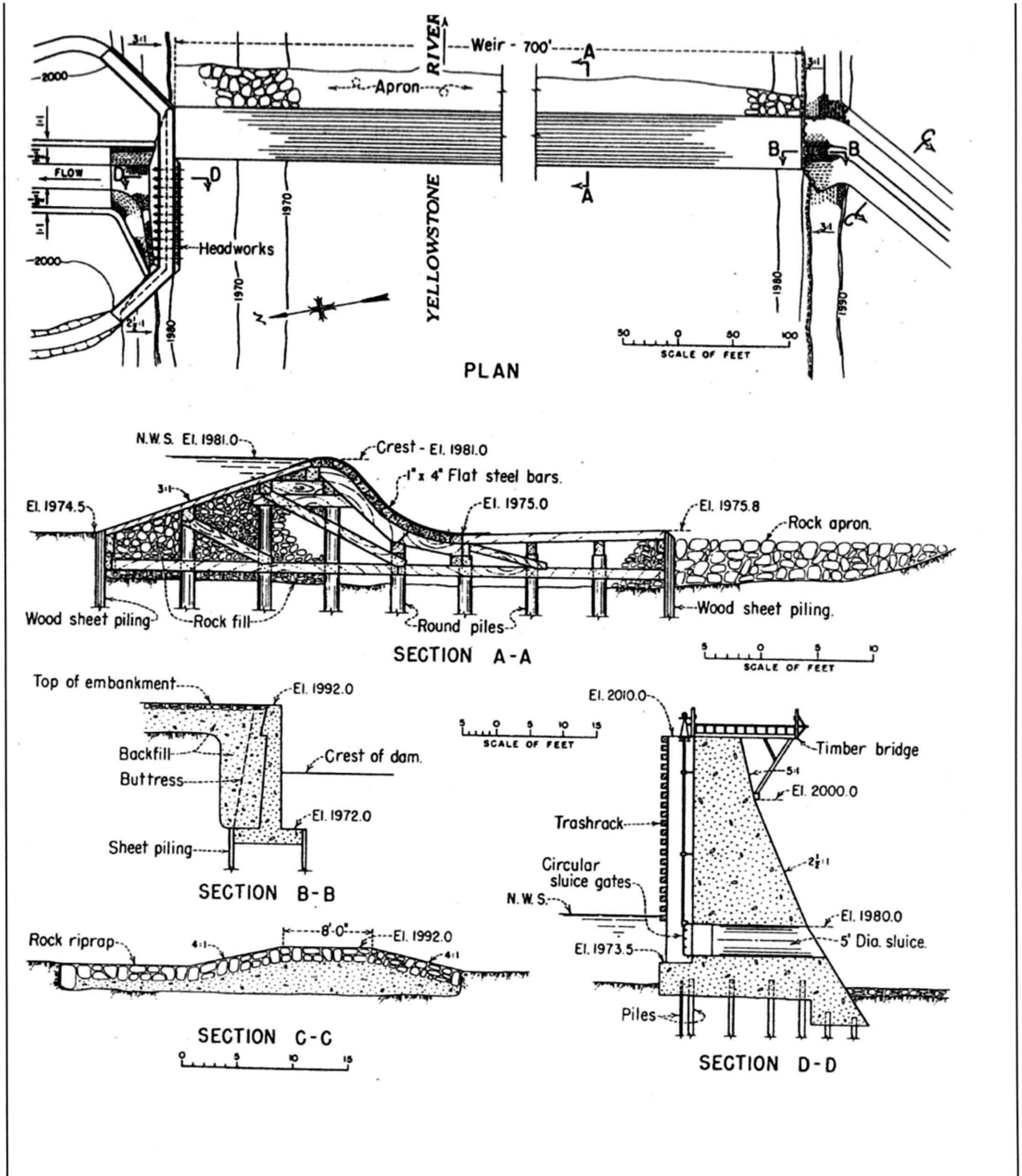


Figure 2. Site Plans and Sections



Note: Elevations on this figure are original project datum not NAV88 of NVGD datums.

Figure 3. Head Works Photo

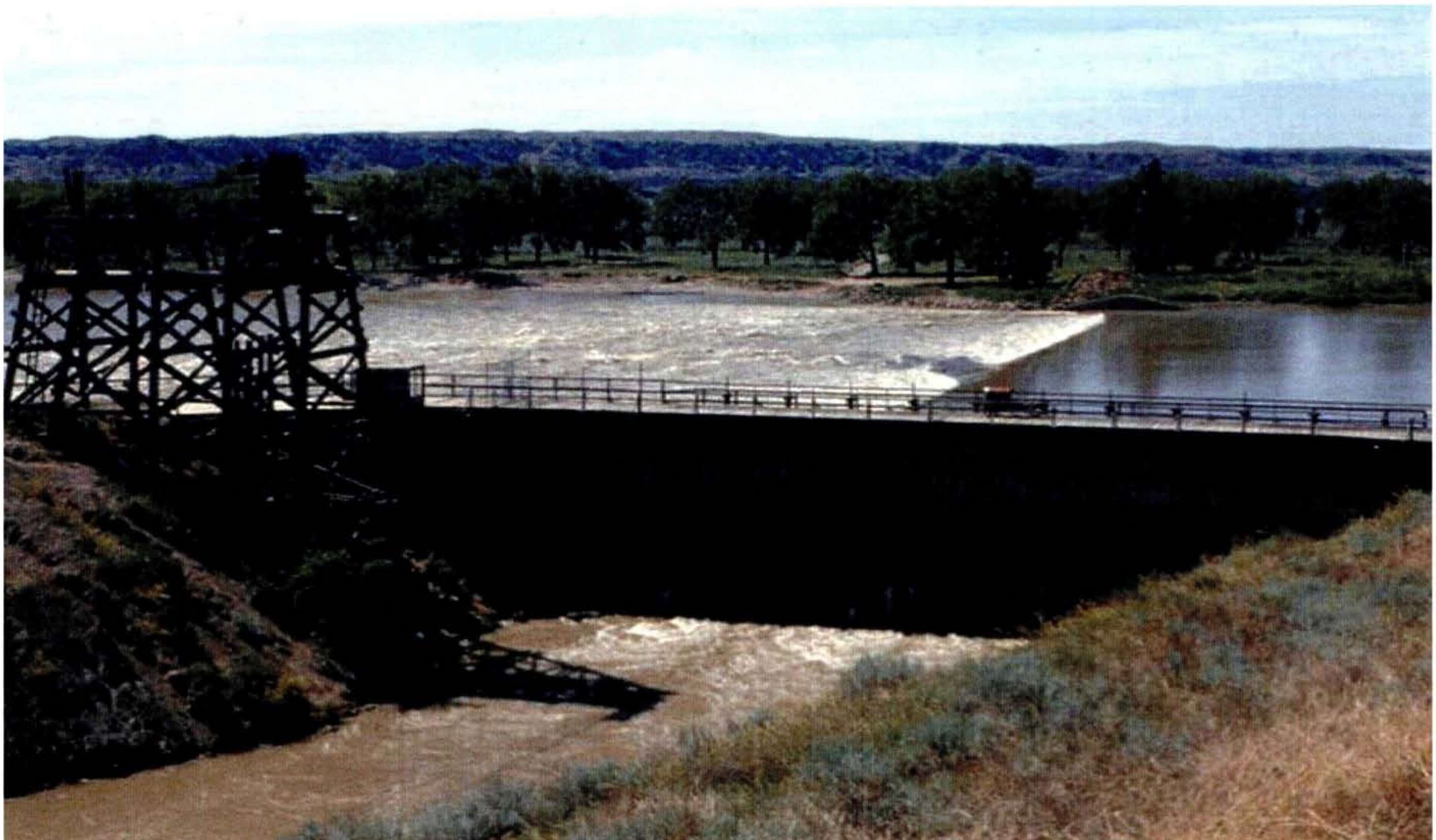


Figure 4. Photo, Downstream Riprap

Figure 5. Proposed Fish Screen and Bypass

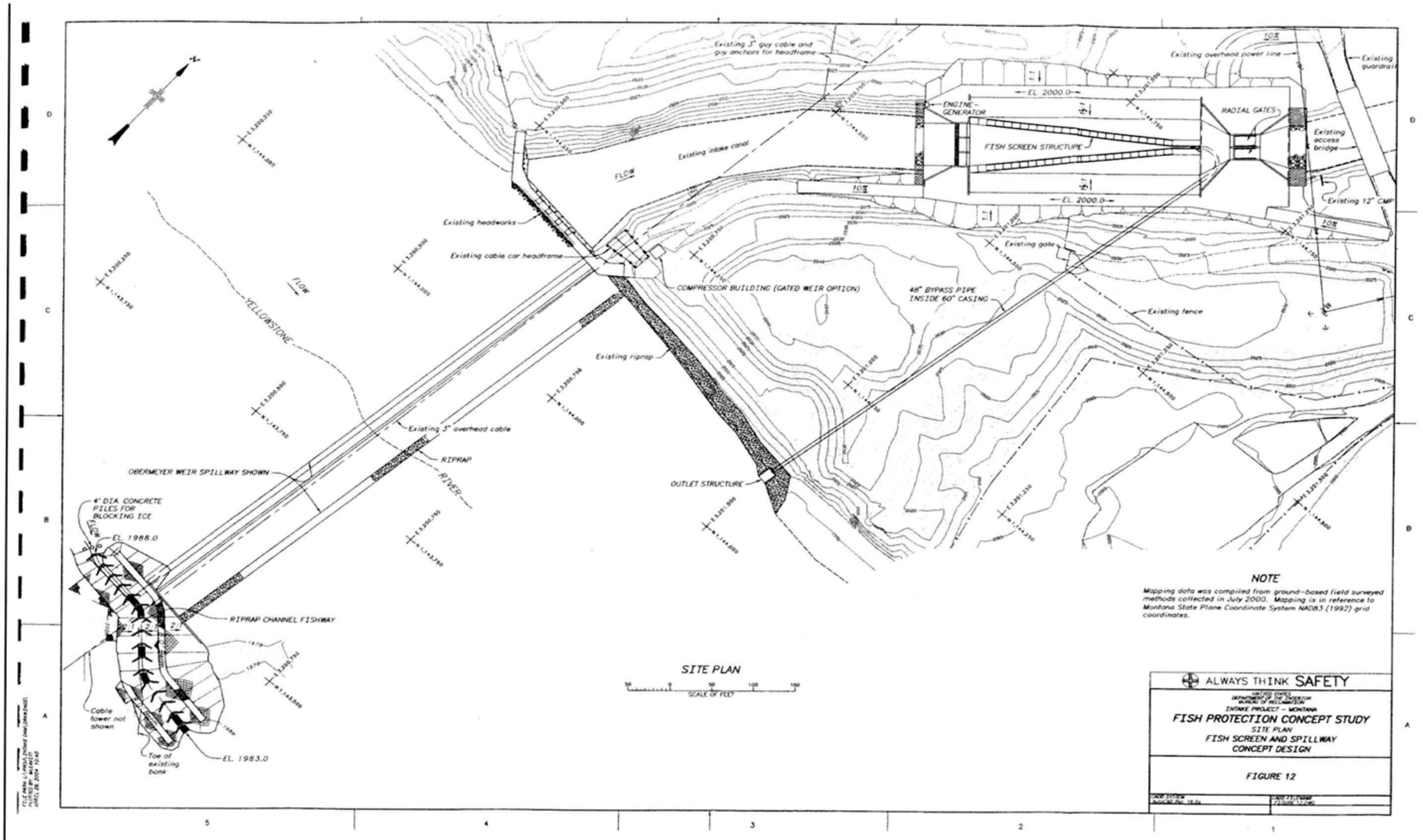
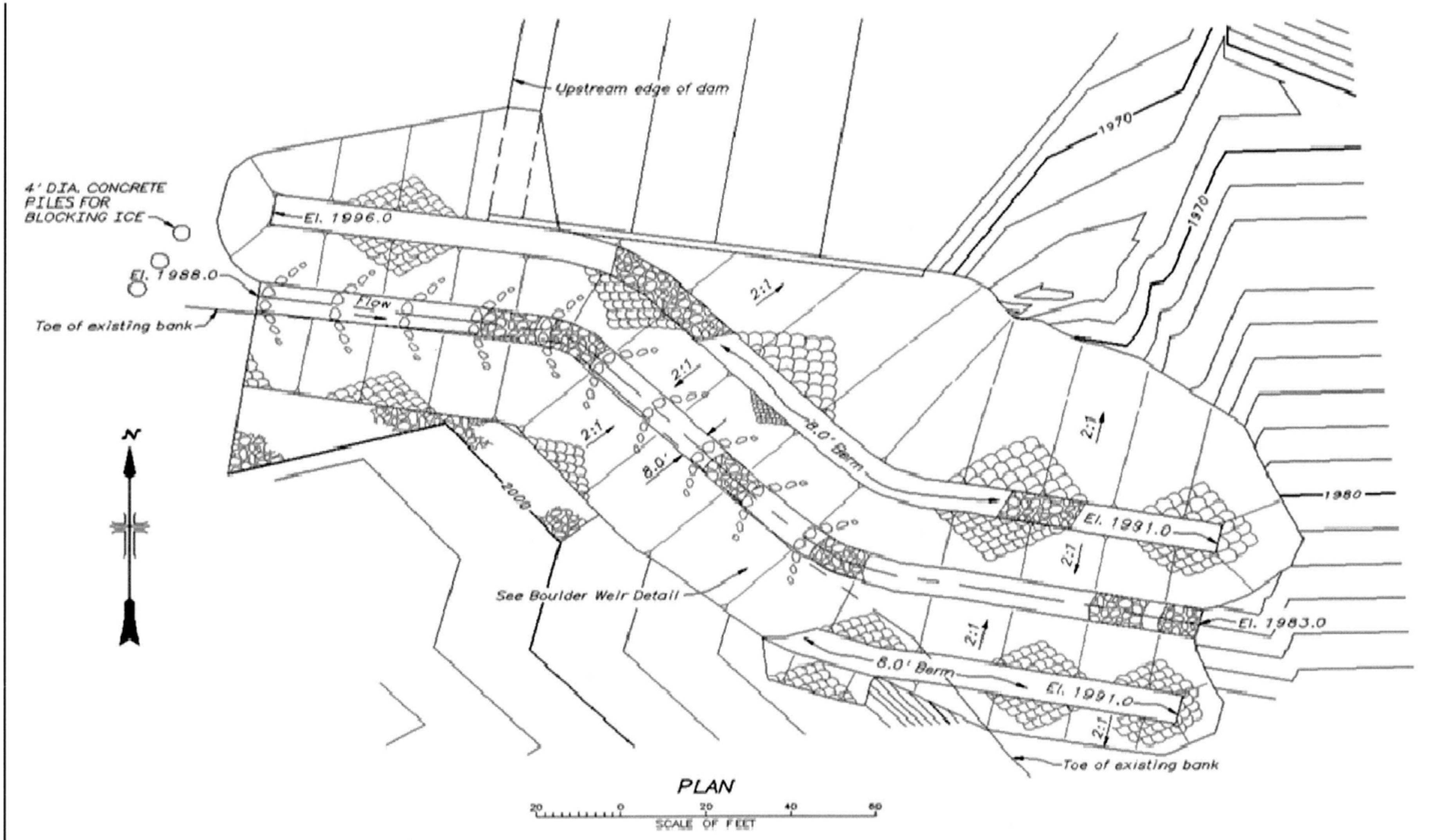


Figure 6. Proposed Fish Passage



Owner, Users, and Stakeholders List

Identification and Issues Determination

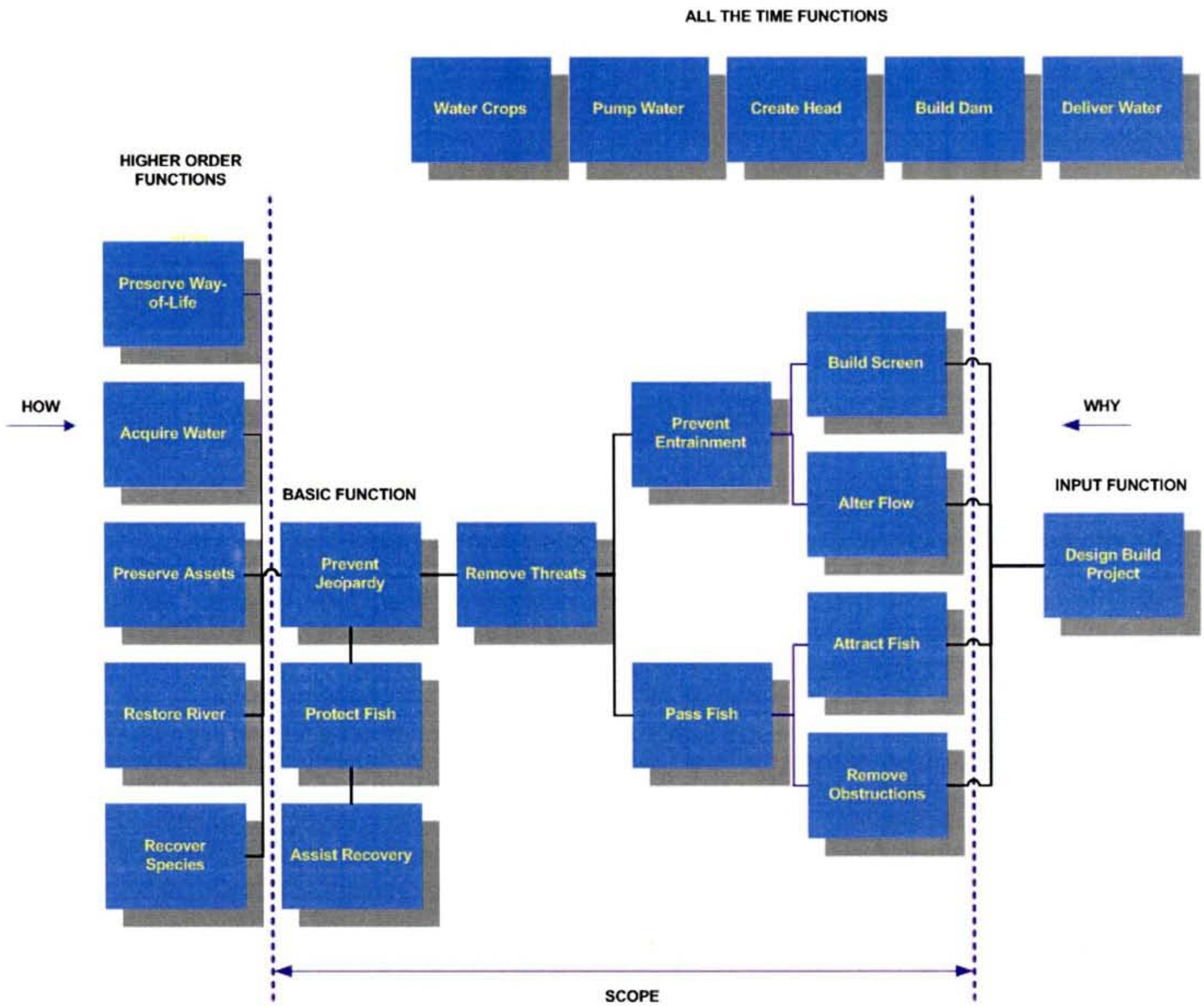
Owner (Identification of the owner or owners)	Owner Issues (Identification of issues important to every owner)	Desire/ Criteria?
Bureau of Reclamation	Maintain the Lower Yellowstone Irrigation Project for Public Benefit Construct the structural modifications required to implement Section 7 consultation with US Fish and Wildlife Service associated with Pallid Sturgeon	C C
User **(Identification of the user or users)**	**User Issues** **(Identification of issues important to every user)**	**Desire/ Criteria?**
Lower Yellowstone Irrigation District No. 1	Diversion of irrigation water for public benefit	C
Lower Yellowstone Irrigation District No. 2	Diversion of irrigation water for public benefit	C
Savage Irrigation District	Diversion of irrigation water for public benefit	C
Intake Irrigation District	Diversion of irrigation water for public benefit	C
State of Montana	Diversion of irrigation water for public benefit	C
Stakeholder **(Identify of the stakeholders)**	**Stakeholder Issues** **(Identification of issues important to every stakeholder)**	**Desire/ Criteria?**
Montana Department of Fish Wildlife and Parks	Pallid sturgeon recovery plan for public benefit Species of interest: Sturgeon Chub, Paddlefish Sauger, Shovelnose Sturgeon, Sicklefin Chub	C D
North Dakota Game and Fish Department	Pallid sturgeon recovery plan for public benefit Species of interest: Sturgeon Chub, Paddlefish Sauger, Shovelnose Sturgeon, Sicklefin Chub	C D
United States Fish and Wildlife Service	Pallid sturgeon recovery plan for public benefit Species of interest: Sturgeon Chub, Paddlefish Sauger, Shovelnose Sturgeon, Sicklefin Chub	C D
City of Glendive	Angler, boater, and sportsman	D
Glendive Chamber of Commerce and Agriculture	Angler, boater, and sportsman Paddlefish fishery and caviar	D
Glendive Rod and Gun Club	Fishing	D
Sportsman Association of Southeast Montana	Fishing	D

Function Analysis

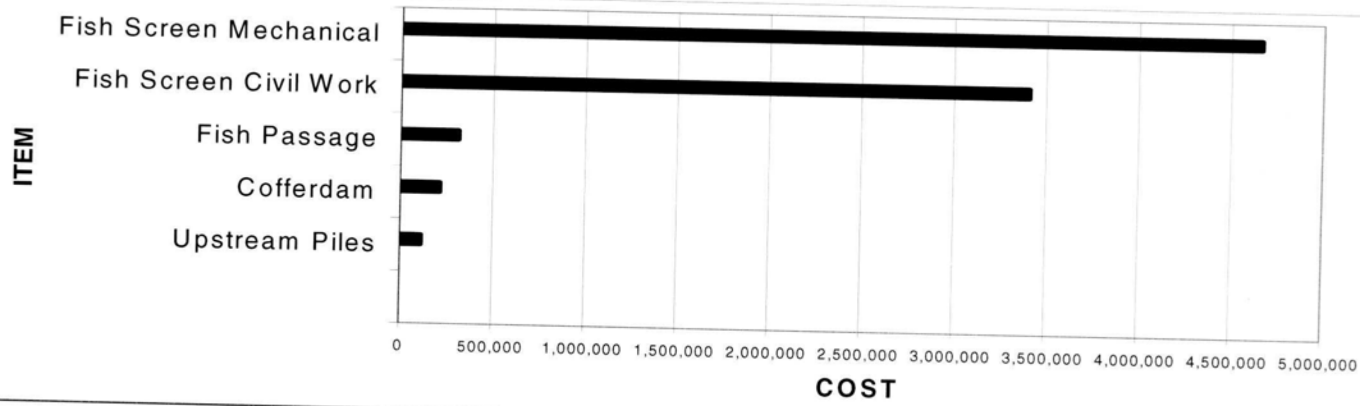
Function Type	Active Verb	Measurable Noun
Higher Order	Preserve	Way-of-Life
Higher Order	Acquire	Water
Higher Order	Preserve	Assets
Higher Order	Restore	River
Higher Order	Recover	Species
Basic	Prevent	Jeopardy
Secondary (When)	Assist	Recovery
Secondary	Remove	Threats
Secondary (When)	Protect	Fish
Secondary	Prevent	Entrainment
Secondary	Pass	Fish
Secondary	Build	Screen
Secondary	Alter	Flow
Secondary	Attract	Fish
Secondary	Remove	Obstructions
Secondary	Build	Fishway
All The Time	Water	Crops
All The Time	Deliver	Water
All The Time	Create	Head
All The Time	Pump	Water
All The Time	Build	Dam
Input	Design/Build	Project

Function Analysis System Technique (FAST)

The Value Study Team used the function-analysis process to generate a Function Analysis System Technique (FAST) diagram, designed to describe the present solution from a function viewpoint. The FAST diagram helped the Team identify those design features that support critical functions and those that satisfy non-critical objectives. The FAST diagram also helped the Team focus on potential value mismatches, and generate a common understanding of how project objectives are met by the present solution.



Lower Yellowstone Fish Passage Alternatives Value Planning Study			
COST MODEL			
Item	Estimated Cost in $Millions	Estimated Cost in $Millions w/Markups	Percentage of Total
Upstream Piles	$81,900	$113,513	1%
Cofferdam	$154,500	$214,137	2%
Fish Passage	$225,280	$312,238	4%
Fish Screen Civil Work	$2,458,980	$3,408,146	39%
Fish Screen Mechanical	$3,365,000	$4,663,890	54%
TOTAL	$6,285,660	$8,711,925	100%



Cost Model and Estimate Information

The Value Study Team cost model is based on the estimate contained in the Fish Protection and Passage Concept Study Report II dated April 2004.

Cost avoidances/savings and the original design concept estimates are of the same general level of development, although these costs may vary as final designs are pursued.

Note: The cost estimates prepared for this study have been developed for the sole purpose of comparing costs of proposals to the functional equivalent in the baseline concept. The value study schedule dictates the time and resources allowed for preparation of cost estimates for each proposal alternative. Therefore, these cost estimates are not recommended to be used for budgeting or construction purposes. At final specification the design team will more accurately quantify any savings/avoidances resulting from acceptance of proposals. This information will be reported in the accountability report. If as a result of the Value Study a cost estimate is required for appropriations, we recommend that a new total baseline cost estimate be completed. The mark-ups column contains mobilization at 5%, unlisted items at 10%, and contingencies at 20%.

Proposal No. 1

Description

Proposal No. 1. L-Shaped Dam

Proposal Description: Replace present diversion structure with an L-Shaped dam. This would create a relatively natural gradient fish by-pass channel on the south side of the river, with a continued diversion dam on the north side of the main channel. In order to develop the present head of 5 feet, and avoid having all river flow divert to the by-pass channel in low water, a long L-leg would be constructed up river until 5 feet of head is developed. The channel on the north side of the river could be constructed to be approximately the width of the main irrigation canal, gradually widening to the upstream terminus to divert water into the channel.

Critical Items to Consider:

- The L-wing would have to be much longer than the total length of the present diversion dam, which spans the entire channel at a length of 700 feet. The gradient of the river at this point is 4 feet per mile, creating a minimum length estimate for the L-wing of approximately 6,600 feet.
- An advantage in construction would be the potential to reduce the width of the remaining dam to approximately the surface width of the main canal, but with the disadvantage of needing to anchor the north end of the diversion in mid-river.
- The L-wing, with a minimum 6,600 foot length (See Figure 7), would have at least 4 changes in direction, with a total deflection of about 105 degrees. Should the L-wing have to be extended to 20,000 feet (See Figure 8) to reach a stable river reach, these directional issues would multiply by a factor of three.
- Critical construction items would include (1) designing for lateral forces of current and ice at the angles/corners in the L-wing; and (2) designing for protection from ice movement. To create a stable structure would require one of three scenarios:
    - A grouted rock structure, which would take up significant space in the center of the river channel, with a probable 8 foot width at the top of the structure, and at 2:1 slopes 30 or more feet on each side of the center, creating new erosion and deposition issues.
    - A concrete structure, requiring footings at least 10 feet deep, and a construction height of 10 feet to avoid overtopping until flow reaches 30,000 CFS. Construction would require dewatering, and concrete would be tremendously expensive.
    - A structure composed of sheet pile steel, driven into the bed of the river. This alternative would have the advantage of occupying a minimum of bed space. The upstream terminus would have the same issues as the other two scenarios. It also would be possible to construct without dewatering issues.
- A critical design issue would be the upstream terminus of the L-wing, both to stabilize it in the river and maintaining the amount of flow to either side of the terminus. The river is actively eroding the south bank at the potential terminus; and, geomorphologically, further migration of the channel to the south and east is likely. In order to stabilize the river and channels, about 2000 feet of bank stabilization would be required on the south bank of the river. There is evidence that the opposite north bank has active sedimentation, which would be a continued issue in maintaining the channel on the north side of the L-wing.
- The L-wing would have to be substantially lengthened to place it at a location in the river where the channel is relatively stable. The first location in which that occurs is about

20,000 feet upstream of the diversion.

Ways to Implement:

- Changes from the Baseline Concept: Eliminates a portion of the baseline diversion.
- Eliminates constructed rock fishway in favor of a natural gradient channel.

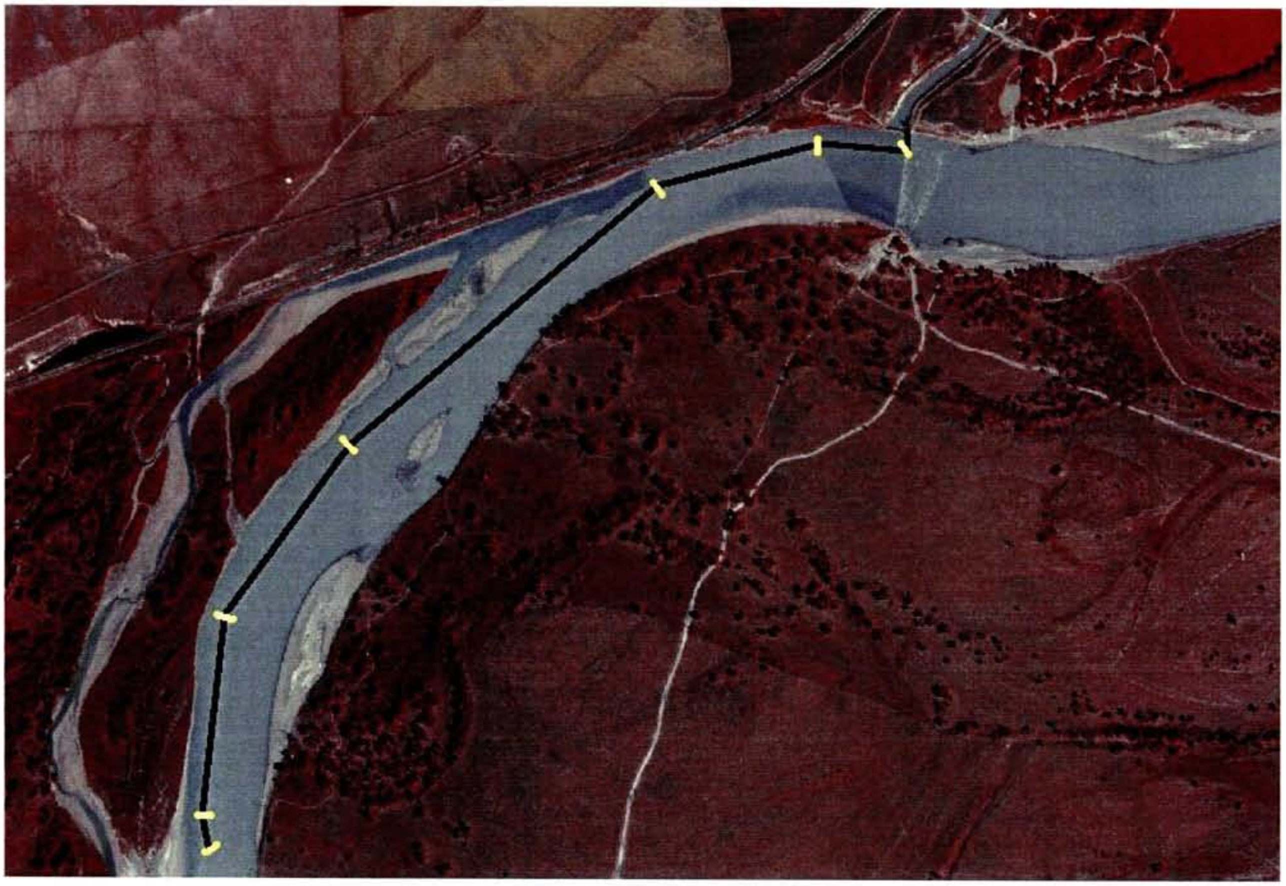
Replaces removed portion of diversion with an L-wing from the present diversion to an upstream terminus at the point on the river that will provide a head of 5 feet.

Potential Risks

- Risk of failure from flood waters: Probability, likely; Severity, high.
- Risk of failure from ice jamming: Probability, likely; Severity, very high.
- Channel movement altering flow in each channel: Probability almost certain; severity moderate.
- Erosion and scouring at new mid-stream terminus of diversion: Probability, almost certain; Severity moderate to very high.
- Deposition in north channel: Probability almost certain; Severity moderate.
- Risk of loss of irrigation water at critical need times: Probability unlikely, Severity very high.

Cost Item	Nonrecurring Costs	
Original Baseline Concept	$	8,740,000
Value Concept w/ 20,000 ft L-wing	$	29,463,993
Avoidance	$	-20,723,993 (B)
Value Concept w/ 6600 ft L-wing	$	17,088,251
Avoidance	$	-8,348,251 (A)
Value Study Costs	$	50,000
Net Avoidance (A, B)	$	-8,398,251 (A) -20,773,998 (B)

Figure 7. L-Shaped Dam 6,600 Ft Alternative A



L-Shaped Dam Proposal, 6600 Ft alternative
Sheet Pile location in black
Corners and termini requiring concrete revetment

Figure 8. L-Shaped Dam 20,000 Ft Alternative B

L-Shaped Dam, 20,000 foot alternative
Extent of sheet pile in black
Corners requiring concrete revetment or rip rap

Proposal No. 2

Description

Proposal No.2. Island (See Figure 9.)

Proposal Description: Proposal includes the construction of an island in the Yellowstone River to split the flow into a natural Yellowstone River channel to allow fish passage and a smaller channel conveying flows to the Lower Yellowstone Irrigation District diversion intake. The island would tie into the existing intake dam and extend about 2,750 feet upstream to an existing island. The island width is about 160 feet near the dam but narrows after 440 feet to a 100 foot width. Total area filled by the island is about 6.9 acres. The island would be constructed by first placing rock dikes with a 10-foot top width and 1 vertical to 2 horizontal side slopes around the perimeter of the island. Dredging about 7,000 feet of the 70 foot wide channel (for flow conveyance to the intake) would be used to fill the interior of the rock dike area; thus creating the island. The option could potentially extend this new side channel upstream about 9,900 feet. About 500 feet of the existing 700 foot long rock dam (including rock displaced downstream) would be removed to restore the stream to natural conditions. Average velocities would increase from about 3 to 4 fps to 5 to 6 fps in the area where the dam was removed. Since the new intake still poses a potential for fish entrainment, a screening facility was included in the construction costs. Six concrete piles would be driven across the channel entrance to prevent ice damage within the side channel from 3 foot thick ice.

Critical Items to Consider: Timing of the construction to not interfere with irrigation and endangered species. A substantial effort may be needed to obtain a 404 permit since a significant amount of channel fill and dredging is needed. Consideration should be given to reusing the rock from the dam and downstream, but may interfere with appropriate construction sequencing (i.e. rock from the dam may not be available until after island construction is completed).

Ways to Implement: Normal construction methods.

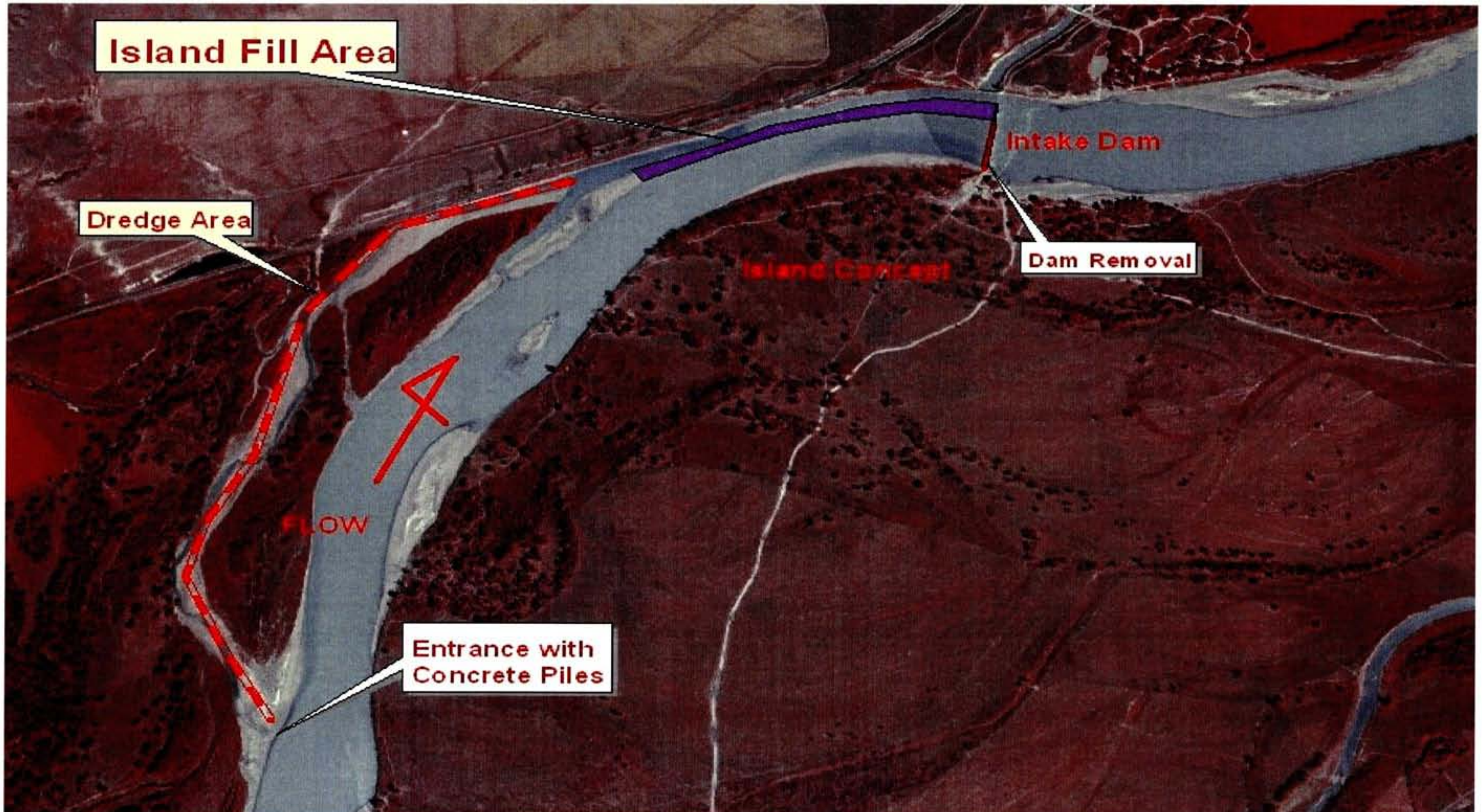
Changes from the Baseline Concept: The basic change from the baseline concept is the replacement of the fish rock passage with the removal of 500 of the 700 foot rock dam. This is allowed by the construction of a side channel (by constructing the island) that supplies irrigation flows to the intake. A screening system will still be required as in the baseline concept.

Potential Risks

Construction of an island to create a side channel and removing most of the existing dam raises the potential to have a significant geomorphic response by the Yellowstone River. Specifically the constructed and existing upstream island will be constructed along an outside bend exposing it to higher velocities, erosive attack, ice damage, and sediment deposition (particularly near the entrance or beginning of the bend). It is unsure how the construction of the island would cause the Yellowstone River to respond. More study on the impacts to the Yellowstone and if the new side channel would deliver the irrigation flows required will need to be done. In addition, the island only extends about 2,750 feet upstream; more analysis would be required to determine if additional erosion protection would be required upstream to maintain the upstream islands to provide the 9,900 foot long side channel. Currently the proposed entrance has a sandbar present that may impact capacity. This could be offset by moving the entrance downstream (closer to the irrigation canal) to an area that may have less sediment deposition. More study would be needed to determine the appropriate location.

Cost Item	Nonrecurring Costs	
Original Baseline Concept	$	8,700,000
Value Concept	$	15,519,000
Avoidance	$	-6,819,000
Value Study Costs	$	50,000
Net Avoidance	$	-6,869,000

Figure 9. Island



Proposal No. 3

Description

Proposal No. 3: Widen Fishway (See Figure 10.)

Proposal Description: The baseline proposal does not include provisions for improving attraction to the fishway entrance. The proposed fishway has been the subject of skepticism as to whether it would provide effective passage for sturgeon. Swim studies have shown the fishway to be successful for shovelnose sturgeon in laboratory prototype testing, but there is some uncertainty that fish will be able to find the fishway entrance for several reasons. There is also concern about continued placement of rock in the river to maintain the dam. This proposal is intended to enhance attraction by widening the fishway channel and modification of the existing dam.

Widen fishway

There is some doubt the fishway is designed large enough to carry a sufficient percentage of the river flow for fish to be attracted to the fishway entrance. The baseline proposal is a fishway with an 8-foot bottom width and 2:1 side slopes. This proposal is to increase the bottom width to 16 feet with the same side slopes. This would result in increased flows through the fishway; the depths would remain the same as baseline. The fishway flows of the baseline and this proposal are shown in the table below, represented as both flow in cfs and a percentage of the total river flow.

Upstream Surface Elevation	River Flow	Depth	Baseline Fishway Flow/Percentage of River Flow (8-Foot Bottom)		Proposal Fishway Flow/Percentage of River Flow (16-Foot Bottom)	
1990.3	4,500	2.0	50 cfs	1.1%	72 cfs	1.6%
1991.3	8,200	3.0	80 cfs	0.9%	135 cfs	1.6%
1992.3	13,000	5.0	555 cfs	4.0%	800 cfs	4.3%
1994.3	28,000	6.0	1,300 cfs	4.6%	1,857 cfs	6.9%
1995.8	40,000	7.5	2,160 cfs	5.4%	2,952 cfs	7.6%

Dam Modification

Dam maintenance over time has resulted in a long riffle extending downstream of the dam. There are two issues with the existing dam that may affect the fishway performance. First, the riprap appears to be at a flatter slope near the north bank (opposite the fishway side). This could cause fish passage problems as fish may be attracted to the north bank. This could pull fish away from the south side where the proposed fishway would be located, as well as subject fish to entrainment if they do negotiate upstream passage there. Second, the riprap extending downstream on the south side of the river may cause disorientation of the fish before they reach the entrance to the fishway.

The proposal is to grout the crest of the dam to reduce downstream movement of rock, thereby reducing the need for maintenance. Some additional rock would be added to the north side to discourage fish passage on that side. In addition, the toe of the dam on the south side would be reworked downstream as far as possible to provide a stabilized channel without turbulence to guide fish to the fishway entrance from the thalweg of the river. The fishway entrance would be adjusted to tie into the river at approximately 1,975 feet elevation. The scope of the rock removal and dam rework would need to be determined with more instream topography data.

Critical Items to Consider:
Need additional data on in-river topography to accurately estimate dam modification work.

Ways to Implement:
Same as baseline.

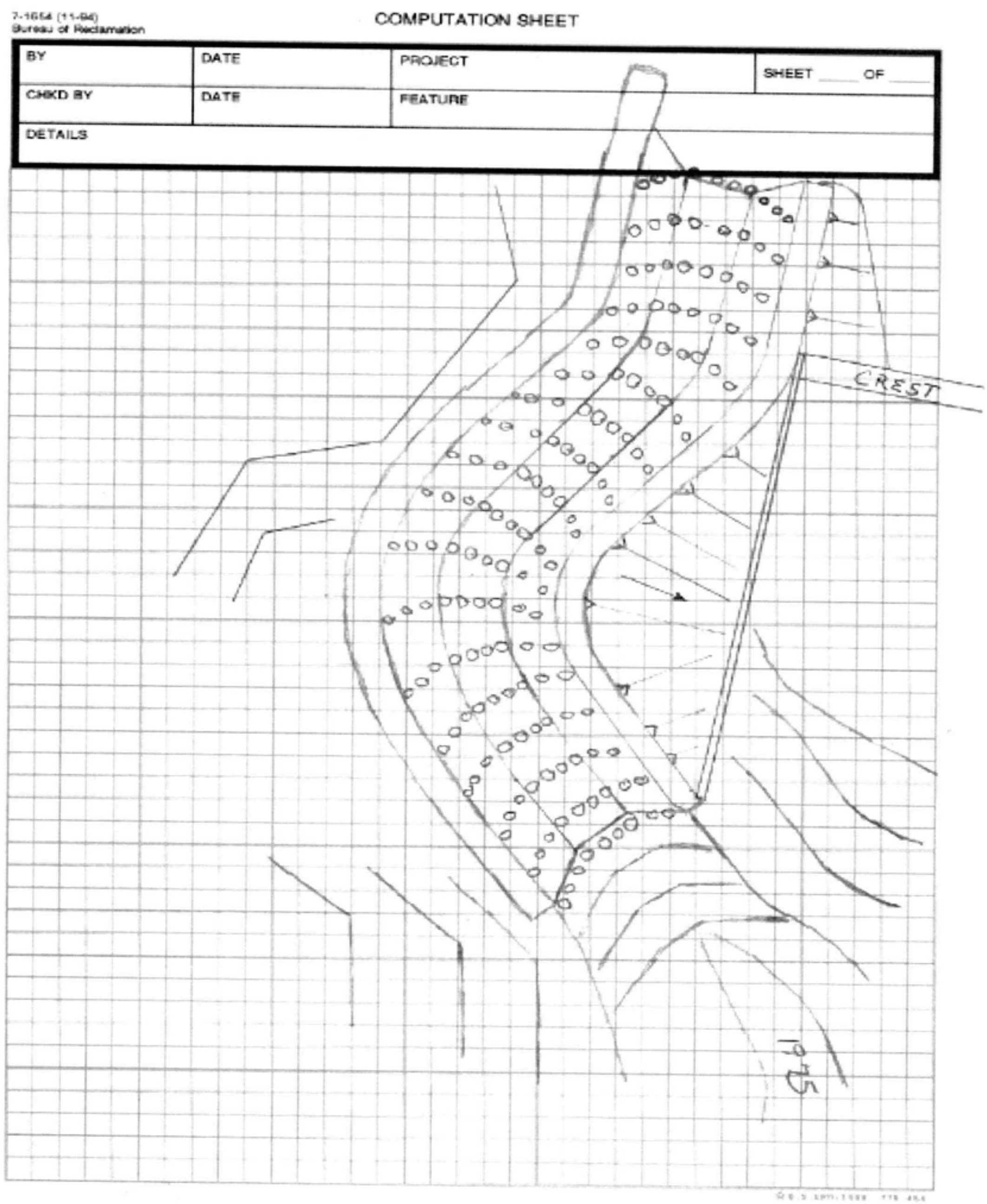
Changes from the Baseline Concept:
Makes baseline fishway wider and adds fish attraction features.

Potential Risks

There is no data available to prove pallid sturgeon passage through rock fishways. Even with added attraction features, passage would still not be guaranteed.

Cost Item	Nonrecurring Costs	
Original Baseline Concept	$	8,740,000
Value Concept	$	11,639,000
Avoidance	$	-2,899,000
Value Study Costs	$	50,000
Net Avoidance	$	-2,949,000

Figure 10. Widen Fishway



Proposal No. 4

Description

Proposal No. 4. Multiple pump stations

Proposal Description:
This proposal would supply water to the irrigation district using multiple pumping plants distributed along the project. Operation of the existing project requires frequent operation of four wasteways to meet water supply along the 72 miles of the Main Canal. During normal operation, wasteway flow is about 50 cubic feet per second (cfs) per wasteway totaling about 200 cfs of unused diversion flow. This proposal assumes the gravity diversion would be replaced by three pumping plants. The first plant would provide 375 cfs flow at 8 ft of head. The plant would be located at the head of the canal. The second plant would be a 450 cfs plant at 30 ft of head. The second plant would be located about 25 miles downstream of the canal headworks. The third plant would be a 575 cfs plant at 60 ft of head. The third plant would be located at Second Hay Creek (about 50 miles downstream of the canal headworks). The first plant would contain 4 submersible high volume low head propeller pumps. The second and third plants would contain multiple 75 cfs vertical turbine pump units with a single 25 cfs unit. The second and third plants would be similar in design. Each plant would supply water from the Yellowstone River to the Main Canal. Each plant would be constructed adjacent to the river. The diversion channel to each plant would contain inclined flat plate wedgewire fish screens that could be raised at the end of each irrigation season. Several large ice piles would be constructed in front of the intake channels to protect the structures from river ice.

Critical Items to Consider:
Road access and right-of-way for pipelines and power would be required.

Ways to Implement: Standard construction, would require three separate cofferdams.

Changes from the Baseline Concept: Replaces dam with three pumping plants with individual fish screens. Long term fish monitoring is not required, fish will be able to move freely in the Yellowstone River.

Potential Risks

Sediment deposition in the entrance channels.
Loss of power to pumps
River stability (channel migration)

Ability to draw the 1,400 cfs needed for canal flows during low river flows.

Cost Item	Nonrecurring Costs
Original Baseline Concept	$ 8,740,000
Value Concept	$ 37,450,000
Savings	$ -28,710,000
Value Study Costs	$ 50,000
Net Savings	$ -28,760,000

Proposal No. 5

Description

Proposal No. 5. Long, low- gradient channel (See Figure 11.)

Proposal Description:
This project would restore connectivity to an existing side channel to serve as a relatively natural fish bypass channel. To prevent entrainment the in-ditch screen as proposed in the baseline would be utilized. The dam itself would remain intact.

Designed channel: 130 foot top width, 50 foot bottom width, 1:5 side slopes, depth of 8 foot Mannings N of .035. With a Q of 22,000 cfs on Yellowstone River, the channel would flow 1,900 cfs with an average velocity of 2.6 fps. Some in channel obstructions (boulders, trees) could be placed to diversify habitat.

Critical Items to Consider:
There must be access to the southern dam abutment for maintenance of the dam and bypass structure. This likely would require a bridge across the bypass channel in two locations or building a single access road with one bridge.

A) The natural channel water inlet would need to be modified and extended upstream to collect water from the river thalweg and prevent sediment deposition at the inlet structure. Concrete piles would be needed to prevent ice damage

B) The channel outlet structure would need to be located close to the dam for fish attraction but not so close that the channel would have an adverse affect on dam integrity. The outlet area would need to be stabilized where the outflow empties into the Yellowstone River.

C) The remaining original channel would serve as a high flow channel and would need to be protected for such events and built at an elevation that would prevent it from being captured and becoming the bypass channel.

Channel may need more stability to insure the bypass does not capture the Yellowstone River.

Channel would need to be constructed to mimic the slope of the Yellowstone in the vicinity to accommodate sediment transport.

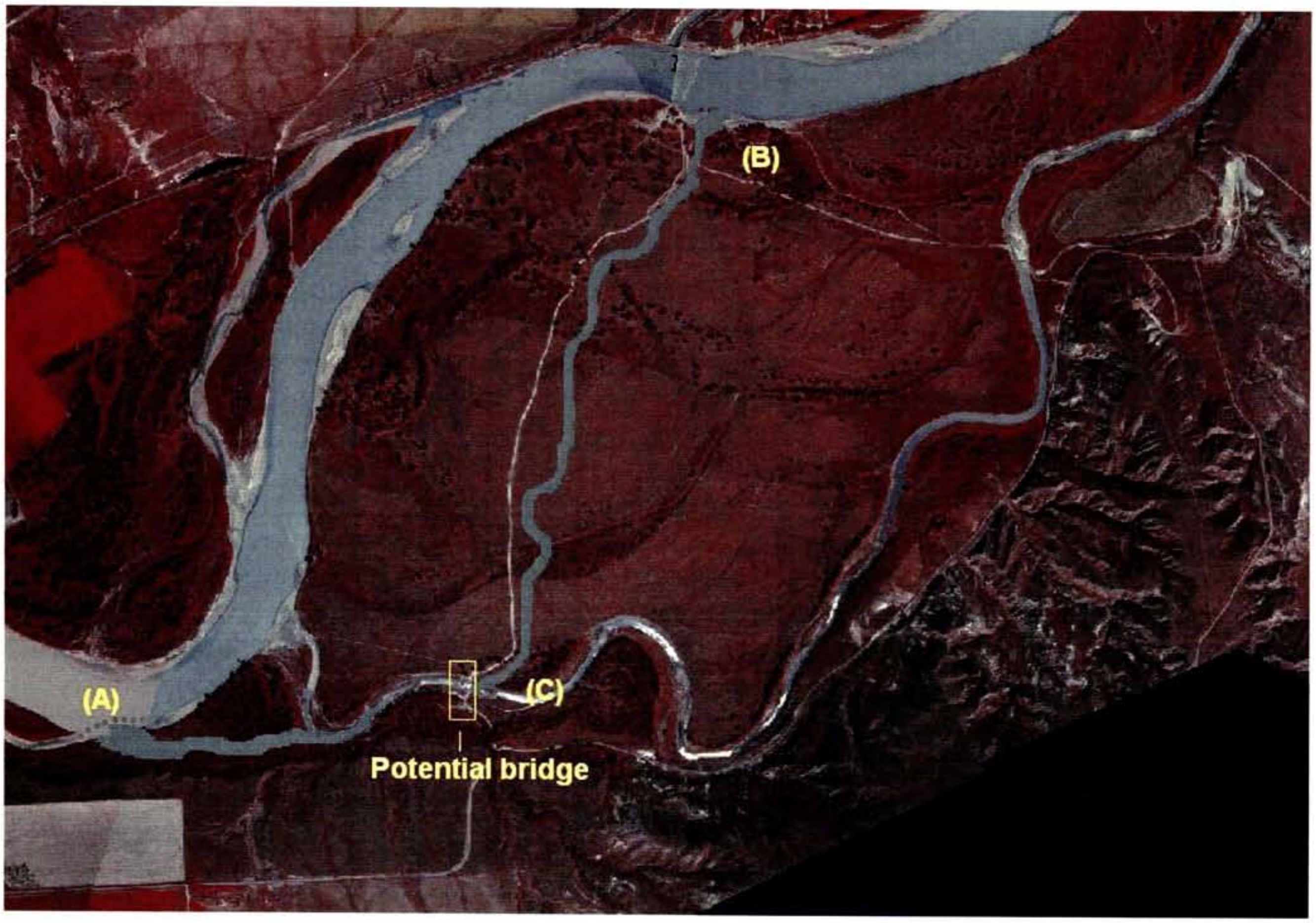
Ways to Implement: Standard construction methods.

Potential Risks

Side channel water outflow may affect dam integrity. The channel construction could capture the Yellowstone River and flank the dam. Would attraction flows be adequate?

Cost Item	Nonrecurring Costs	
Original Baseline Concept	$	8,740,000
Value Concept	$	10,496,000
Avoidance	$	-1,756,000
Value Study Costs	$	50,000
Net Avoidance	$	-1,806,000

Figure 11. Long Low-Gradient Channel



Natural Channel Inlet (A), Channel Outlet Structure (B), and High Flow Channel (C)
Constructed channel would be from (C) to (B), with channel enhancement from (a) to (C) and inlet modification/stabilization at (A).

Proposal No. 6

Description

Proposal No. 6. Remove Dam and Move Diversion Upstream

Proposal Description:

This proposal would relocate the existing intake diversion structure approximately 2.5 miles upstream from the existing intake structure to take advantage of the natural river gradient. There is a 14-foot difference in elevation between the existing intake structure and the new intake structure location. A canal with a bottom width of 50 feet and 1.5 to 1 side slopes would be constructed to convey the water from the new intake structure location to the existing canal, just downstream of the existing intake structure. To reduce the amount of cut, and to compensate for the 14-foot difference in elevation, a drop structure would be constructed near the existing intake structure. Rights-Of-Way or easements would have to be executed with local land owners and the Burlington Northern Santa Fe Railroad (BNSF) prior to construction. The canal alignment would cross the BNSF Railroad in two places and a county secondary road. Bridges would be required at these locations. The canal alignment would also cross Thirteen Mile creek which is a natural drainage coming from the North and exiting into the Yellowstone River. A twin set of 90" diameter steel siphon pipes, 600 feet long each would have to be constructed. A 1,100 foot riprap levee would be constructed to protect a portion of the canal from flood waters just downstream from the new intake structure. The already proposed fish screen would be located downstream of the new intake structure.

Critical Items to Consider:
Ice damage to the intake structure
River channel moving
Deep cuts
Sloughing of side slopes
Erosion of canal side slopes
Sedimentation
Waste of excavated material from deep cuts
Providing passage under railroad and secondary roads
Providing access to intake structure for maintenance

Ways to Implement:
Standard construction methods.

Changes from the Baseline Concept:
Diversion dam would be removed

Potential Risks

Ability to draw the 1,400 cfs needed for canal flows during low river flows.
By removing the diversion dam the geomorphological response of river away from the side channel would need to be evaluated.

Cost Item	Nonrecurring Costs	
Original Baseline Concept	$	8,740,000
Value Concept	$	41,088,000
Avoidance	$	-32,348,000
Value Study Costs	$	50,000
Net Avoidance	$	-32,398,000

Proposal No. 7

Description

Proposal No. 7. Rock Ramp (See Figure 12)

Proposal Description:

A rock ramp fishway would incorporate a natural rock riffle design to provide adequate irrigation head and allow fish passage for the majority of Yellowstone River fish species. Designed to mimic a natural river riffle the structure would reduce river elevation over a 1000 foot length, creating the necessary 0.5 % slope favorable for warm water fish species passage across the entire width of the Yellowstone River.

The structure would be designed to incorporate a series of rock weirs beginning at the existing diversion dam and moving downstream to reduce gradient. Placement of large boulders in an upstream pointing chevron pattern would allow designers to shift the existing thalweg away from the intake pipes toward the center of the channel thereby reducing fish entrainment into the canal works. The series of boulder weirs would provide resting habitats for upstream migrant fish.

Benefits of this design include:

- Breadth of the river fish passage available at all flow levels providing a variety of velocities attractive to various species. Examples would include paddlefish and sauger moving up the higher velocity thalweg while weak swimming species such as suckers and cyprinid minnows would find attractive velocities along river bank margins.
- Boat and floater recreational passage both up and downstream would be a secondary benefit inherent in this design.

Critical Items to Consider:

- Structure design could be developed to mimic existing examples within the Yellowstone River. Buffalo Rapids is a natural bed-rock rapids upstream of Intake and could provide basic direction for design of the rock ramp. The Yellowstone Irrigation Diversion located T6N, R35E, Sec 23 was constructed as a rock ramp design and functions to provide irrigation demand, fish passage and bi-directional recreational boat passage.
- The project would need to be designed to minimize impacts due to ice scour and large floating debris (cottonwood trees). Thalweg area would need to incorporate imbedded and grouted boulders.
- Project construction timing would need to be determined to avoid high flow periods and fish spawning migrations (April-July)
- Utilizing rock salvaged from the removal of the existing dam would provide cost avoidance by foregoing purchasing rock for the new rock ramp.
- Design of rock ramp fishway to accommodate high flow condition back eddies.
- Availability of adequate sized rock?
- Grouting of rock may be necessary to ensure the capacity to withstand ice flows and

reduce maintenance. This component of the project may entail coffer-dams and dewatering.

- Rock weirs may need to be placed behind driven sheet pile to secure and hold material in place.

Ways to Implement:

- Dam crest would need to be notched to accommodate the shift of the thalwag away from the outside bend of the river at the canal intake.
- Crescent shaped weirs should be designed to form a concaved profile on the downstream end of the rapid becoming flat in cross section as it approaches the crest of the dam. Rock weir slopes along the bank margin approach a 30^{O} angle.
- Weirs would be integrated into the bank with gaps between large boulders filled with smaller rock.
- Weir spacing would need to be determined to reduce elevation at a 0.5% grade.
- Materials for the rock ramp could be obtained in part by harvesting and re-use of existing rock from the Intake Diversion and immediate downstream areas.

Changes from the Baseline Concept:

The rock ramp design would retain some aspects of the baseline project related to fish passage and would retain the fish entrainment protection and canal screening components.

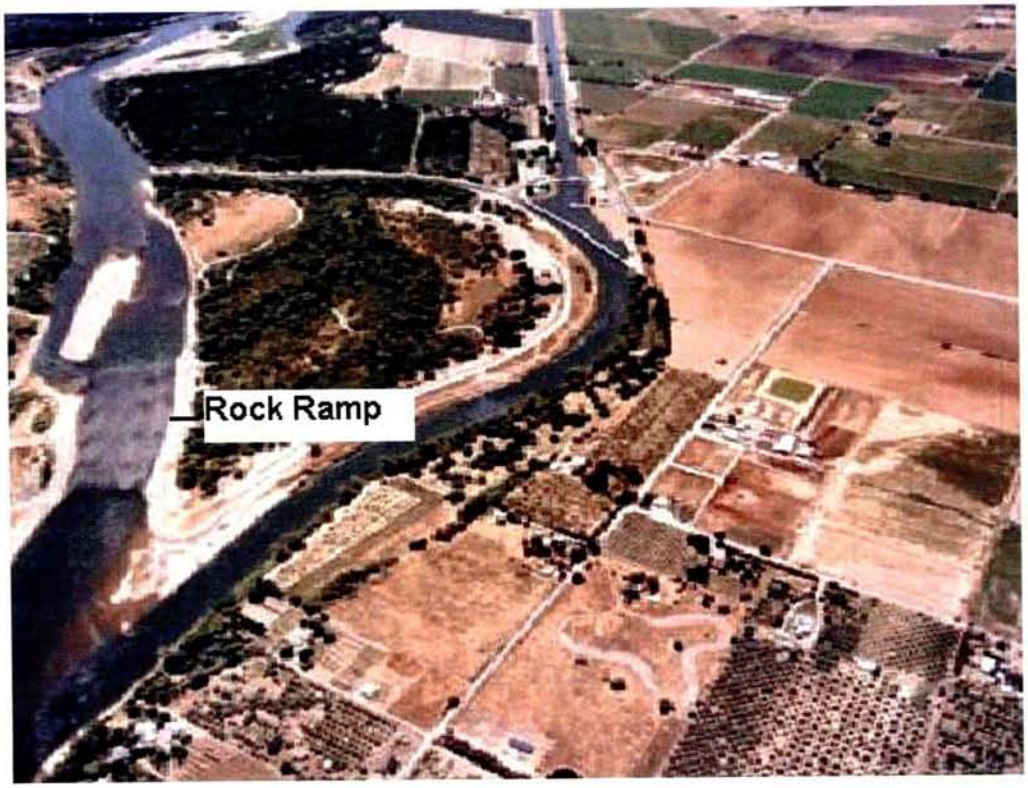
The rock ramp design would incorporate the use of the existing diversion structure as in the baseline concept but would be modified to provide thalweg direction and flow management. Fish passage would occur across the entire breadth of the river with attraction flows dependant upon weir design and placement as related to flow levels. The rock ramp would eliminate the need for a rock fishway channel proposed in the baseline concept.

Potential Risks

The risk of rock loss or shift due to ice scour and or large woody debris impacts would be the most prevalent concern with this design. Rock ramp structures can be designed and constructed to pass ice and debris and are currently in use on similarly sized systems in Minnesota (Midtown Dam – Red River) and Manitoba (Churchill River).

Cost Item	Nonrecurring Costs	
Original Baseline Concept	$	8,740,000
Value Concept	$	16,712,000
Avoidance	$	-7,972,000
Value Study Costs	$	50,000
Net Avoidance	$	-8,022,000

Figure 12. Rock Ramp



Ramp Rock on left side of photo above.

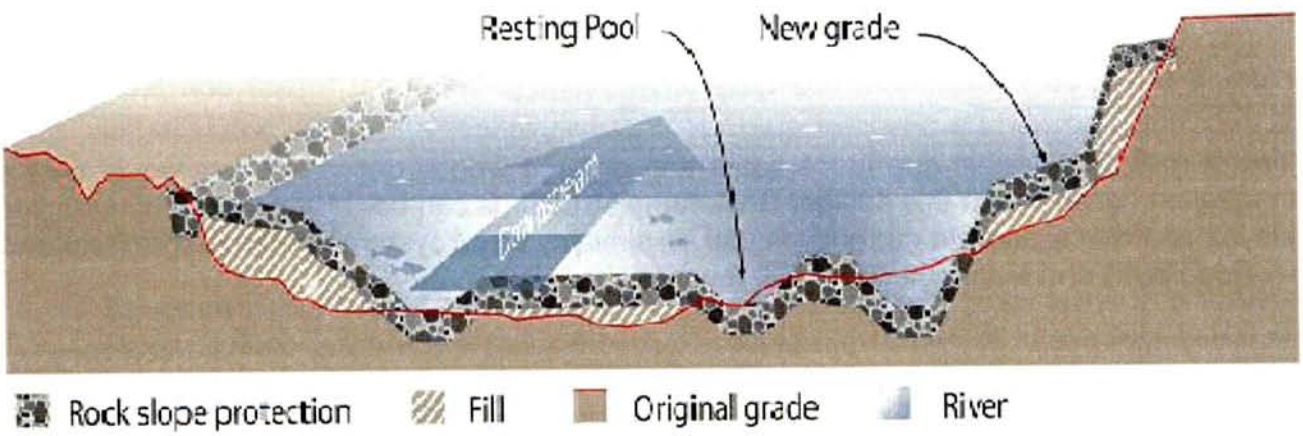


Diagram of rock ramp.

Proposal No. 8

Description

Proposal No. 8. Collapsible Gate (See Figure 13.)

Replace existing dam with a collapsible gate system and rock fishway (including screen system as proposed in Design Concept II)

Proposal Description:

- Collapsible Gate System: This proposal would remove the existing dam and replace it with hinged, collapsible gates (Obermeyer style) on a concrete foundation. An H piling/bearing would be incorporated to the front and back of foundation for added stability. The 660 foot river channel would be spanned with approximately 20, 33-foot wide gates. A rock fishway would be located near the south abutment to provide fish passage. During high-flow events, the gates would be lowered, removing obstructions to fish passage. As river discharge decreased, gates would be raised as necessary to divert flows into the irrigation canal.

  The existing dam has exceeded its design life and requires annual addition of material (i.e., rock) to maintain head at the irrigation canal intake. Existing data suggests that rock deposited on the dam crest has washed downstream and hinders the passage of pallid sturgeon, paddlefish and burbot given the resulting obstructions and turbulent flows. Under this alternative, rock that has washed downstream would be removed and incorporated into the project where applicable. Removing the existing rock dam would eliminate existing maintenance requirements, substantially improving conditions for upmigrating fish.

- Rock Fishway: For planning and comparison purposes, the general dimensions of the proposed rock fishway considered under this alternative would be similar to Design Concept II. However, modifications to the alignment would be necessary at both the downstream and upstream ends of the fishway to reflect installation of the collapsible gate structure. Construction of the new dam would move the existing barrier upstream several hundred feet, requiring a comparable relocation of the fishway entrance. The fishway exit, upstream of the dam, would be moved further upstream than currently proposed to protect against fish falling back over the dam during periods of high flow or when spill is being shaped to improve fishway operations during lower flow periods.

  The Design Concept II fishway is operational at all river flows above 5,000 cfs (i.e., about 80% of the time based on annual exceedence curves at Sidney, Montana). During the pallid sturgeon upstream migration (the target species for design purposes), the fishway should be operational about 95% of the time. To facilitate entrance into the structure, the fishway should be enlarged as much as possible to increase entrance attraction flows.

  The fishway entrance and exit would be located approximately 100 feet downstream and 150 feet upstream of the dam, respectively. The bottom width would be 8 feet and the sides at a 2.5:1 slope – under the Design Concept II configuration. Chevron-shaped boulder arrays would be placed within the fishway to create hydraulic drops about every

16.5 feet along the channel. The boulder arrays would provide the flow depth and resting areas necessary to support pallid sturgeon swimming abilities.

Critical Items to Consider:

- Collapsible Gate System:
  - Construction timing is critical to minimize environmental effects and a short construction season.
  - Evaluation of existing sheet piling to anchor the foundation slab should be conducted.
  - The existing structure has required major rehabilitation work on a 25-year cycle, with the last major repair being completed in 1979. A rock fishway without dam removal would be problematic due to the remaining large boulders that create turbulent flow and may prevent pallid sturgeon movement up rock fishway.
  - Retaining the existing structure would require continued additions of rock which may interfere with the fishway (i.e., boulders dislodged during ice events may end up in front of the fishway or in the thalweg, affecting entrance efficiency).

- Rock Fishway: The criteria used for the design of the fishway were:
  - Maximum water surface differential across the dam is 5.5 feet.
  - Maximum water surface drop per boulder weir is 0.35 feet.
  - Maximum passage velocity through slots is 4.8 ft/s.
  - Minimum flow depth is 2.0 feet.
  - Maximum channel slope of 2 percent.

  Stability of the riprap structure would be a major design concern. River ice moves the existing rock riprap relatively frequently, necessitating the addition of new rock on an annual basis. A rock fishway would be subject to these same issues, requiring protection to prevent recurring damage.

  Existing boulders in the stream channel would be removed to facilitate fish passage into the fishway. Post construction evaluation and monitoring would take place during various discharge years to determine whether the structure was meeting its intended purpose. Monitoring would include radio telemetry investigations, observations in the fishway, and mark and recapture efforts downstream and upstream of the project. Project success criteria would be developed and adaptive management concepts discussed prior to project construction.

Ways to Implement:

- Collapsible Gate System: Riprap washed out from existing project would be reclaimed by heavy equipment during the low water period in the fall or by hydraulic excavator. Existing riprap would be grouted to be used as the foundation slab if gate was mounted on bearing beam. Suggested construction schedule would begin construction on south half starting in late July and north half during the late Fall after diversion shutdown. Developing cooperative agreement with Irrigation District for the construction would reduce the overall cost of this proposal.

- Rock Fishway: The fishway would be constructed by excavation and placement of rock from the right abutment of the Diversion Dam downstream approximately 100 feet. It would include excavating, forming, and driving concrete piles in the river channel above the mouth of the fishway (to block ice) and construction of a partial cofferdam on the right side of the river. Construction would be completed in one construction season (September – March), and the cofferdam would be removed to an upland disposal site.

Changes from the Baseline Concept:

- Collapsible Gate System: Removes and replaces existing dam with hinged weir and fish passage channel. This proposal is likely to allow fish passage for a wider variety of species. This alternative:
  - provides opportunity for fish passage across the entire width of the river during the critical spawning period for pallid sturgeon and many native fish species while meeting project purposes;
  - eliminates the need for annual replacement of rock to maintain diversion capability of existing structure;
  - is preferred by the Fish and Wildlife Service, Montana Fish Wildlife and Parks and the Upper Basin Pallid Sturgeon Working Group over other alternatives where the dam remains in place;
  - replaces existing dam that has lost significant structural integrity due to exceedance of design life, thereby minimizing annual maintenance and avoiding future replacement;
  - when not in operation, this structure is aesthetically pleasing and provides unimpeded recreational boat passage;
  - gates can be operated to maximize effective performance of the rock fishway;
  - construction costs for the collapsible gate option are less than the infiltration gallery option, and the maintenance costs of the new structure would be moderate. With moderate costs, the Corps of Engineers recommends a dam removal option.

- Rock Fishway: The rock fishway proposed in this alternative is consistent with the baseline concept. However, several modifications are considered necessary to reduce the risks associated with long-term operations. These include realigning the channel to reflect changes in dam design and enlarging the fishway to allow more flow for improved entrance efficiency (i.e., how quickly pallid sturgeon locate the fishway and enter the structure). Also, success criteria would be developed prior to project construction and adaptive management options would be considered. Overall costs of the fishway, under the current design concept, would not change from the baseline. Additional costs would be incurred, however, to enlarge the fishway.

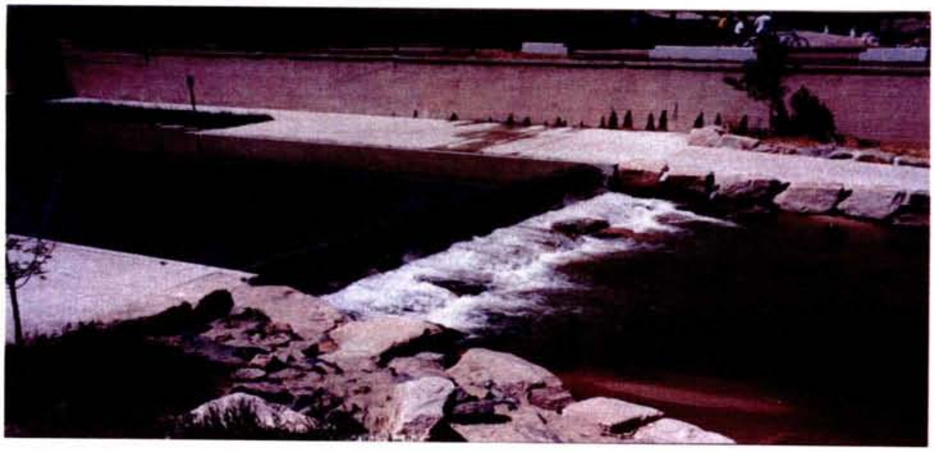
Potential Risks

- Collapsible Gate System: Fish movement would be limited to the fish passage channel when all gates were raised.
- Rock Fishway: The primary unknown is the efficiency of the fishway entrance. Given the difficulty in evaluating the project (few fish in the area that can be tagged, influence of migration behaviors, annual variations in river discharge, etc.), all reasonable measures to improve access to the entrance should be incorporated into the initial design. As such, additional consideration should be given to a guide wall, channel realignment and stabilization structures. Rocks should be removed from the tailrace as much as possible.

  Other risks include fallback at the fishway exit, and possible structural damages associated with ice flows.

Cost Item	Nonrecurring Costs	
Original Baseline Concept	$	8,740,000
Value Concept	$	21,657,000
Avoidance	$	-12,917,000
Value Study Costs	$	50,000
Net Avoidance	$	-12,967,000

Figure 13. Obermeyer Weir Photos



Proposal No.9

Description

Proposal No 9. Remove Dam and Build Single Pumping Plant (see Figure 14.)

This proposal consists of three main components: first, replacing the existing diversion dam with a single pumping station at the entrance to the canal; second, implementation of water conservation measures throughout the irrigation delivery system to reduce the amount of water needed for the project; and third, 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.

The diversion dam would be replaced with an electrically-powered pumping station to deliver up to 1,400 cfs from the Yellowstone River to the Main Canal. For this proposal the pumping station would be located within the existing Main Canal approximately 900 feet downstream from the existing headworks. The pumping station would allow gravity diversion from the Yellowstone River when flows are high enough to supply the head necessary for the system (on average about 20 days per year), and then would utilize the pumps at times of lower river flows. Since gravity diversion was assumed to be possible under this proposal, a fish screening structure would be required to reduce entrainment, the baseline concept design (single-vee with fish bypass pipeline) was assumed to be a component for this project. The screen would also serve the dual purpose of preventing fish entrainment into the pumping station during pump operations.

The pumping station itself was designed for 11 active pumps with a delivery capacity of 133 cfs each with four standby pumps for backup. The total power load for the pumping station would be approximately 2.8 MW. 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 plant with site work for roads, parking, and infrastructure; (3) removal and replacement of the existing headworks structure with inlet pipes lowered 7 feet to allow open channel diversion under low flows and excavate the Main Canal from the headworks structure downstream approximately 1,000 feet to the location of the pumping station; (4) construct fish screen structure from baseline plan; and (5) construct new high power transmission line to route power to the pumping station and auxiliary/backup power generation capability in the event of power outages. Conceptual costs for these items were developed for this proposal and are summarized in Table 1.

TABLE 1. PUMPING PLANT CONCEPTUAL COST ESTIMATE	
Project Element	**Conceptual Cost Estimate**
Remove Existing Dam	$ 1,394,000
Construct New Pumping Plant & Infrastructure	$ 7,763,000
Replace Headworks & Excavate Canal	$ 4,044,000
Construct Fish Screen Structure *	$ 6,114,000
Electricity Infrastructure & Backup Power Supply	$ 1,316,000

Sub-Total	**$20,631,000**
Contingency (30%)	$ 6,189,000
Pumping Plant Total	**$26,820,000**

* Fish screen estimate is baseline estimate without contingencies.

The second element of this proposal was the implementation of water conservation measures within the irrigation delivery system to reduce the demand for water and make efficient use of the water that is diverted. Conservation measures considered for this proposal included: (1) installation of water control/check structures within the canal and lateral system; (2) installation of flow measuring devices; (3) conversion of open channel laterals to enclosed piping to reduce evaporation and seepage losses; and (4) lining lateral channels with concrete to reduce seepage losses. Conceptual costs for the water conservation measures were developed for this proposal and are summarized in Table 2.

TABLE 2. WATER CONSERVATION CONCEPTUAL COST ESTIMATE	
Project Element	**Conceptual Cost Estimate**
Install Water Control/Check Structures	$ 2,500,000
Install Flow Measurement Structures	$ 800,000
Convert Open Channels to Pipes	$14,700,000
Line Open Channels with Concrete	$ 8,800,000
Sub-Total	**$26,800,000**
Contingency (30%)	$ 8,040,000
Water Conservation Total	**$34,840,000**

The intent of the water conservation measures would be to increase the efficiency of the Project water delivery system and/or water use. This proposal would also include economic measures to offset the increased annual and long-term O&M costs to Project water users resulting from the operation of the pumping station. Such measures could include investigating the use of Pick-Sloan preferred power rates for electricity and establishing an interest bearing trust fund such that the interest earned would be utilized to provide funding for power and maintenance costs in excess of present costs. The proposal would include measures to mitigate adverse environmental impacts such as visual impacts of power lines and pumping station building, noise, recreation activities (i.e. paddlefish sport fishery) and cultural resources. Because the water conservation measures are not specific to this proposal and could be implemented as an add-on to any of the proposals evaluated as part of the VE Study, that element is not presented as part of the cost for this proposal. Final costs for Proposal 9 only include those costs associated with the removal of the existing dam and constructing a single pumping plant at that location.

Critical Items to Consider:

- Dual system needed to allow gravity diversion at high flows and pumping at low flows.
- Potential erosion damage to railroad and road infrastructure upstream and downstream from diversion site once the dam is removed.
- Operation, Maintenance and Replacement costs.
- Economical power rate and transmission costs.

Ways to Implement:

- Conventional construction mostly during non-irrigation season.

Changes from the Baseline Concept:

- Long term fish monitoring is not required, fish will be able to move freely in the Yellowstone River.
- Major changes: existing dam would be removed, existing headgate structure would be replaced, upper 1,000 feet of the canal would be excavated lower by 7 feet, rock would be removed from river, new pumping station would be installed, no fishway would be needed.

Potential Risks

- Channel migration away from headgate impeding diversion under low flow: Probability - somewhat likely; Severity - moderate.
- Ability to draw the 1100 cfs needed for canal flows during low river flows.
- Loss of irrigation water at critical time: Probability - unlikely; Severity - very high.

Cost Item	Nonrecurring Costs	
Original Baseline Concept	$	8,740,000
Value Concept	$	26,820,000
Avoidance	$	-18,080,000
Value Study Costs	$	50,000
Implementation Costs	$	1,877,000
Net Avoidance	$	-20,007,000

Figure 14. Remove Dam & Build Single Pump Plant

Area Map

Proposal No.10

Description

Proposal No. 10. Do Nothing

Proposal Description: This proposal involves two possible scenarios: (A) nothing would be done to improve fish passage at Intake Diversion Dam on the lower Yellowstone River, but the proposed fish screen would be installed in the Main Canal; or (B) nothing would be done to improve passage or reduce fish entrainment (i.e. no fish screen). Under both scenarios, the irrigation districts would continue to operate and maintain the Lower Yellowstone Irrigation Project (Project) using the dam as presently configured and operated. About 300 to 1,200 cubic yards of large, quarried rock would continue to be placed on the crest of the dam annually (if needed) to replace rock displaced by high flows and/or ice -- this is necessary to maintain sufficient upstream head to allow diversion from the river into the Main Canal during low flow periods. The dam would continue to impede pallid sturgeon upstream migration and reduce access to their spawning and nursery habitats. Other native fishes in decline would likely continue that trend. Paddlefish would continue to be concentrated at the dam as they migrate upstream. Under scenario (A), fish that pass upstream and downstream of the dam would be protected from entrainment by the fish screen -- pallid sturgeon that did pass the dam or hatchery-reared sturgeon released upstream from the dam would be protected from entrainment. Under scenario (B), pallid sturgeon and other fish would be exposed to the same threats and adverse effects as present.

Critical Items to Consider:

- Pallid sturgeon populations and habitat in the Yellowstone River would continue to be severely impaired and degraded. If the present diversion dam remains in place and operated as in the past, it would be viewed as the principal contributor to the endangered status of the pallid sturgeon in the Yellowstone River. The pallid sturgeon is on the verge of extirpation from the Yellowstone River by 2017.
- There is widespread concern and interest in taking action at Intake Diversion Dam to improve passage for pallid sturgeon. "Doing nothing" to provide passage and/or reduce entrainment could be perceived as an indication of lack of commitment by Reclamation to protect a listed species; or comply with the requirements of the ESA; or pursue cooperative partnerships with other interested or effected parties to resolve a recognized problem.
- "The value of restoring the Yellowstone River as a natural migratory route for sturgeon and making the upper Yellowstone function as the spawning and nursery ground for pallids cannot be overstated.
- There is growing interest and intense pressure on water management agencies (BR and COE) in doing something substantive in the Missouri River basin to benefit pallid sturgeon and other native fish to offset the adverse effects of these agency's activities. Failure to improve passage and/or reduce entrainment would draw substantial criticism and possible litigation from environmental advocacy groups.

Ways to Implement:
Scenario (A) – Do nothing to improve fish passage, but install fish screen to reduce entrainment.

Scenario (B) – Do nothing to improve fish passage or reduce fish entrainment (no screen).

Changes from the Baseline Concept:
Scenario (A) – No action is taken to improve fish passage, but entrainment reduction is addressed through installation of a fish screen as included in the baseline concept.
Scenario (B) – No action is taken to improve fish passage or reduce fish entrainment.

Potential Risks

- Under both scenarios, unauthorized incidental take of pallid sturgeon could occur as a result of Project operation.
- Under both scenarios, the FWS may determine, through ESA-Section 7 consultation with BR, that continued operation of the Project using Intake Diversion Dam jeopardizes the continued existence of the pallid sturgeon and that either: (1) there is no reasonable and prudent alternative (RPA) to avoid jeopardy; or (2) a RPA is developed that involves modifications of Project operation to avoid jeopardy – such modifications could adversely affect Reclamation's ability to deliver water to Project water users.
- Under both scenarios, all or most of the agricultural crop production and direct/indirect economic benefits accruing from Project operation** would be at risk. The RPA, if one is developed, could require Reclamation to provide fish passage irregardless of cost or effect on Project water users.
- Under both scenarios, other native fish populations may continue to decline and could be federally-listed as threatened/endangered and require protection under ESA in the future.

** Annual crop value = $30 million (J. Nypen, 2005) times an economic multiplier of three (2001 Klamath Project Analysis of Economic Impacts Resulting from No Delivery of Project Water) up to nine equates to direct and indirect economic benefits of the Project of $90 million to $270 million ($180 million midpoint)

Cost Item	Non-Recurring Costs	
	Scenario (A)	Scenario (B)
Original Baseline Concept	$ 8,740,000	$ 8,740,000
Value Concept	$ 8,100,000	0
Avoidance	$ 640,000	$8,740,000
Value Study Costs	$ 50,000	$ 50,000
Implementation Costs	$100,000 (Sec. 7 consultation) plus cost of improving fish passage per RPA requirement (at least $640,000, up to $11.4 million, the cost of Obermeyer or similar measure to improve passage.)	Same as Scenario (A), plus $8,740,000 to install fish screen per RPA requirement.
Net Avoidance	$ 590,000	-$ 50,000

Evaluation of Alternatives Using Choosing By Advantages

As mentioned in the Value Method Process above, Choosing By Advantages (CBA) techniques were used to evaluate and prioritize the alternatives developed in the study. This sound decisionmaking approach was developed by Jim Suhr (formerly with U.S. Forestry Service) and is detailed in his 1999 book entitled The Choosing By Advantages Decisionmaking System.

CBA permits evaluation of all alternatives on a single scale, handles quantitative and qualitative data together, encourages innovation and avoids weighing relatively unimportant advantages too heavily by not pre-determining factor weights. It also provides a very transparent view into the "why" of alternative evaluation. The team used the CBA process to do a preliminary evaluation and ranking of the proposals. This process was useful to display the advantages of proposals nd to make recommendations for several alternatives to be carried forward for further study. However, due to time constraints on this process, this should not be considered the final ranking of alternatives or formal selection of a single best alternative for selection purposes.

The team began, during the Information Phase of the study, by generating a preliminary list of factors which it felt might represent beneficial differences among the alternatives likely to be developed.[3] This list was completed during the development phase of the study as follows.

Factor	Sub-factor	Attributes
Biological Effectiveness	Performance	Open channel, fishway, full fishway, or combinations
	Monitoring	Short term, medium term, long term
Constructability	Operability	Easy, medium difficulty, difficult, very difficult
	Maintainability	Easy, medium difficulty, difficult, more difficult
Risk	Biological Risk	Low, medium, high
	Water Risk	Low, medium, high
	Construction Risk	Low, medium, high
Tweakability (or how easily minor adjustments may be made to the completed construction)		Easy, medium difficulty, hard
Environmental Impacts (impacts of implementation of the alternative on the human environment such as cultural resources, aesthetics, noise, footprint of the project, etc.)		Low, medium, high
Acceptability (How well the project would be accepted overall, including all stakeholders involved in the process as well as the general public and surrounding communities.)		Scale from 1 (most acceptable) to 5 (least acceptable)

The alternatives developed in the study were placed on a matrix along the horizontal axis (10) and the factors along the vertical axis (11); total 110 cells. This matrix is one of several

[3] Definitions: A ***factor*** is an element, or a component, of a decision. It is also a container for criteria, attributes, advantages, and other types of data. This list of factors was finalized during the development process of the study. (Note that a factor names are high-order abstractions.) A ***criterion*** is a decision-rule or guideline; some criteria are musts, others are wants. A criterion is any standard on which a judgment is based, or any decision that guides further decisionmaking. (Criteria may be high-order, middle-order, or low--order abstractions.) An ***attribute*** is a characteristic or consequence of one alternative. An attribute is neither good nor bad except in comparison with another attribute. (Note that attributes are low-order abstractions.) An ***advantage*** is either a favorable dissimilarity (in quality), or a favorable difference (in quantity) between the attributes of two alternatives. An attribute is also the difference from a least-preferred attribute. (Note that a proper description of an advantage is a low-order abstraction.

approaches to CBA evaluation and is referred to as the Tabular Method. It was chosen because of the number of alternatives and factors.

The team then undertook, as a group, to determine the appropriate attribute for each factor/sub-factor for each alternative. These attributes are written into the matrix.

Then, as a group, the team identified the least desirable attribute(s)[4] within each factor and across all alternatives. These are usually underlined; for clarity, the team's CBA matrices colored these cells red.

Then, again as a group, the team determined the advantage of each attribute within each factor and across all alternatives. This is the beneficial difference between the attribute being examined and the least desirable attribute in the factor. The team then determined the most desirable advantage(s)[5]. These are usually circled; for clarity, the team's CBA matrices colored these cells green. From this group of most desirable advantages, the team, as a group, determined the paramount advantage – defined simply as that one of greatest importance in achieving the project's purposes. To this paramount advantage an importance value of 100 is assigned.

Following completion of this step, the team then undertook to subjectively determine the importance values for all remaining advantages in relation to the value of 100 assigned to the paramount advantage. These importance scores are summed for each alternative and compared. Adjustments are made as necessary. The team accomplished this part of the evaluation individually or in very small groups in the two weeks following the study in Billings. Results were sent to the team leader.

Through the CBA process (See Table 15. Compilation of CBA Scores and Rankings) there appeared to be readily separated into three tiers of alternatives by looking at compiled scores and analysis of individual matrices.

First, there are four alternatives that scored relatively high in the importance of their advantages with scores from 6,764 down to 5,625. These alternatives are recommended to be carried forward for further study and consideration. They are:

- Proposal #5: Long, Low-Gradient Channel
- Proposal #7: Rock Ramp
- Proposal #9: Remove Dam and Build Single Pumping Plant
- Proposal #3: Widen Fishway

Second, there are four alternatives that received scores from 5,496 down to 4,109. Although not in the highest tier of recommended options in the compiled score, some individuals rated these fairly high and they may be considered for further study. They are:

- Proposal #6: Remove Dam and Move Diversion Upstream
- Proposal #4: Multiple Pump Stations
- Proposal #8: Collapsible gates

Third, there are three alternatives that received relatively low scores (3,648 down to 2,712) and it is not recommended to carry them forward for any further consideration. They are:

- Proposal #2: Island

[4] There can be more than one if they are identical.

[5] There can be more than one if they are identical.

- Proposal #1A: L-Shaped Dam 6,600'
- Proposal #1B: L-Shaped Dam 20,000'

Alternative #10, Do Nothing, was not considered in the CBA process because it was not considered to be a viable alternative for fish passage.

The alternatives are listed below in order of descending compiled score. Twelve individual team members submitted matrices. Individual matrices also showed several members placed the same four alternatives in the top, but in different order. Each alternative title is followed by "Compiled Score", then the "Top Four" representing how many individual team members ranked that alternative in the top four of their scores, and then the "Top Score" indicating how many individuals ranked that alternative with the highest advantage score. The advantages that placed each of the alternatives in each respective category were analyzed from individual team members' score matrices and are discussed. Items that need to be considered for further study are also included for the alternatives that either are recommended or could be considered for further study.

Tier 1 – Recommended For Further Study

Proposal #5, Long, Low-Gradient Channel
Compiled Score: 6,674
Top Four: 11
Top Score: 7
This alternative received high scores for advantages in water risk, acceptability, and ease of operability and maintainability. Some members also gave this alternative a relatively high score for biological performance. This alternative is recommended to be carried forward for further study. Areas to be addressed include the feasibility of capturing enough water to function without eventually moving the bulk of the river flow to the side channel, effects of outflow on the dam integrity, and the adequacy of fish attraction to the constructed channel. The ongoing dam maintenance issues may also need to be addressed. Some critical items to consider may also add cost to this proposal that were not included in the estimate, and these should be explored.

Proposal #7, Rock Ramp
Compiled Score: 6,411
Top Four: 10
Top Score: 3
This proposal received high scores indicating important advantages in the factors of low water risk and ease of operability and maintainability. It also scored high in the area of overall acceptability, and received some importance scores in the biological performance and biological risk categories. This indicates somewhat of a compromise between the best alternative biologically and the best alternative for the irrigation districts to operate and maintain. It is recommended for further study to address uncertainty in the area of rock loss or shift due to ice scour or high flows, and to determine biological effectiveness for sturgeon species.

Proposal #9, Remove Dam and Build Single Pumping Plant
Compiled Score: 5,895
Top Four: 10
Top Score: 0
The advantage of removing the entire dam and thereby providing river-wide unobstructed fish passage in the factor of biological performance was chosen by the team as the paramount advantage. This proposal also received high scores for having low biological risk and a short

monitoring requirement. While this is the best alternative biologically, the scores were tempered by somewhat lower scores in the areas of operability, maintainability, environmental impact, and overall acceptability. This proposal is recommended to be carried forward for further study to explore operation and maintenance issues and costs, acceptability issues, and potential risks of dam removal affecting river geomorphology and possible infrastructure damage up- and down-stream of the existing dam.

Proposal #3, Widen Fishway
Compiled Score: 5,625
Top Four: 7
Top Score: 0
High scores in the areas of operability, maintainability, acceptability, and low environmental impacts indicated the team felt these advantages were important. This alternative was assigned a zero score in the biological performance category because, although it may be sufficient for fish passage it was considered the least desirable due to uncertainty. This proposal is recommended for further study to address questions with fish attraction and successful passage. The dam modification work is estimated for this proposal, but further in-river topography information is needed to fully design the necessary dam modifications.

Tier 2 – Could Be Considered for Further Study
Proposal #6, Remove Dam and Move Diversion Upstream
Compiled Score: 5,496
Top Four: 5
Top Score: 2
This alternative received high scores in the biological performance factor for providing an open river channel, and in the biological risk factor. It also received some high scores in the tweakability factor. However, this alternative was assigned a high risk in the water factor due to team uncertainty about the reliable delivery of water with this alternative, which was rated as an important advantage for other alternatives. It also rated low in the overall acceptability factor, most likely due to the realty issues involved with crossing private land and railroad tracks. However, this proposal is the next highest alternative, after pumping, that involves removal of the diversion dam and restoration of the channel for full fish passage, which was considered the paramount advantage by the team. It also ranked highly on some individual matrices. If further study of higher ranking alternatives show them to be infeasible or undesirable, this alternative could prove viable, and should be considered further. The water reliability issues would need to be investigated to ensure function, and the effects of removing the dam on river geomorphology would need to be examined.

Proposal #4, Multiple Pump Stations
Compiled Score: 5,283
Top Four: 5
Top Score: 0
Similar to the Single Pumping Plant, this alternative was rated the paramount advantage for providing a full open channel for fish passage in the biological performance factor. Analysis of the individual matrices shows scores similar to the single pumping plant in other factors as well, with the exception of maintainability and acceptability. The maintainability difference is probably a result of the pump stations being spread out so far apart. This alternative was assigned the least desirable attribute in the acceptability factor (resulting in a zero score), most likely due to resistance of the water users to use and maintain multiple pumping plants. However, if further analysis of the single pumping plant option solves the issues with pumping in general, this

alternative may be viable for consideration at that time. Other issues with this alternative are similar to the pumping plant alternative, including geomorphology issues and pumping operation, maintenance, and costs.

Proposal #8, Collapsible Gates
Compiled Score: 4,109
Top Four: 0
Top Score: 0
Because it provides an open channel part of the year and relies upon a fishway the rest of the year, this alternative received mid- to high-range scores in the biological performance factor. It was assigned the least desirable attribute, resulting in a zero score in the operability factor, which was rated fairly important for other alternatives. It was also designated a medium biological risk due to the uncertainty of being able to construct and operate the facility in a manner conducive to full fish passage. Uncertainty of the ability to construct this type of gates in this large of river system was reflected in low scores in the construction risk factor. This alternative has been examined in previous alternative analyses and was preferred by some as the best alternative at the time for fish passage. This study has developed other alternatives that address issues with previous ideas resulting in higher ranking alternatives. This alternative could still be viable for further study of higher ranking alternatives proved to be infeasible or undesirable.

Tier 3 – Not Recommended for Further Study
Proposal #2, Island
Compiled Score: 3,648
Top Four: 0
Top Score: 0
This alternative received the least desirable attribute in water risk, construction risk, tweakability, environmental impacts, and acceptability. Although it would be good biologically by providing a partly open river channel, the team rated it low due to these factors. The idea was considered to be developed, but upon further study the concept was determined to require such significant construction that other alternatives were considered superior.

Proposals #1A and #1B, L-Shaped Dam, 6,600' and 20,000'
Compiled Score: 3,027 and 2,712 (#1A, #1B)
Top Four: 0,0
Top Score: 0,0
These two alternatives received the least desirable attribute in water risk, construction risk, tweakability, environmental impact, and acceptability factors. Like the island alternative, this idea showed promise until analysis indicated the significance of the construction that would be required to implement it. Either alternative carried high risk of potential failure from flood waters, ice jamming, erosion, or channel movement altering the flow in each channel.

Figure 15. Compilation of CBA Scores and Rankings

Proposal Name	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 IMPORTANCE	3027	2712	3648	5625	5283	6764	5496	6411	4109	5895
RANKING	9	10	8	4	6	1	5	2	7	3

Disposition of Ideas

Value Study Elements Considered as Potential and Their Disposition	
Idea	Disposition
1. Remove dam	Combined with 43
2. Use elevators	Combine with 104
3. Catch and truck 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 B of R 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

Disposition of Ideas	
Idea	Disposition
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 water levels on Lake Sacagawea to lengthen Missouri River and increase larval drift time before reservoir	Infeasible
33. Add meanders and side channels to reduce slope and 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 Cantersville Dam	Infeasible
37. Use inchannel infiltration pipes	Rated 5
38. Guide fish with louver system	Infeasible
39. Make hydro facility including larger concrete fishway	Infeasible

Disposition of Ideas

Idea	Disposition
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, canals to reduce consumption, build pump sites, build wind farm with Pick-Sloan, and 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
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

Disposition of Ideas

Idea	Disposition
60. Buy out irrigators to reduce demand	Water conservation issue; out 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 catapault	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. Inchannel 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

Disposition of Ideas

Idea	Disposition
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 (not useful for comparison)
97. Concept II, Alternative 1A – riprap fishway around fishway	Rated 4
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

Disposition of Ideas

Idea	Disposition
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

List of Consultants

Consultant or Contact	Topic or Information
Name Title Organization Address Phone	**No Consultants Utilized**

Data and Documents Consulted

Title, Author, and Date	Information
Lower Yellowstone River – Water Diversion Inventory, Bureau of Reclamation and Montana Fish, Wildlife, and Parks, January 1999	
Intake Diversion Dam Yellowstone River Montana – Fish Protection and Passage Concept Study Report, Water Resources Research Laboratory, January 2000	
Fish Entrainment at the Lower Yellowstone Diversion Dam Intake Canal Montana 1996-1998, Steve Hiebert, Rick Wydoski, and Tom Parks, April 2000	
Assessment of Behavior and Swimming Ability of Yellowstone River Sturgeon for Design of Fish Passage Devices, Robert G. White, Ph.D., and Brent Mefford, P.E., January 2002	
Lower Yellowstone River Intake Dam Fish Passage Alternatives Analysis, U.S. Army Corps of Engineers, June 2002	
Value Engineering Final Report for Intake Diversion Dam Fish Protection and Passage Concept Design, Lower Yellowstone Project, Bureau of Reclamation Technical Service Center, July 2002	
Intake Diversion Dam - Fish Protection and Passage Concept Study Report II – Lower Yellowstone Project Yellowstone River Montana, Bureau of Reclamation Technical Service Center, 2004	

Design Team Presentation Attendance List
July 1, 2005 - 10:00 a.m.

Name/Title/Discipline	Address/Phone-Fax Numbers/E-mail
Michael Adams Value Study Team Leader Certified Value Specialist	Enlign Consultants 6309 Carmichael Street, Fort Collins, CO 80528-7071 Phone: 970-223-0702 Fax: 720-221-0771 E-mail: mike@enlignconsultants.com
Sue Camp Fisheries Biologist	Bureau of Reclamation, Montana Area Office P.O. Box 30137, Billings, MT 59107 Phone: 406-247-7668 Fax: 406-247-7338 E-mail: scamp@gp.usbr.gov
George Jordan Yellowstone River Coordinator Pallid Sturgeon Recovery Team Leader	U.S. Fish and Wildlife Service 2900 4th Avenue North, Room 301, Billings, MT Phone: 406-247-7365 Fax: 406-247-7364 E-mail: george_jordan@fws.gov
Dan Fritz Environmental Specialist	Bureau of Reclamation, Great Plains Regional Office PO Box 36900 Billings, MT 59107-6900 Phone: 406-247-7638 Fax: 406-247-7793 E-mail: dfritz@gp.usbr.gov
Lyle Lallum Civil Engineer	Bureau of Reclamation, Great Plains Regional Office PO Box 36900 Billings, MT 59107-6900 Phone: 406-247-7644 Fax: 406-247-7793 E-mail: llallum@gp.usbr.gov
Lou Hanebury Wildlife Biologist USFWS-ES	U.S. Fish and Wildlife Service 2900 4th Avenue, N., Room 301, Billings, MT 59105 Phone: 406-247-7366 Fax: 406-247-7364 E-mail: lou_hanebury@fws.gov
Bob Dach Federal Activities Specialist USFWS-ES	U.S. Fish and Wildlife Service 134 Union Boulevard, Suite 645 Lakewood, CO 80228 Phone: 303-236-4264 Fax: 303-236-0027 E-mail: robert_dach@fws.gov
Larry Tandeski Engineering Technician	Bureau of Reclamation, Great Plains Regional Office PO Box 36900 Billings, MT 59107-6900 Phone: 406-247-7633 Fax: 406-247-7793 E-mail: ltandeski@gp.usbr.gov
Patrick Erger Hydraulic Engineer	Bureau of Reclamation, Montana Area Office P.O. Box 30137, Billings, MT 59107 Phone: 406-247-7313 Fax: 406-247-7359 E-mail: perger@gp.usbr.gov
Jerry Nypen Manager	Lower Yellowstone Irrigation Project Route 1 Box 2064, Sidney, MT 59270 Phone: 406-433-1306 Fax: 406-433-9188 E-mail: jnypen@midrivers.com

Design Team Presentation Attendance List
July 1, 2005 - 10:00 a.m.

Name/Title/Discipline	Address/Phone-Fax Numbers/E-mail
Burt Williams	Nature Conservancy 208 North Broadway, #402, Billings, MT 59101 Phone: 406-256-7512 Fax: 406-256-7526 E-mail: burt_williams@tnc.org
Brent Mefford Hydraulic Engineer	Bureau of Reclamation PO Box 25007 (D-8560), Denver, CO 80225-0007 Phone: 303-445-2149 Fax: 720-544-0554 E-mail: bmefford@do.usbr.gov
Jeff McClenathan Hydraulic Engineer Chief Hydraulic Section	U.S. Army Corps of Engineers 106 S. 15th Street, Omaha, NE 69104 Phone: 402-221-4578 Fax: 402-221-3408 E-mail: jeffrey.t.mcclenathan@usace.army.mil
J. Greg Johnson Program Manager	U.S. Army Corps of Engineers 106 S. 15th Street, Omaha, NE 69104 Phone: 402-221-7258 Fax: 402-221-4890 E-mail: greg. johnson@usace.army.mil

Value Study Team Presentation Attendance List
July 1, 2005 – 10:00 a.m.

Name/Title/Discipline	Address/Phone-Fax Numbers/E-mail
Todd Dixon Administrative Officer	Bureau of Reclamation, Montana Area Office P.O. Box 30137, Billings, MT 59107 Phone: 406-247-7300 Fax: 406-247-7338 E-mail: tdixon@gp.usbr.gov
C.J. McKeral Deputy Area Manager	Bureau of Reclamation, Montana Area Office P.O. Box 30137, Billings, MT 59107 Phone: 406-247-7667 Fax: 406-247-7338 E-mail: cmckeral@gp.usbr.gov
Scott Boelman Supervisor Facility Operations	Bureau of Reclamation, Great Plains Regional Office PO Box 36900 Billings, MT 59107-6900 Phone: 406-247-7652 Fax: 406-247-7793 E-mail: sboelman@gp.usbr.gov
Stephanie Hellekson Civil Engineer	Bureau of Reclamation, Montana Area Office P.O. Box 30137, Billings, MT 59107 Phone: 406-247-7306 Fax: 406-247-7338 E-mail: shelekson@gp.usbr.gov
Hillary Kembel Civil Engineer Student	Bureau of Reclamation, Montana Area Office P.O. Box 30137, Billings, MT 59107 Phone: 406-247-7300 Fax: 406-247-7338 E-mail: tdixon@gp.usbr.gov
Dick Long Facility Operation and Maintenance Division Manager	Bureau of Reclamation, Montana Area Office P.O. Box 30137, Billings, MT 59107 Phone: 406-247-7307 Fax: 406-247-7338 E-mail: rlong@gp.usbr.gov
Marc Hamlet Mechanical Engineer/Estimator	Bureau of Reclamation, Great Plains Regional Office PO Box 36900 Billings, MT 59107-6900 Phone: 406-247-7649 Fax: 406-247-7793 E-mail: mhamlet@gp.usbr.gov
Jamie Macartney Business Resource Manager	Bureau of Reclamation, Great Plains Regional Office PO Box 36900 Billings, MT 59107-6900 Phone: 406-247-76644 Fax: 406-247-7793 E-mail: llallum@gp.usbr.gov

Team Concerns at Outset of Study

The following is a list of the stated concerns of the Value Team at the outset of the study.

1. Develop alternatives that allow water and fish of co-exist equally – not mutually exclusive.
2. Mitigate negative environmental impacts (if any).
3. Address all species – not just one or two.
4. Maintain and improve diversity.

Team Aspirations and Expectations

The following is a list of the stated aspirations and expectations of the Value Team at the outset of the study.

1. Choose alternative and proceed.
2. Devine alternatives and schedule.
3. Information on what is being considered.
4. Provide local input. See a workable solution.
5. Get definite direction and schedule.
6. Clear explanations on alternatives and water/fish effects.
7. Identify how environmental mandates incorporated into decision making.
8. Make sound recommendations to management.
9. Solution to fish passage and satisfy water requirements.
10. Assistance in picking alternative.
11. Generate good ideas and reach resolution on alternatives.
12. Find out what fish need.
13. Protect all fish.