Value Engineering

Final Report

Intake Diversion Dam Fish Protection and Passage Concept Design, Lower Yellowstone Project

(A10-1409-MTTT-001-00-0-1(6); 6B318)

July 29, 2002

Conducted in Cooperation with the Lower Yellowstone Irrigation Project Board of Control, Fisheries Department University of Idaho, United States Fish and Wildlife Service Bureau of Reclamation, Great Plains Region and Montana Area Office

U.S. Department of the Interior · March 3, 1849

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Bureau of Reclamation, Technical Service Center, Denver, Colorado

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Executive Summary

The Value Study Team met on July 8, 2002, for a 4-day study of the Intake Diversion Dam Fish Protection and Passage Concept Design. Intake Dam is a feature of the Lower Yellowstone Project . The total estimated cost of the baseline concept is $7,550,000. This amount includes 20 percent for design, contract administration and oversight. The Team developed ten proposals which are summarized below. If all the avoidance proposals are accepted, their maximum avoidance potential is $2,520,000 (Proposal Nos. 5-9). Note that in calculating the maximum potential avoidance, the cost of the study ($50,000) was deducted only once, rather than for each proposal item.

The proposed in-canal fish screen, fish bypass, and rock channel fish passage are not currently funded, but are a priority for funding by Reclamation.

Independent Proposals: The following proposals (except Proposal No. 10) are independent of all other proposals and could be accepted or rejected individually without affecting other proposals.

Proposal No. 1. Replace the Dam with a Collapsible Gate System and Fish Passage Channel. An Obermeyer gate system was used as an example in this proposal. The estimated life-cycle added costs of this proposal are $360,000 before adding any study and/or implementation costs.

Proposal No. 2. Increase Height of the Concrete Sill under Screens to 18 Inches. This proposal should improve sediment flushing and reduce screen plugging. The estimated added costs of this proposal are $150,000 before adding any study and/or implementation costs.

Proposal No. 3. Build a Fish Trapping Facility into the By-pass Area of Intake Canal Screen. The trap would enable information collection for downstream passage monitoring and other biological studies. The estimated added costs of this proposal are $82,000 before adding any study and/or implementation costs.

Proposal No. 4. Install Trashrack in Front of the Fish Screen. The trashrack would reduce the potential for screen damage and bypass plugging. The estimated added costs of this proposal are $380,000 before adding any study and/or implementation costs.

Proposal No. 5. Reduce Concrete in the Fish Screen Structure. This proposal simplifies construction. The estimated avoidances of this proposal are $590,000 before deducting any study and/or implementation costs.

Proposal No. 6. Use light, durable polyethylene material for flat plate screens at the Intake Canal Fish Screen. The estimated avoidances of this proposal are $740,000 before deducting any study and/or implementation costs.

Proposal No. 7. Reduce Screen Structure Wall Thickness. The estimated avoidances of this proposal are $50,000 before deducting any study and/or implementation costs.

Proposal No. 8. Replace Baffles with Perforated Plate. The estimated avoidances of this proposal are $725,000 before deducting any study and/or implementation costs.

Proposal No. 9. Install a 3-brush Cleaning System in Place of a Single Brush System. The estimated avoidances of this proposal are $415,000 before deducting any study and/or implementation costs.

Proposal No. 10. Replace Dam with Pumps. The estimated added life-cycle costs of this proposal are $10,750,000 before deducting any study and/or implementation costs.

Other Ideas: The Team identified 22 additional ideas for further consideration and development that are listed in the "Disposition of Ideas" table near the end of this report.

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Acknowledgment of Design Team and Consultant Assistance

The Value Study Team wishes to express their thanks and appreciation to Ms. Susan Kelly, the Montana Area Office Area Manager, and the members of the design team, who fully and cordially provided all requested information and consultation on the conceptual design and to the Lower Yellowstone Board of Control for providing meeting facilities, operational and maintenance information, and hospitality. 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 the component features of the program, project or activity to define the critical functions (performed or desired), governing criteria, and associated costs. Using creativity (brainstorming) techniques, the team suggested alternative ideas and solutions to perform those functions, consistent with the identified criteria, 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.

This report is the result of a "formal" Value Study, by a team comprised of people with the diversity, expertise, and independence needed to creatively attack the issues. The team members bring a depth of experience and understanding of the discipline 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 No. 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 1981.0 (original project datum; about 8 feet higher than NAV88 datum). See Figure No. 2. The dam was completed in 1909. The canal was originally designed with a 30-foot bottom width with 1.5:1 side slopes. The canal is designed to carry its full capacity of 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 diversion into the canal. Fish population studies by 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.

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 Figure Nos. 3 and 4.

A Fish Protection and Passage Concept Study Report for Intake Diversion Dam (January, 2000) recommended a 300-foot long, 10-foot high, linear, flat-plate, stainless steel fish screen located in the canal about 600 feet downstream of the canal headworks with a 3-foot diameter bypass pipe to return fish to the river, at an estimated Field Cost of $5,500,000. See Figure No. 5.

A Lower Yellowstone River Intake Dam Fish Passage Alternative Analysis (June, 2002) recommended a grouted riprap fish passage with a 2 percent gradient, a 10-foot bottom width, 2:1 side slopes, and boulder weirs. The estimated Field Cost of the ladder is $790,000. The proposed passage is similar to that shown in Figure No. 6. The report also included an Alternate Analysis considering dam removal and diversion via an infiltration gallery and pumping plant, and dam replacement with collapsible gates such as Obermeyer gates.

The total estimated cost of both the screen and passage components (the baseline concept) is $7,550,000. This amount includes 20 percent for design, contract administration and oversight. The life-cycle cost of the baseline was estimated by the study team to be about $13,050,000 for a 50 year life (see life-cycle cost analysis in the appendix).

Figure 1. Location Plan

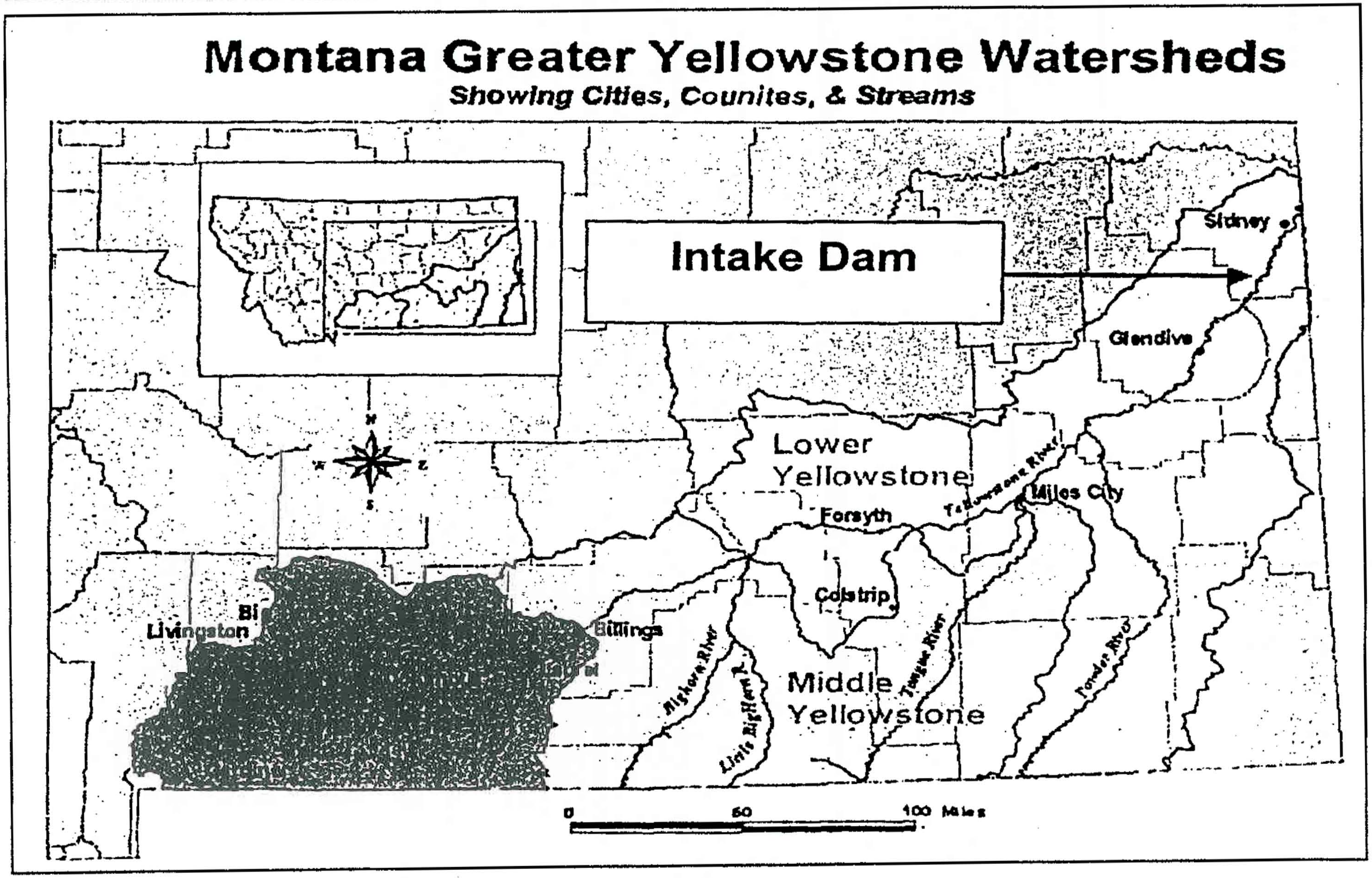
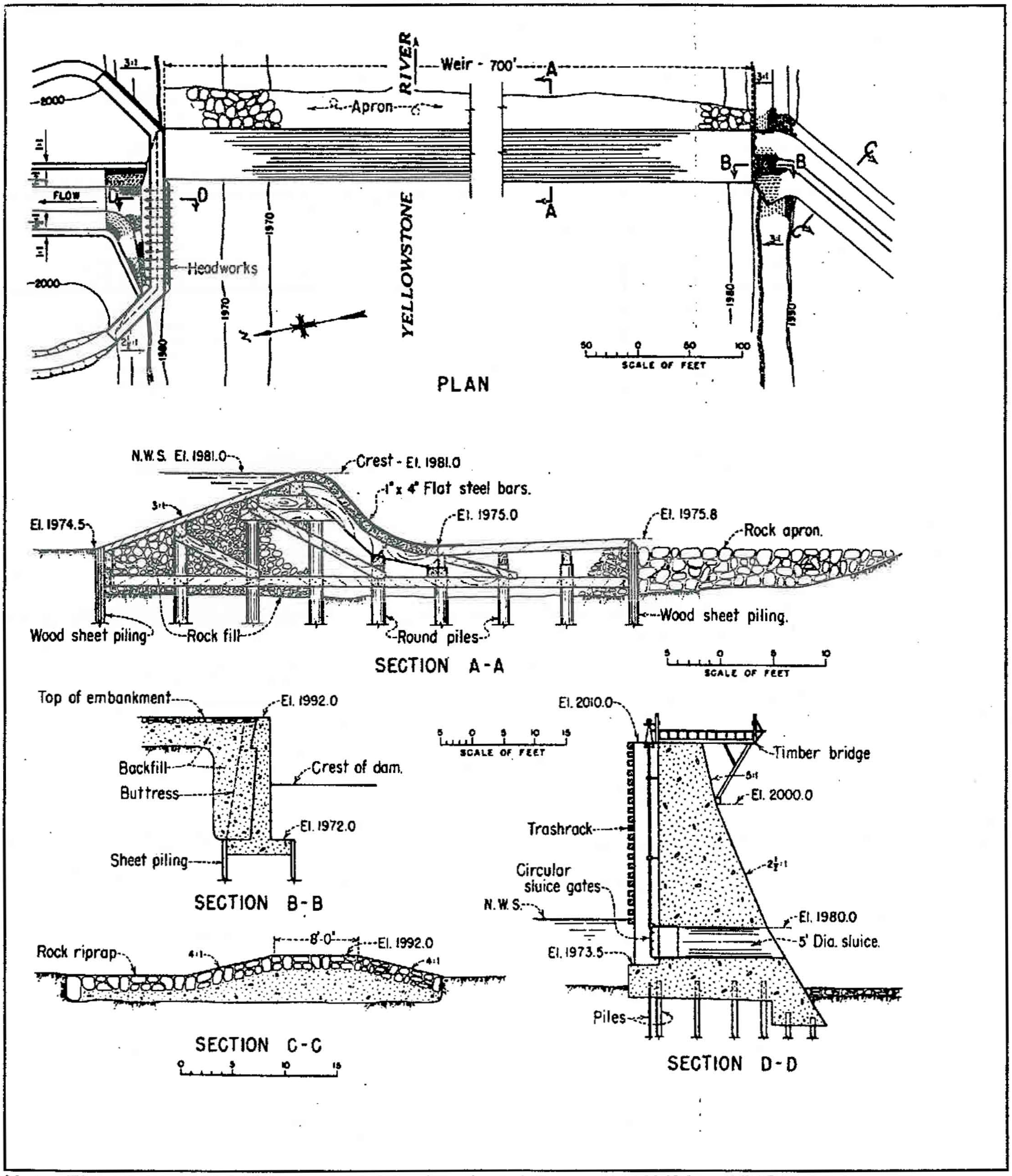


Figure 2. Site Plans and Sections



Note: Elevations on this figure are original project datum <u>not</u> NAV88 or NVGD datums.

[illegible] Photo

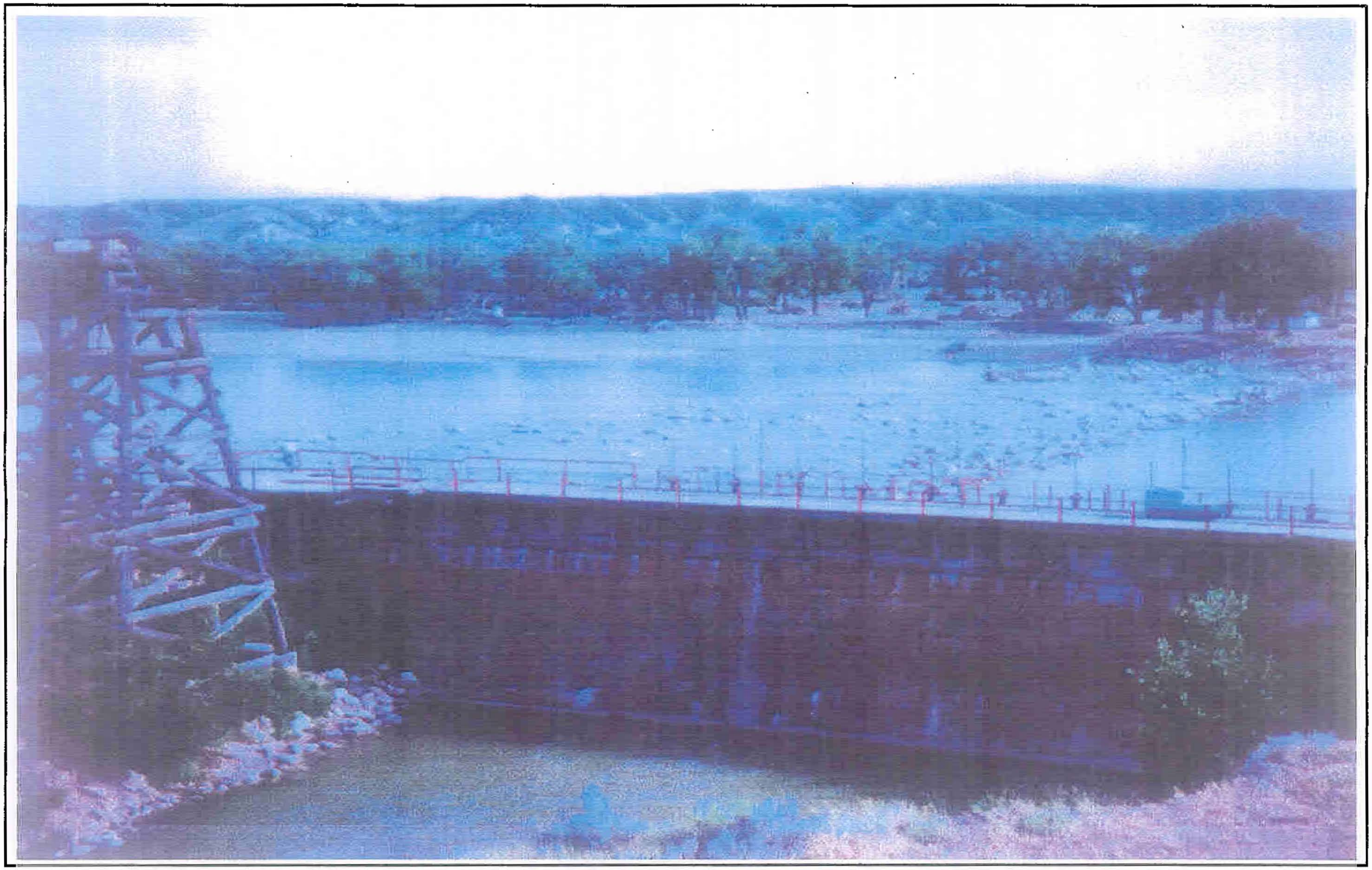
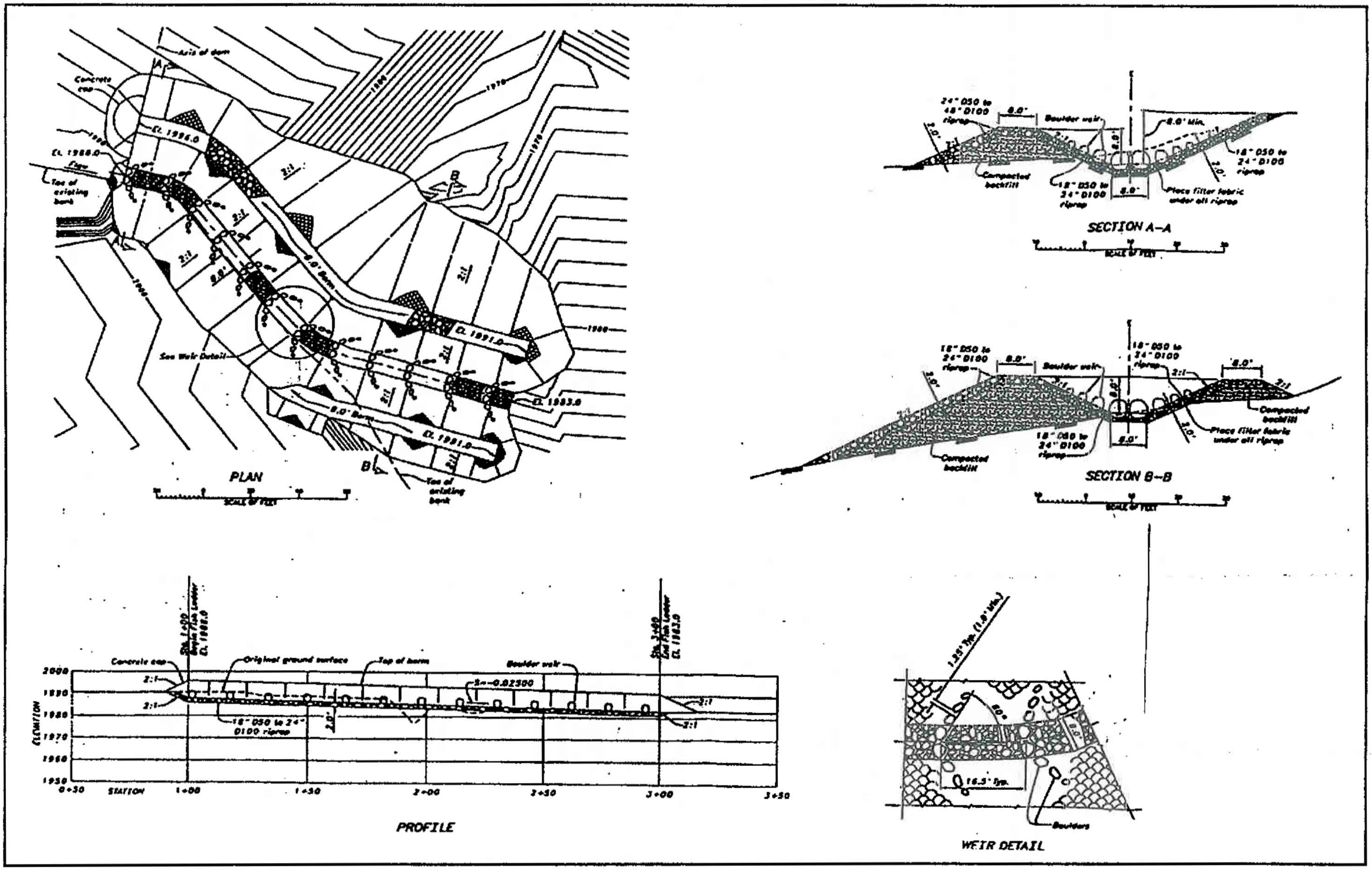


Figure 5. Proposed Fish Screen and Bypass

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

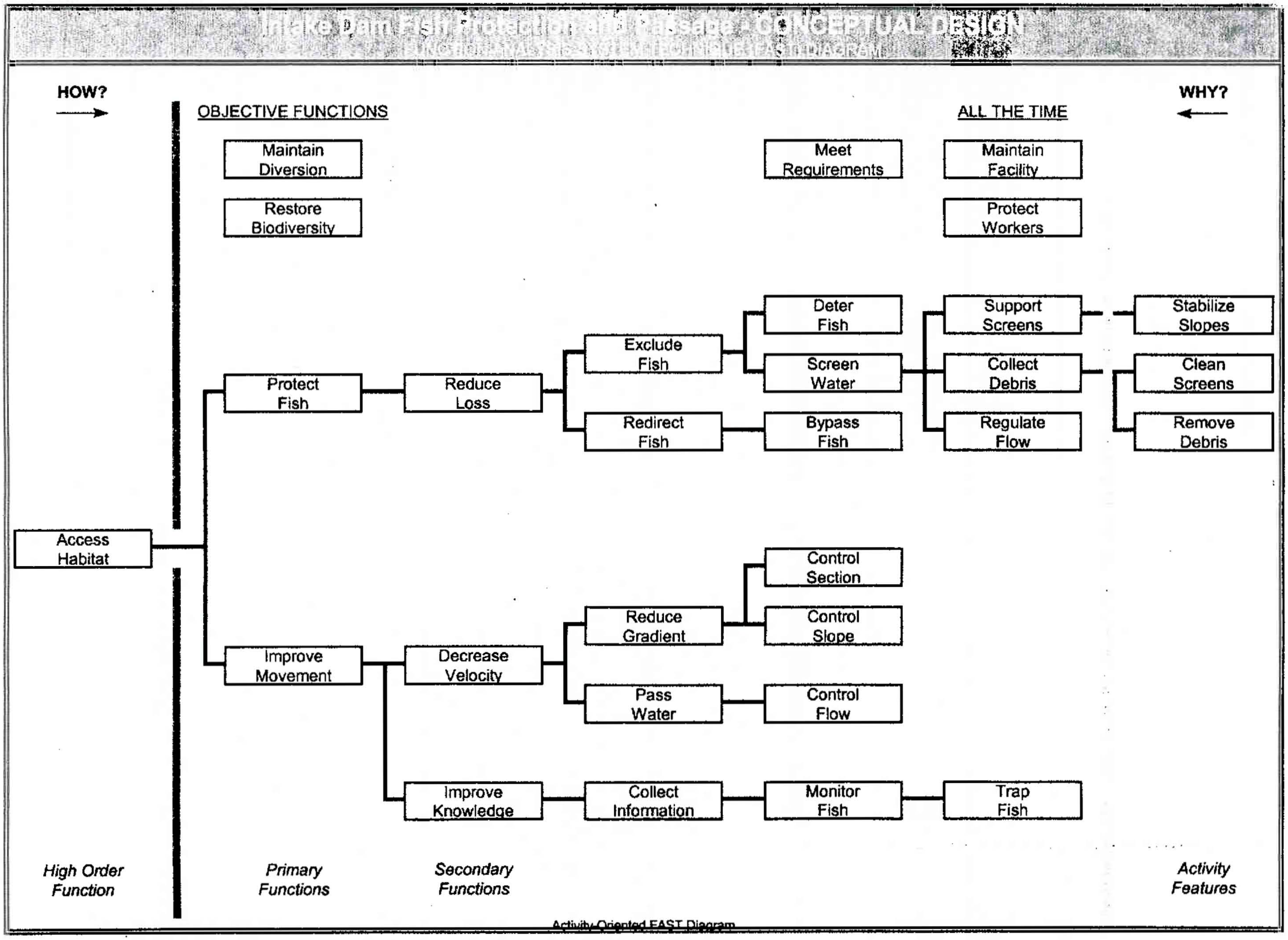
Component	Active Verb	Measurable Noun
Stainless Steel Screen	Screen Exclude Filter Decrease Exclude Collect	Fish Life Water Velocity Trash Trash
Structural Concrete	Support Control House Stabilize Eliminate Increase Enhance	Screen Shape Screen Section Erosion Life Maintenance
Adjustable Baffles	Regulate Tune	Flow Flow
Guides, Supports, Bracing	Support Simplify Support	Screens Maintenance Sweeper
Trash Rake/Brush System	Clean Prevent Move Require	Screen Plugging Debris Maintenance
Bypass Pipe	Move Return Flush Collect	Fish Fish Debris Debris
Grouted Riprap	Stabilize Disrupt Maintain Pass Pass Prevent Immobilize	Channel Flow Channel Fish Water Damage Rock
Divert River to construct Passage	Enable Reduce Protect	Construction Turbidity Workers

Function Analysis

Earthwork for Screen Structure	Prepare Allow Increase Stabilize Prevent Prepare Reduce	Site Forming Access Slopes Erosion Foundation Piping
Riprap	Protect Reduce Harden Increase Degrade Reduce	Structure Erosion Surface Erosion Bed Maintenance

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 functional point of view. The FAST diagram helped the Team identify those design features that support critical functions and those that satisfy noncritical 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.



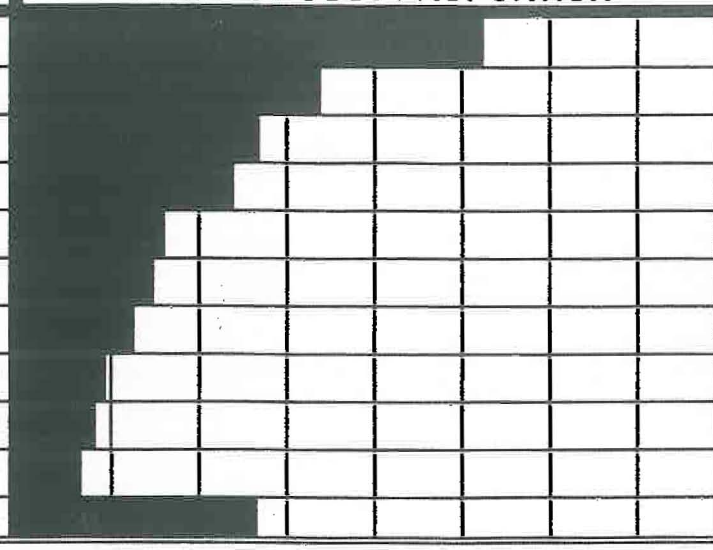
Intake Dam Fish Protection and Passage - CONCEPTUAL DESIGN
HOW?
WHY?
OBJECTIVE FUNCTIONS
ALL THE TIME
Maintain Diversion
Restore Biodiversity
Meet Requirements
Maintain Facility
Protect Workers
Access Habitat
Protect Fish
Reduce Loss
Exclude Fish
Redirect Fish
Deter Fish
Screen Water
Bypass Fish
Support Screens
Collect Debris
Regulate Flow
Stabilize Slopes
Clean Screens
Remove Debris
Improve Movement
Decrease Velocity
Reduce Gradient
Pass Water
Control Section
Control Slope
Control Flow
Improve Knowledge
Collect Information
Monitor Fish
Trap Fish
High Order Function
Primary Functions
Secondary Functions
Activity Features
Activity Oriented FAST Diagram

Intake Dam Fish Protection and Passage

VALUE STUDY

COST MODEL

COMPONENT/PERCENT PROJECT COST		PROJECT COST PROPORTION
Structural Concrete & Rebar	(22.6%)	
Stainless Steel Screen Panels	(14.6%)	
Adjustable Baffles	(11.6%)	
Guides, Supports, Bracing	(10.3%)	
Bypass Pipe	(7.0%)	
Trash Rake/Brush System	(6.4%)	
Grouted Riprap	(5.5%)	
Cofferdam for Passage	(4.1%)	
Earthwork for Screen	(3.6%)	
Riprap	(2.9%)	
All Other Items	(11.5%)	



Cost Model and Estimate Information

The Value Study Team cost model is based on the conceptual design estimates provided by the design team for the preferred project design. The cost model was developed by the Value Study Team and was used to focus on features with the greatest potential for avoidance and to highlight areas of value mismatch. Unit prices were reviewed by the Cost Estimator and Value Study Team members, to ensure reliability and applicability.

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.

Proposal No. 1

Description

Proposal No. 1. Replace the Dam with a Collapsible Gate System and Fish Passage Channel.

- Proposal Description: Because the existing dam has exceeded its design life and requires annual addition of material to the crest to maintain integrity, consider replacing the structure at this opportunity. This proposal would remove the existing dam and replace it with hinged, collapsible gates (Obermeyer style) on a concrete foundation slab. An H piling/bearing should be incorporated to the front and back of foundation slab for added stability. The gates will span about 660 feet across the crest of the dam and will consist of 20 gates that are 33 feet wide. A fish passage channel would be located at or near the south abutment to provide fish passage during low-flow conditions (drought). During high-flow conditions, most or all of the gates could be completely lowered presenting almost no obstruction to movement. As flows begin decreasing in the river, additional gates could be raised, creating sufficient head for diversion of irrigation water. Existing data suggests that the rock that has been deposited on the dam crest through maintenance and has washed downstream has contributed to the impediment of passage of fish such as the pallid sturgeon. Rock that has washed out from the existing structure would be removed and incorporated into the project where applicable.

- Critical Items to Consider: Construction timing is critical to minimize environmental effects and a short construction season. Check for differences between project datums and current National Vertical Geodetic Datum (NVGD). 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.

- Alternative Ways to Implement: Riprap washed out from existing project could be recovered for the use with the proposed project. It is expected that this rock could be reclaimed by heavy equipment (dozer) physically removing the rock during the low water period in the Fall or by hydraulic excavator. Existing riprap could 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 a cooperative agreement with Irrigation District for the construction could greatly reduce the overall cost of this proposal.

- Changes from the Baseline Concept: Removes and replaces existing dam with hinged weir and fish passage channel. This proposal is likely to increase opportunities of providing fish passage for a wider variety of native fish species over the baseline.

Advantages	Disadvantages

Proposal No. 1

• A hinged weir would greatly improve fish passage for gravity diversion system. 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. • Expressed by Fish and Wildlife Service (FWS) as the preferable alternative in informal Section 7 consultation. • 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 fish channel.	• Increased construction period. • May require a more complex permitting process.

Potential Risks

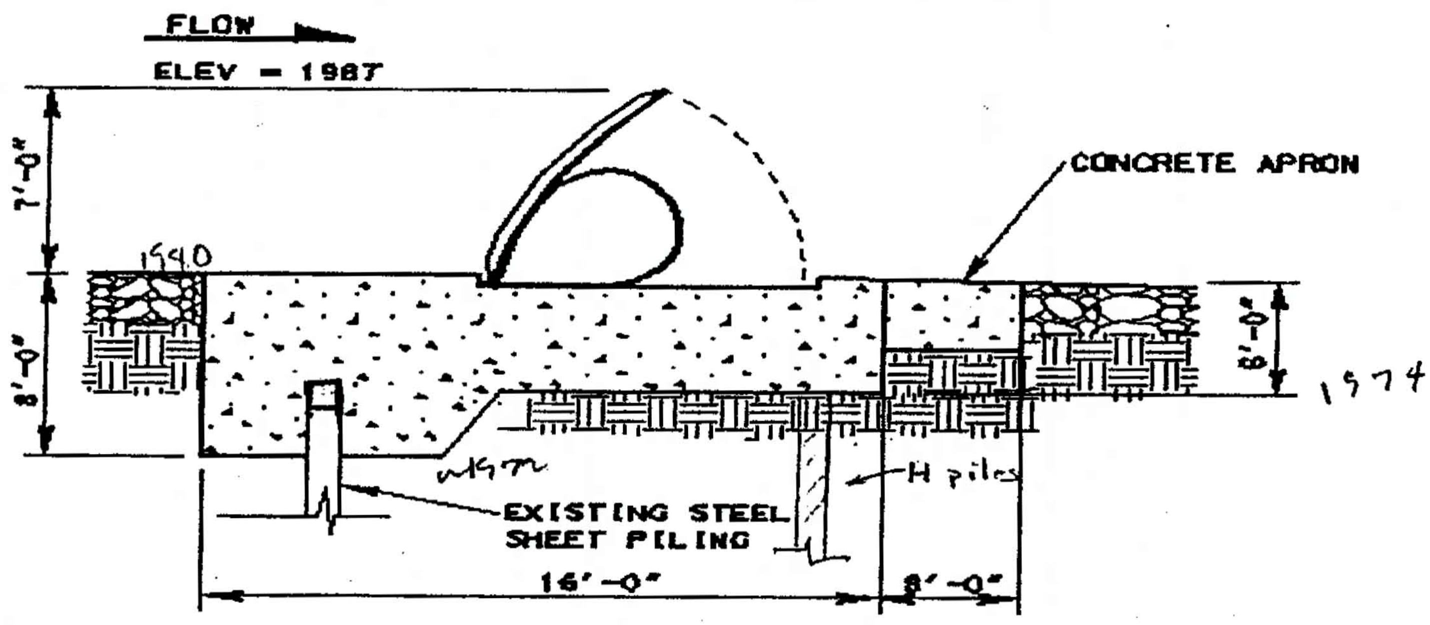
There is the possibility of limited fish movement over the existing dam, which would remain in place in the baseline. With this proposal, when all gates are raised, fish movement would be limited to the fish passage channel. This is a low risk, however, because this would be during times of low flow, such as a severe drought, and would not likely occur during a critical time for fish movement. There is also a potential risk for increased entrainment of native fish while downstream migration occurs. The bypass channel would divert most of the small native fish, however, the potential for entrainment of large number of the paddlefish could be increased. This will require further evaluation of fish behavior and entrance size into the canal and fish bypass. The south side of this structure would be attractive to anglers and recreational users and require security measures to exclude unauthorized persons.

Cost Items	Life-Cycle Costs*
Original Baseline Concept	$ 13,050,000

Proposal No. 1		
Value Concept	$	13,410,000
Avoidance	$	(360,000)
Value Study Costs	$	50,000
Implementation Costs	$	0
Net Avoidances	**$**	**(410,000)**

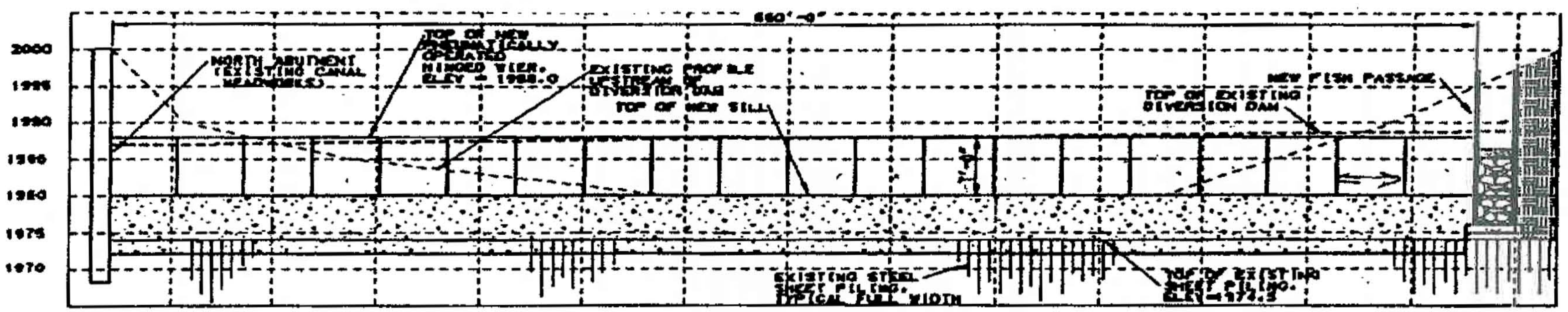
* See Life-Cycle Cost Analysis Table in Appendix for derivation of baseline and value concept costs.

Figure 7 – Hinged Weir Detail



NEW HINGED WIER DETAIL

NO SCALE



DIVERSION DAM PROFILE (ALTERNATIVE 1)

NOTE: VERTICAL SCALE = 5 x HORIZ SCALE

Figure 8. Obermeyer Weir Photos

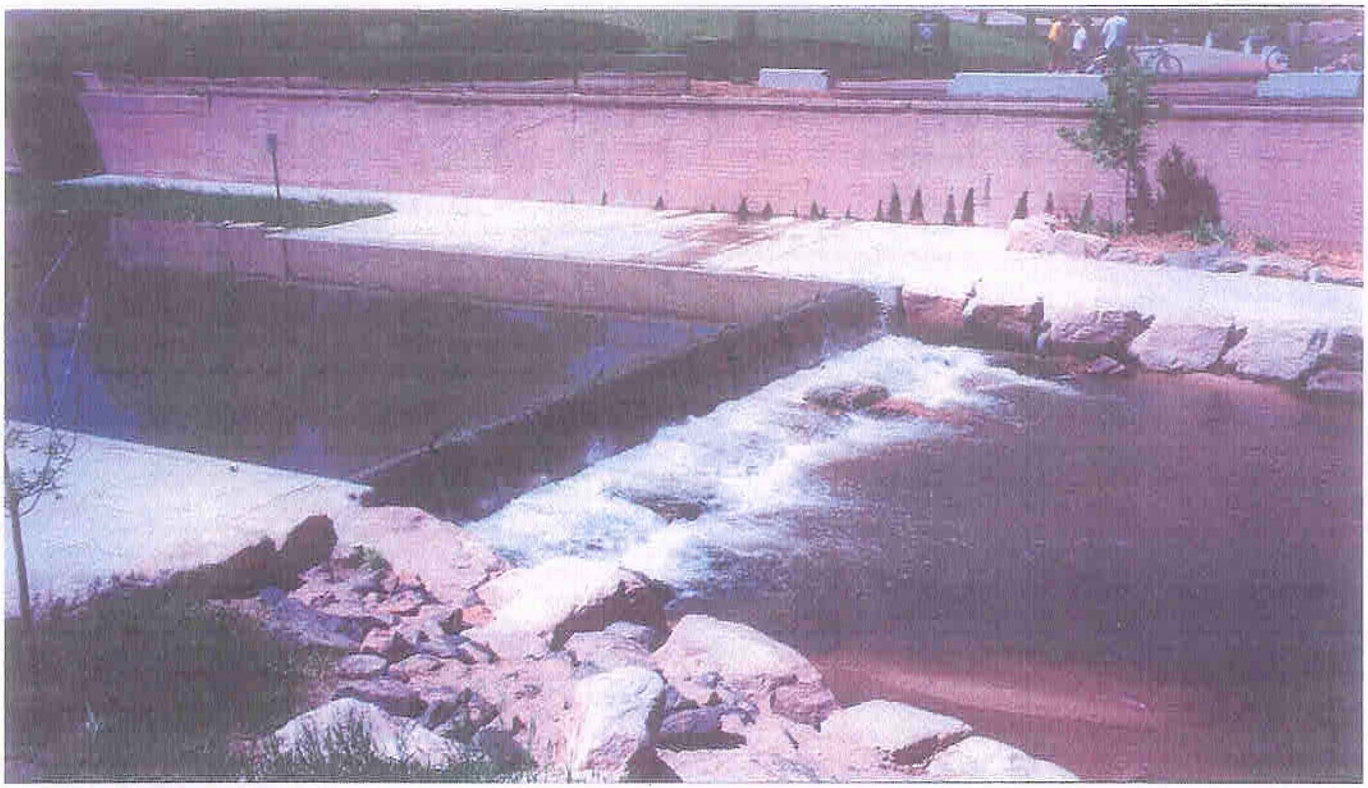
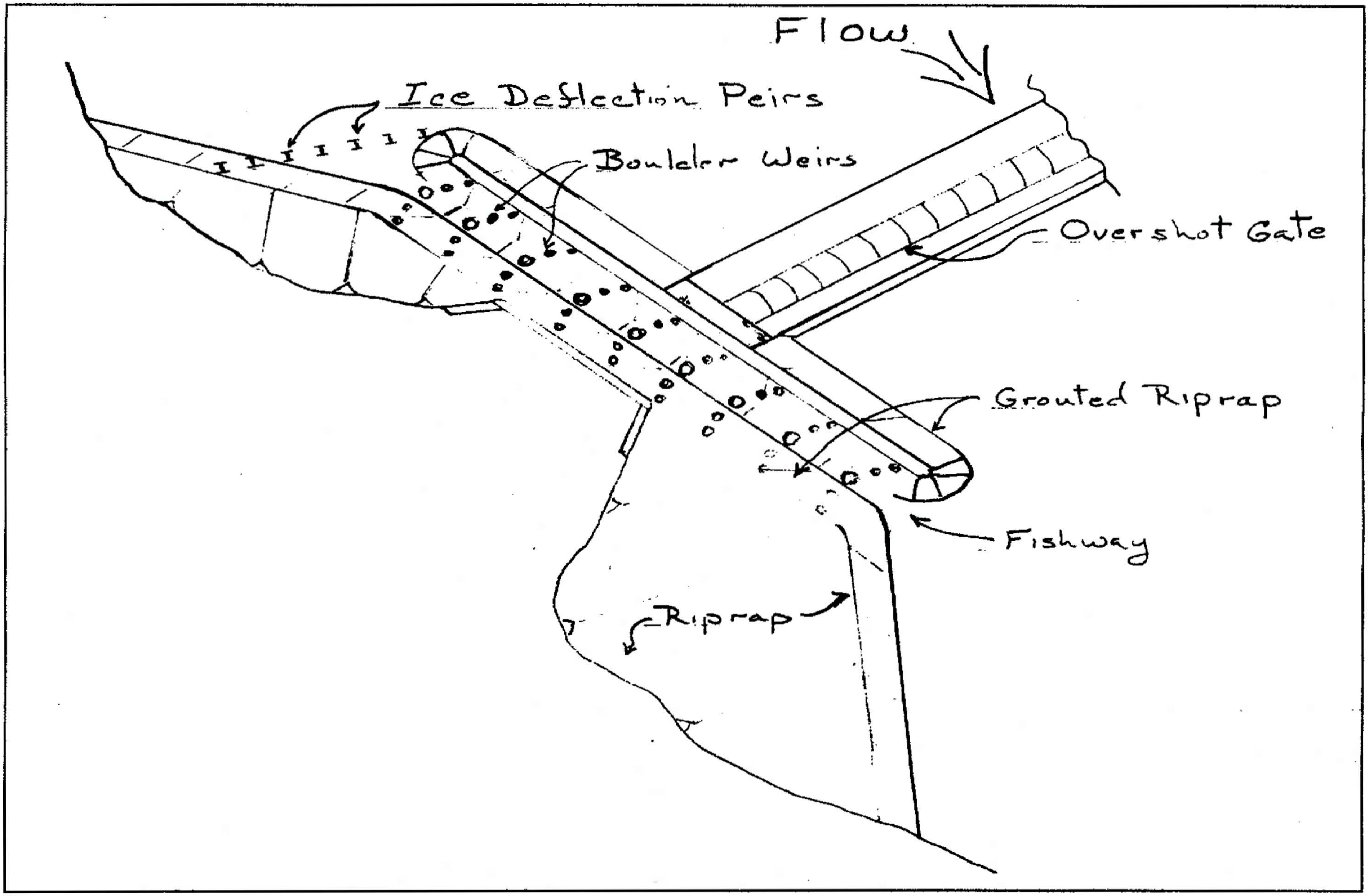


Figure 9 - Isometric View of Fishway



Proposal No. 2

Description

Proposal No. 2. Increase Height of the Concrete Sill under Screens to 18 Inches.

- Proposal Description: This proposal is to change the height of the concrete sill along the base of screen array from 6 inches to 18 inches, primarily to reduce exposure of bottom swimmers to the screens and to prevent silt buildup from impeding the screen cleaning brush. To keep the same wetted screen area, it will be necessary to substitute 37 - 9-foot by 9-foot screens in place of the 30 - 10-foot by 10-foot screens, lengthening the screen array by 33 feet.
- Critical Items to Consider: Exposure time to the screen is increased for some fish and reduced for others.
- Ways to Implement: Use sheet piles for screen support, as an alternative.
- Changes from the Baseline Concept: Total screen length will increase from 300 to 333 feet As a result, the constant width section length will increase from 350 to 380 feet. The angle of the screen array to the flow will decrease from 9.8 to 8.9 degrees.

Advantages	Disadvantages
• Protection from impingement for bottom fishes. • Prevent bottom of screen cleaning brush from dragging in the silt. • Possible increased fish guidance. • Increased sweeping flows along screen face because of a lower angle. • Allows sediment buildup along base of screen without requiring in-season maintenance.	• Lengthen facility and screen array.

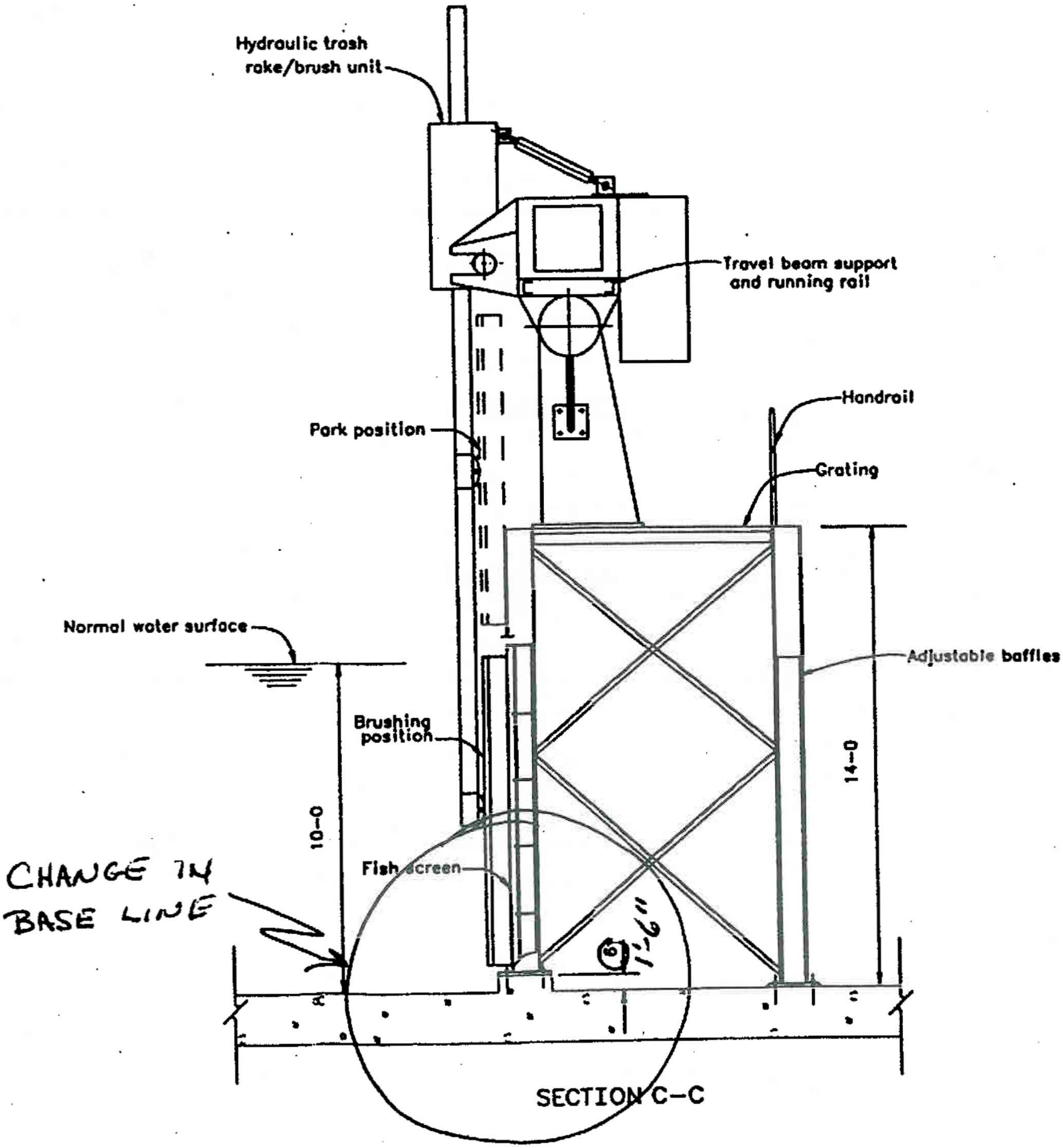
Potential Risks

None noted.

Proposal No. 2

Cost Items		Nonrecurring Costs
Baseline Concept for Screen Structure	$	2,800,000
Value Concept for Screen Structure	$	2,950,000
Avoidance	$	(150,000)
Value Study Costs	$	50,000
Implementation Costs	$	0
Net Avoidances	**$**	**(200,000)**

Figure 10. Screen Sill Section



Proposal No. 3

Description

Proposal No. 3. Build a Fish Trapping Facility into the By-pass Area of Intake Canal Screen.

- Proposal Description: This proposal is to add a fish collection area and trapping device at the downstream end of the screen array, close to the entrance to the by-pass. The trap would be submerged in the by-passed flow for brief intervals to collect live fish for monitoring and research purposes.
- Critical Items to Consider: The head available at high river flows will be minimal and might necessitate increasing the head at the baffles to increase flows through the by-pass. The diameter of the by-pass pipe may need to be increased to effectively pass fish and debris.
- Ways to Implement: Hand nets could be used as an alternative, but fish collection efficiencies would be greatly reduced without the trapping device. Design engineer will need to review ways to orient device in a confined area.
- Changes from the Baseline Concept: The baseline does not include a trapping facility. Changes include structural modification at bypass entrance and addition of a hoisting device.

Advantages	Disadvantages
• In-expensive and highly effective fish monitoring/ sampling site associated with fish screen. • Useful in monitoring benefits of upstream fish passage improvements for reproduction of pallid sturgeon and other native species. Sampling approach will maximize catch but minimize mortality of sampled fish. • Trapping device will be easily removed when not in use.	• Additional structural modifications and hoist needed at by-pass.

Potential Risks

None noted.

Proposal No. 3

Cost Items	Nonrecurring Costs	
Original Baseline Concept	$	0
Value Concept	$	82,000
Avoidance	$	(82,000)
Value Study Costs	$	50,000
Implementation Costs	$	0
Net Avoidances	**$**	**(132,000)**

Figure 11. Plan of Trap

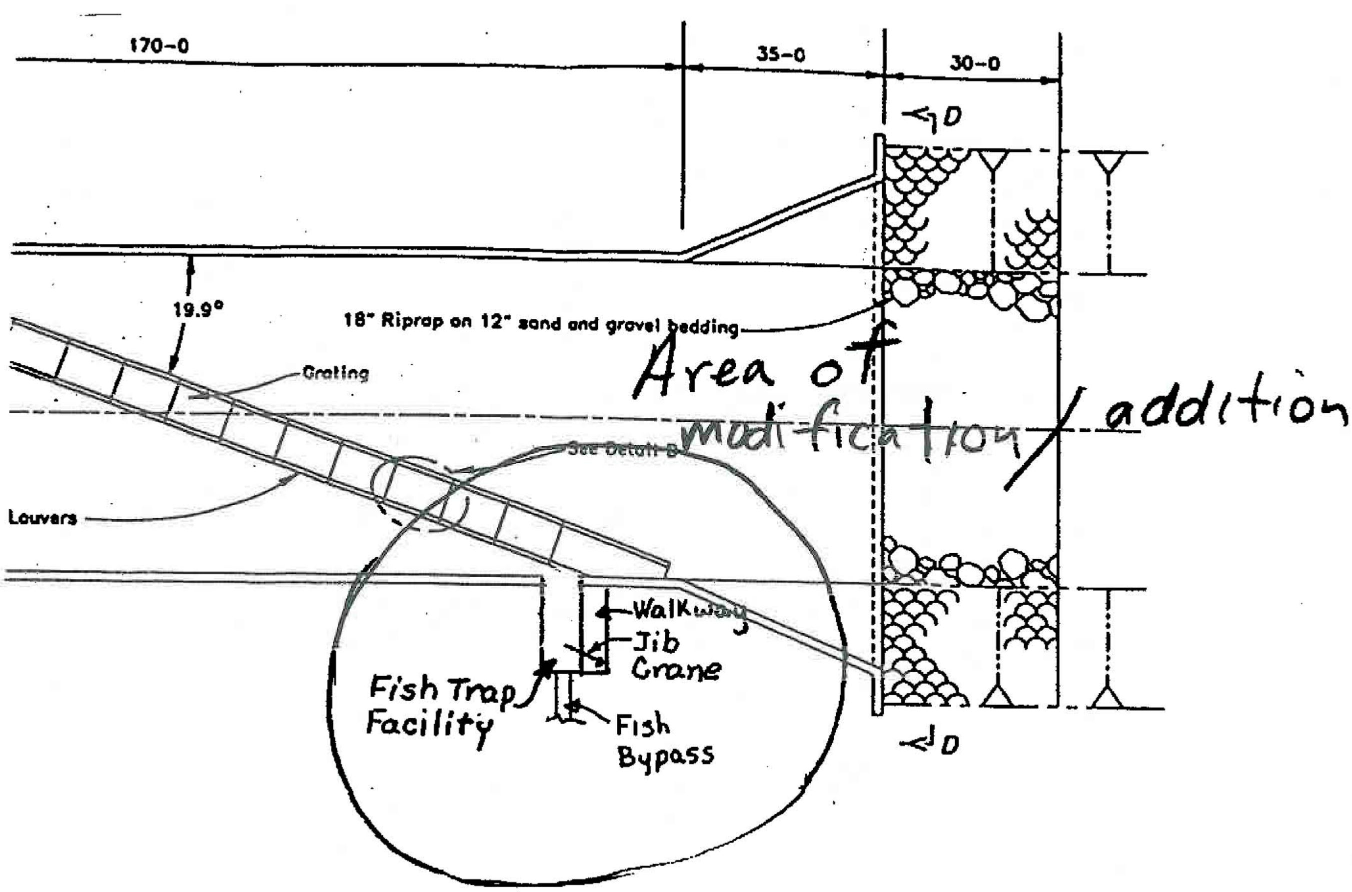


Figure 12. Trap Sections

Figure 13. Fish Trap Concept

Proposal No. 4

Description

Proposal No. 4. Install Trashrack in Front of the Fish Screen.

- Proposal Description: This proposal would install a trashrack upstream of the fish screen to collect and remove large debris that is entrained through the primary intake. The rack would consist of a structure with a middle pier with variable bar spacing to provide the greatest opportunity for fish passage. The portion of the rack in the upper half of the water profile would consist of bars set vertically with a 4-inch spacing, the mid-section of the water profile would have a spacing of about twelve inches and the lower 3-foot portion would have a spacing of approximately 24 to 48 inches. A hydraulic trash rake and conveyor would be included to provide a mechanical means of removing the debris for collection and removal.
- Critical Items to Consider: Trashrack needs to maintain sufficient spacing upstream of the fish screen to allow orientation to the fish screen for effective passage. Additional study may be needed to ensure structural integrity of bar width recommendation.
- Ways to Implement: None identified.
- Changes from the Baseline Concept: This proposal would be the addition of a trashrack to increase the effectiveness of the fish screen to function by removing the larger debris.

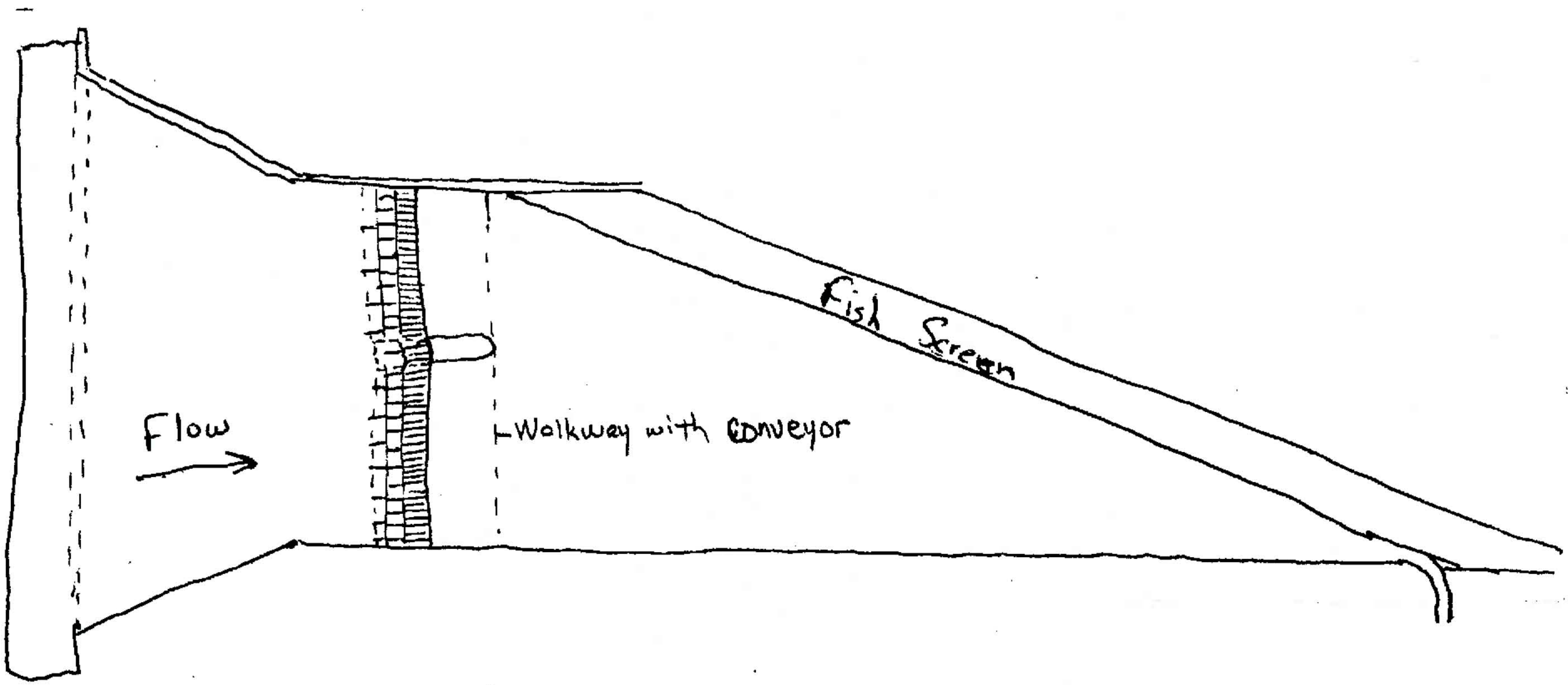
Advantages	Disadvantages
• This proposal would reduce the wear and tear of the screen by reducing larger debris impacts. • Would reduce the amount of debris that enters the Main canal, thereby reducing the amount of debris that collects on downstream structures, resulting in reduced maintenance. • Increases the effectiveness of the fish screen by removing larger debris before the screen and fish bypass. • Reduces the amount of debris that would be entrained through the bypass tube, thereby reducing the occurrence of blockage. • Would provide a centralized collection point for debris entrained into the Main canal.	• Would increase construction period slightly. • Would require daily attention to remove debris.

Proposal No. 4

Potential Risks	
This structure may attract non-authorized persons and require security measures to prevent access.	

Cost Items	Nonrecurring
Original Baseline Concept	$ 0
Value Concept	$ 380,000
Avoidance	$ (380,000)
Value Study Costs	$ 50,000
Implementation Costs	$ 0
Net Avoidances	$ **(430,000)**

Figure 14: Plan, Trashrack in Front of Screen



Proposal No. 5

Description

Proposal No. 5. Reduce Concrete in the Fish Screen Structure

- Proposal Description: This proposal would eliminate a section of concrete floor and wall downstream of the fish screens. The left side of the transition at the lower end of the structure would be relocated to just downstream from the upper end of the fish screen. The concrete floor of the canal would be reduced to only that needed for a foundation for the screen structure.
- Critical Items to Consider: Analysis may be performed to determine if bank armor and canal floor riprap are needed to control scour on the downstream side of fish screen.
- Ways to Implement: None noted.
- Changes from the Baseline Concept: This proposal would reduce the area of concrete.

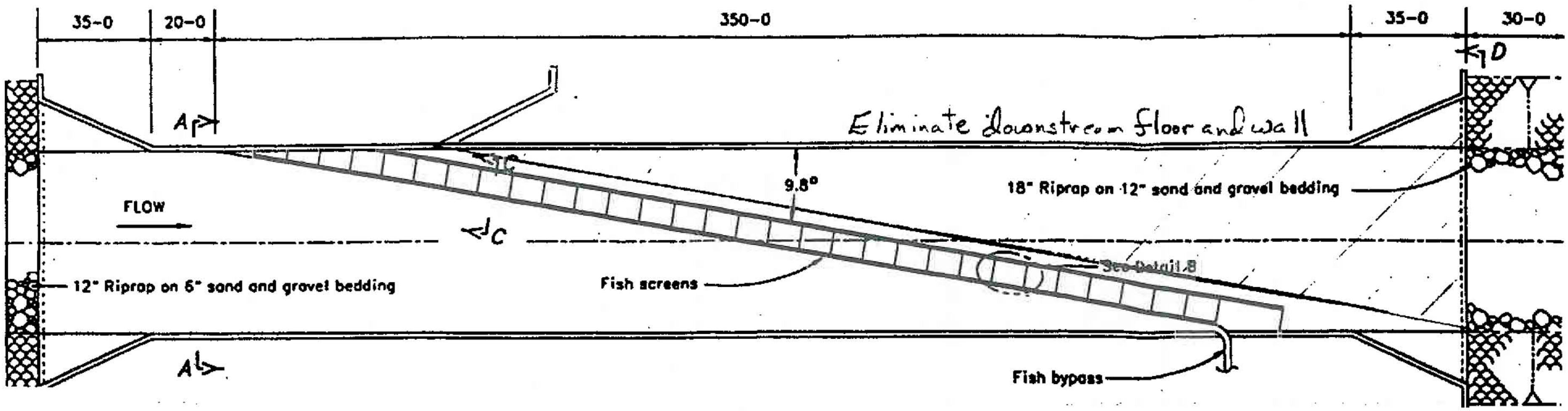
Advantages	Disadvantages
• Shorten construction time.	• Removal of sediment on downstream side of screen could be more difficult.

Potential Risks

None noted.

Cost Items	Nonrecurring
Baseline Concept Screen Structure Concrete	$ 1,835,000
Value Concept Screen Structure Concrete	$ 1,245,000
Avoidance	$ 590,000
Value Study Costs	$ 50,000
Implementation Costs	$ 0
Net Avoidance	**$ 540,000**

Figure 15. Plan of Wall and Slab Eliminated



Proposal No. 6

Description

Proposal No. 6. Use Light, Durable Polyethylene Material for Flat Plate Screens at the Intake Canal Fish Screen.

- Proposal Description: This proposal is to substitute polyethylene plastic screen material for stainless steel screen. Polyethylene is lighter and less expensive than stainless steel. Damaged sections are more easily replaced than wedge wire. To maintain existing diversions and approach velocities, a larger screen area may be required.
- Critical Items to Consider: Research the highest porosity available in polyethylene at 3/32-inch opening. Estimate life-cycle costs for this proposal.
- Ways to Implement: Use other material such as monel or brass for screens.
- Changes from the Baseline Concept: This is a change in screen material from the base proposal using polyethylene material in place of stainless steel.

Advantages	Disadvantages
• Polyethylene installs on the same frame work as base plan designed frame work. • Lightweight and easier to handle. • Cleans well. • Damaged sections can be replaced in strips much more easily than wedge wire. • Less debris accumulation on polyethylene than on wedge wire.	• More supporting structure required. • Less porosity requires more screen area than wedge wire.

Potential Risks

None identified.

Proposal No. 6

Cost Items	Nonrecurring Costs	
Original Baseline Concept, Fish Screens	$	1,100,000
Value Concept , Fish Screens	$	360,000
Avoidance	$	740,000
Value Study Costs	$	50,000
Implementation Costs	$	0
Net Avoidances	**$**	**690,000**

Proposal No. 7

Description

Proposal No. 7. Reduce Screen Structure Wall Thickness.

- Proposal Description: This proposal would reduce the thickness of concrete walls from 1 ½-foot to 1-foot. Freeze-thaw problems would be avoided by adding a 1 ½-foot-thick section of drain rock backed by a filter fabric. Water collected between the concrete wall and the filter fabric would drain through a 4-inch perforated pipe at the foot of the wall.
- Critical Items to Consider: Design for freeze-thaw events is essential in this rigorous climate.
- Ways to Implement: Normal construction techniques.
- Changes from the Baseline Concept: The major change is the replacement of thicker (1 ½-foot) walls with thinner (1-foot) walls backfilled with a layer of free drain fill and filter fabric. In the climatic conditions encountered at Intake, 1 ½-foot thick concrete is the baseline concept method of addressing freeze-thaw problems. The free drain fill and filter fabric combined with perforated pipe is designed to greatly improve drainage and allow the successful use of the 1-foot thick concrete.

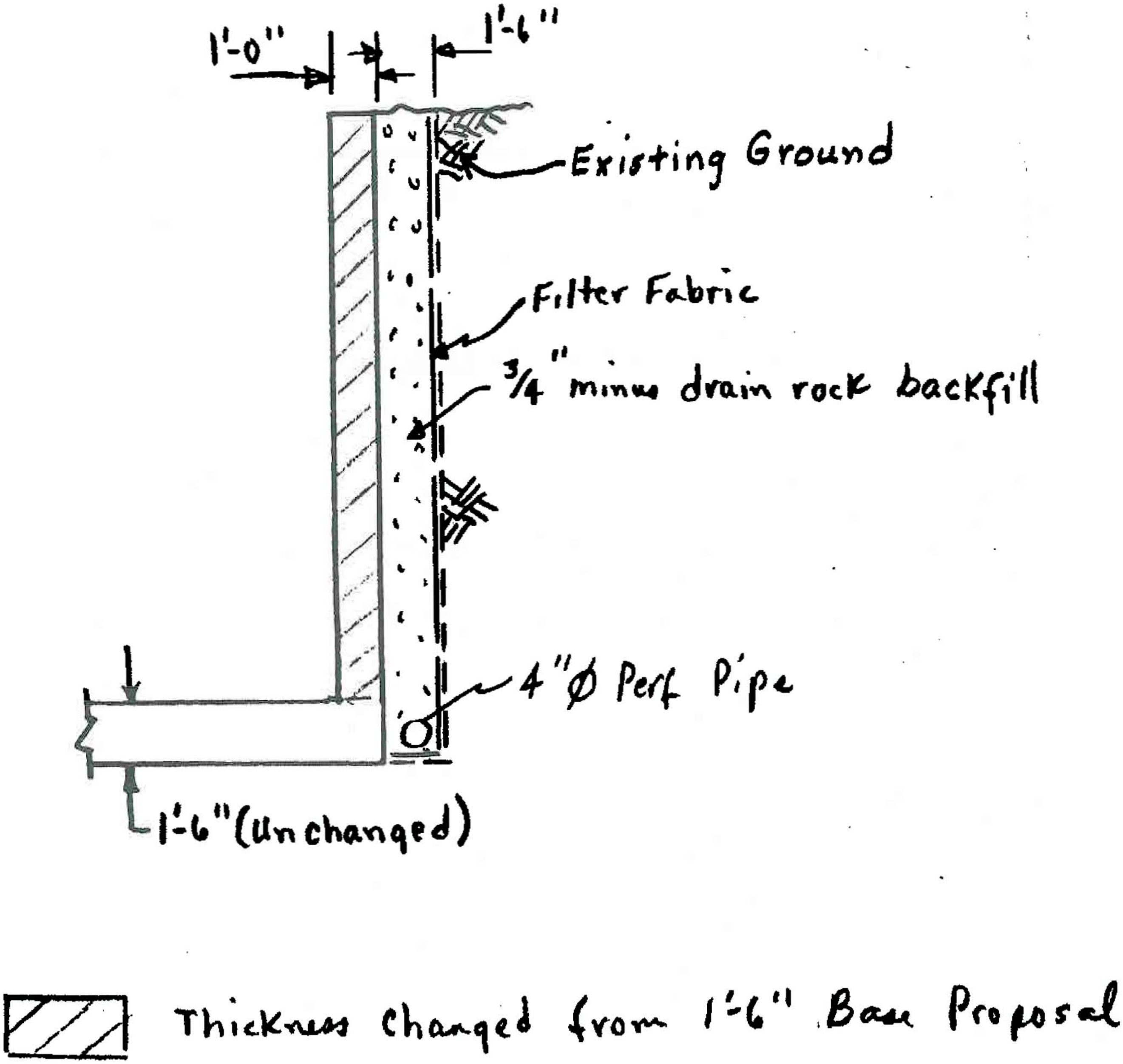
Advantages	Disadvantages
• Thinner, lower cost concrete walls using free draining backfill would successfully insure a structurally sound screen design.	• Change from baseline requires reliance on successful drainage behind concrete walls.

Potential Risks

None identified.

Cost Items	Nonrecurring Costs	
Baseline Concept, Wall Concrete	$	260,000
Value Concept, Wall Concrete, fill and filter	$	210,000
Avoidance	$	50,000
Value Study Costs	$	50,000
Implementation Costs	$	0
Net Avoidances	**$**	**0**

Figure 16. Wall Section



Proposal No. 8

Description

Proposal No. 8 Replace Baffles with Perforated Plates.

- Proposal Description: This proposal is to replace the adjustable baffles behind the fish screen with 10-foot by 10-foot, 3/8-inch-thick perforated epoxy coated steel plates to control the velocity of the water moving through the screen, (maintain the 0.5 feet per second). Two perforated plates will be used behind each 10-foot by 10-foot fish screen panel. One plate will be fixed while the other perforated plate will be on a screw movement system which will allow the perforated plate to slide up or down, thus changing the porosity behind the screen.
- Critical Items to Consider: None identified.
- Ways to Implement: No variation from the proposal.
- Changes from the Baseline Concept: Replaced the thirty adjustable baffles with sixty 10-foot by 10-foot with 1-inch diameter on 1- and 1/4-inch staggered centers perforated epoxy coated steel plates.

Advantages	Disadvantages
• Easier to adjust. • Ease of installation.	• None identified.

Potential Risks

May require additional structural support.

Cost Items	Nonrecurring Costs	
Baseline Concept, Baffles	$	890,000
Value Concept, Perforated Plates	$	165,000
Avoidance	$	725,000
Value Study Costs	$	50,000
Implementation Costs	$	0
Net Avoidances	**$**	**675,000**

Proposal No. 9

Description

Proposal No. 9. Install a Three-brush Cleaning System in Place of a Single Brush System.

- Proposal Description: With the length of the screen, a multiple brush system will clean the screens more successfully than one brush. With three brushes, screen would be cleaned 12 times per hour versus twice per hour with the base concept. The three brush system is designed for brushing, whereas the single brush system included in the base concept is designed for raking. The three-brush system is less expensive and will provide better cleaning at lower cost.
- Critical Items to Consider: None identified.
- Ways to Implement: A two-brush system or four-brush system could be installed, but three is considered adequate.
- Changes from the Baseline Concept: The change consists of a three-brush system instead of the one-brush system.

Advantages	Disadvantages
• Better cleaning capabilities. • Lower cost. • Less maintenance because of no hydraulic system.	• None identified.

Potential Risks

None identified.

Cost Items	Nonrecurring Costs	
Baseline Concept, Single Brush System	$	495,000
Value Concept, Mulitple Brush System	$	80,000
Avoidance	$	415,000
Value Study Costs	$	50,000
Implementation Costs	$	0
Net Savings	**$**	**365,000**

Proposal No. 10

Description

Proposal No. 10. Replace Dam with Pumps.

- Proposal Description: Replace the existing concrete dam and headworks structure with an intake gallery, pump, battery, and manifold. Remove dam and headworks entirely.
- Critical Items to Consider: Non-plugging intake system must be reliable. There must be a backup system if electrical power is used. Additional pump capacity must be provided for pump down time due to failure or routine maintenance or repair. Change in river hydraulics by removing the dam could do physical damage to private owners and public transportation.
- Ways to Implement: Natural gas fueled motors is an option. Pick-Sloan Missouri Basin Program project-use-power should be investigated. Dividing pump locations amongst downstream sites could be investigated.
- Changes from the Baseline Concept: Remove dam, replace with pumps. However, pumps still require fish screen, but not passage.

Advantages	Disadvantages
• The pumps provide the most desirable opportunity for fish passage.	• The pumps are not as dependable as the gravity system. • Pumps still need to be screened. • Annual Operation and Maintenance (O&M) costs are estimated to be $590,000

Potential Risks

Power loss and pump failure. Need to maintain backup power source to continue water pumping.

Cost Items	Lifecycle Costs	
Original Baseline Concept	$	13,050,000
Value Concept	$	23,800,000
Avoidance	$	(10,750,000)
Value Study Costs	$	50,000
Implementation Costs	$	0
Net Avoidance	**$**	**(10,800,000)**

Disposition of Ideas

Value Study Elements Considered as Potential Proposals and Their Disposition	
Idea	**Disposition**
Lengthen screen to better protect smaller fish (lower the approach velocity).	Refer to design team for consideration.
Change approach velocity criteria from 0.5 feet per second (fps) to 0.3 fps.	Refer to design team for consideration.
Add a fish collection trap in the bypass.	Developed as Proposal No. 3.
Add non-positive avoidance measures in front of the screen, e.g., light, electric fields, etc.	Refer to design team for consideration.
Add trashrack in front of gates.	Refer to design team for consideration.
Fabricate corpuscle shaped screens.	The team did not think of any way to make this idea competitive with the baseline.
Use a floating morning glory intake.	The team did not think of any way to make this idea competitive with the baseline.
Use man made riprap for boulders in the fish passage.	Refer to design team for consideration.
Make the fish screen from hard plastic (i.e., polyethylene).	Developed as Proposal No. 6.
Put a trashrack in front of the fish screens.	Developed as Proposal No. 4
Replace the diversion dam with a controlled water surface structure, like Obermeyer gates.	Developed as Proposal No. 1.
Use sheet piling to support screen structure.	Refer to design team for consideration.
Use perforated plate in place of baffles.	Developed as Proposal No. 8.
Use PVC pipe in place of baffles.	The team did not think of any way to make this idea competitive with the baseline.
Add more rock to south side of dam to lengthen gradient.	Refer to design team for consideration.
Add fish monitoring, counting site at the upstream end of the passage.	Not developed in favor of Proposal No. 3.
Improve passage through natural bypass channel as a secondary bypass.	Refer to design team for consideration.
Put an electrical field below the intake in addition to the fish screen.	Refer to design team for consideration.

Disposition of Ideas

Get water from Fort Peck.	The team did not think of any way to make this idea competitive with the baseline.
Get water from another diversion.	The team did not think of any way to make this idea competitive with the baseline.
Use an infiltration gallery.	Not developed in favor of Proposal No. 1.
Move the screen to an in-river location.	The team did not think of any way to make this idea competitive with the baseline.
Eliminate the screen and run entrainment nets permanently.	The team did not think of any way to make this idea competitive with the baseline.
Make screens taller and reduce the length of the assembly.	Not developed in favor of other ideas to reduce concrete use.
Replace the bypass pipe with an open channel.	Not developed due to concerns with public safety and risk of poaching
Move the bypass pipe to near the bridge.	Refer to design team for consideration.
Move the whole screen structure the near the bridge.	Refer to design team for consideration.
Salvage rock from the dam maintenance (recover the rock in the river).	Refer to design team for consideration.
Move the diversion dam and canal inlet downstream in the canal with a new regulating structure behind the screen.	Refer to design team for consideration.
Put fish pumps in the canal and pump fish back to the river (Archimedes screw).	Refer to design team for consideration.
Place soil-cement in the bottom of the fish passage. Color it brown for aesthetics.	Refer to design team for consideration.
Pump the water with Crisafulli pumps; screen intakes seasonally.	Developed as Proposal No. 10.
Extend the bypass pipe 150 feet into the river from the north bank and swing the outlet downstream.	Refer to design team for consideration.
Relocate the river extending its length from Glendive to the confluence.	The team did not think of any way to make this idea competitive with the baseline.
Buy replacement fish.	Does not meet the goals of recovery.
Develop a cost share agreement from a recovery program on a Main Stem Missouri.	Refer to design team for consideration.

Operate a stoplog weir from the overhead cable way.	The team did not think of any way to make this idea competitive with the baseline.
Lower the gradient in the passage to 1.5 percent.	Refer to design team for consideration.
Rebuild dam and incorporate fishway on the south side.	Refer to design team for consideration. May be a way to implement in Proposal No. 1.
Install wind generators to power pumps.	Outside the scope of this project.
Use an air blowout system.	Refer to design team for consideration.
Use an 18-inch sill below the screen panels.	Developed as Proposal No. 2.
Place a trashrack in front of the bypass inlet.	The study team did not think of any way to make this idea competitive with the baseline.
Replace the single brush system with a multiple brush system.	Developed as Proposal No. 9.
Install removable safety panels.	Refer to design team for consideration.
Reduce screen structure concrete on the downstream side.	Developed as Proposal No. 5.
Reduce screen structure wall thickness.	Developed as Proposal No. 7.
Increase bypass entrance width and pipe diameter to accommodate the large size of fish (paddlefish) found in the river.	Refer to design team for consideration.

List of Consultants

Consultant or Contact	Topic or Information
Steve Henrick Screen Sales Hendrick Manufacturing Company PO Box 2900, Memphis TN 38101 Phone: 970-685-5138	Weided wedge wire panel structure and cost
Robert Eckman Vice President Obermeyer Hydro, Inc. PO Box 668 Fort Collins CO 80522 Phone: 970-568-9844	Obermeyer weir installation, design-life, and maintenance.

Data and Documents Consulted

Title, Author, and Date	Information
Intake Diversion Dam, Yellowstone River, Montana, Fish Protection and Passage Concept Study Report, Water Resources Research Laboratory, Technical Service Center, USBR, January 2000	Proposed fish protection and passage alternatives. General project background.
Lower Yellowstone River Intake Dam Fish Passage Alternatives Analysis, Omaha District, United States Army Corps of Engineers, June 2002	Proposed fish passage alternatives. General Project background
Fish Entrainment at the Lower Yellowstone Diversion Dam, Intake Canal, Montana 1996-1998, Hiebert, Wydoski, and Parks, April 2000	Entrainment characteristics

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July 8, 2002 - 1 p. m.

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APPENDIX

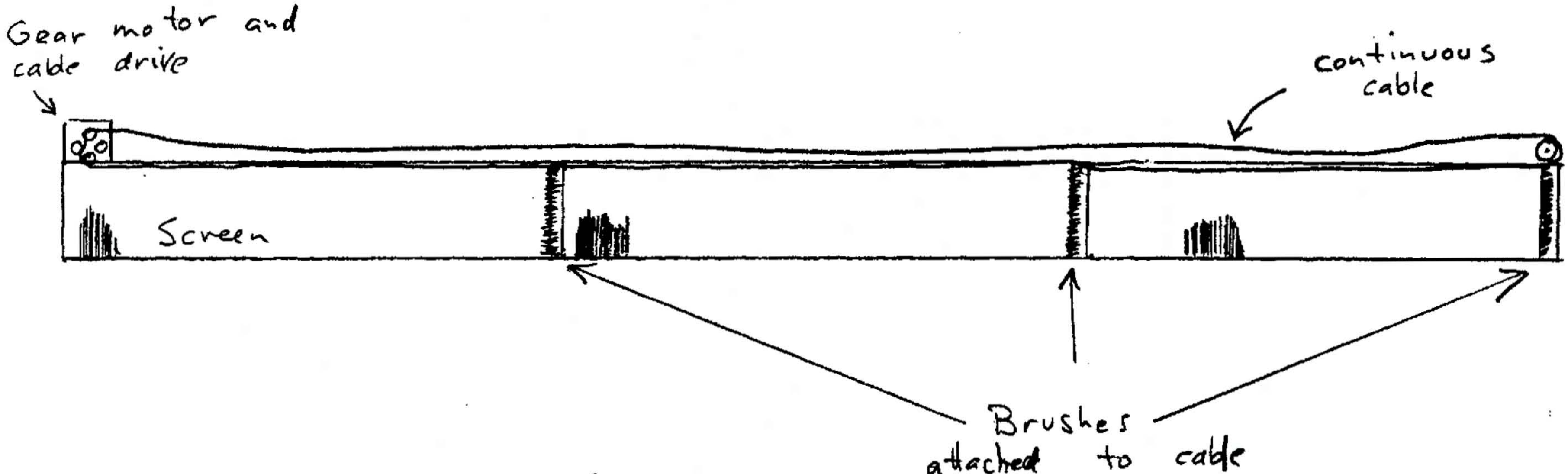
LIFE CYCLE COST ANALYSIS - PRESENT WORTH & UNIFORM ANNUAL COST

Date: 1/29/04

PROJECT: Lower Yellowstone VE
COMPONENT:
Discount Rate: 6.1%
Economic Life: 50

			ORIGINAL CONCEPT		PROPOSAL 1		PROPOSAL 10		PROPOSAL __		PROPOSAL __	
			Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth	Estimated Costs	Present Worth
INITIAL/COLLATERAL COSTS												
A. Diversion Dam			$0		$6,600,000	$6,600,000						
B. Fish Passage			$950,000	$950,000								
C. Fish Screen			$6,600,000	$6,600,000	$6,600,000	$6,600,000						
D. Replace Dam with Pumps							$14,500,000	$14,500,000				
E.												
F.												
G.												
Total Initial/Collateral Costs				$7,550,000		$13,200,000		$14,500,000				
REPLACEMENT/SALVAGE (Single Expenditures By Year)	Year	PW Factor										
A. Major Dam Repair	1.0	0.9423	$3,816,000	$3,595,760								
B. Replace Air Bladders	30.0	0.1681			$530,000	$89,073						
C. Major Dam Repair	25.0	0.2262	$3,816,000	$863,308								
D. Replace Pumps	40.0	0.0927					$750,000	$69,559				
E.												
F.												
G.												
Total Replacement/Salvage Costs				$4,459,068		$89,073		$69,559				
ANNUAL COSTS	Escal Rate	PW Factor w/Escal.										
A. *Maintenance Dam*		*15.491*	$60,000	$929,455	$500	$7,745						
B. *Maintenance Screen & ladder*		*15.491*	$7,300	$113,084	$7,300	$113,084						
C. *Downtime Losses*		*15.491*										
D. Pump energy and O&M		*15.491*					$590,000	$9,139,637				
E. Maintenance Screen		*15.491*					$7,000	$108,436				
F.		*15.491*										
Total Annual Costs				$1,042,539		$120,829		$9,248,073				
PROJECT COST (PRESENT WORTH)				$13,051,607		$13,409,902		$23,817,632				
LIFE CYCLE SAVINGS (PRESENT WORTH)						($358,295)		($10,766,02				
PROJECT COST (UNIFORM ANNUAL COST)				*$842,533*		$865,663		$1,537,523				
SAVINGS (UNIFORM ANNUAL COST)						($23,129)		($694,990)				

Figure 17. Three-Brush Cleaning System Schematic



- Brushes are held against screen with counter weights
- Brushes operate both directions
- Cable is driven by geared motor and direction is controlled by progammable logic controller and pressure switches