Appendixes

Intake Diversion Dam Modification Lower Yellowstone Project, Montana,

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U.S. Department of the Interior
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Appendix A.1 – Alternative Formulation

Introduction

This appendix presents the history and process for development of the alternatives and the screening criteria used to identify the action alternatives evaluated in the Intake EA. Preliminary action alternatives were formulated through an iterative process initiated during informal ESA consultations. In 2008 and again in 2009 the NEPA process (including public involvement, technical information, interdisciplinary and interagency discussions, and professional judgment) was used to identify the reasonable and feasible action alternatives described in Intake EA chapter two. The No Action Alternative was developed in consultation with the Service.

History of Alternative Development

Corps, Reclamation, Service, State of Montana, and The Nature Conservancy sign memorandum of understanding

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

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

- Lower Yellowstone River Fish Passage and Protection Study (Reclamation and Montana Fish Wildlife & Parks 1997)
- Concept I Report (Mefford et al. 2000)
- Fish Entrainment Study (Hiebert et al. 2000)
- Assessment of Sturgeon Behavior and Swimming Ability for Design of Fish Passage Devices (White and Mefford 2002)

- 2002 Alternatives Report (U.S. Army Corps 2002)
- 2002 Value Engineering Study (Reclamation 2002)
- Test Results of Intralox Traveling Screen Material (Reclamation 2003)
- Concept II Report (Glickman et al. 2004)
- Value Planning Study (Reclamation 2005)
- Technical Team Recommendations (Technical Team 2005)
- Biological Review Team Comments (Jordan 2006)
- *Lower Yellowstone River Intake Dam Fish Passage and Screening Preliminary Design Report* (Corps 2006)
- Biological Review Team Comments (Jordan 2008)
- *Intake Diversion Dam, Trashrack Appraisal Study for Intake Headworks*, Lower Yellowstone Project – Montana-North Dakota (Cha et al. 2008)
- *Intake Diversion Dam, Assessment of High Elevation Intake Gates,* Lower Yellowstone Project – Montana-North Dakota (Mefford et al. 2008)
- *Lower Yellowstone Project Fish Screening and Sediment Sluicing Preliminary Design Report* (Corps 2008)

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

Value-Engineering Study

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

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

Value Planning Study

After execution of the MOU in 2005, the MOU partner agencies, along with the irrigation districts, conducted a Value Planning Study to explore various ways to improve fish passage for the Intake Project. The Value Planning

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

Study used the Value Method to compare and contrast these ideas to identify the options with the highest value (Reclamation 2005).

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

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

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

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

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

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

Idea	Disposition
1. Remove dam	Combined with 43
2. Use elevators	Combine with 104
3. Catch and truck fish upstream	Infeasible
4. Use Lenny's "ooze gallery"	Duplicate of 110
5. Use side channel	Duplicate
6. Archimedes screw	Infeasible, adult fish too large
7. Return to dry land farming	Infeasible
8. Provide pumping facilities	Duplicate
9. Provide trust fund (equal to project cost) to subsidize farmers	Beyond study scope
10. Change dam angle to block only half channel	Infeasible
11. Use L-shape dam	Rated 3A – develop
12. Decrease slope of dam	Infeasible

Idea	Disposition
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
20. Use irrigation wells	Infeasible
21. Well field next to Yellowstone	Infeasible
22. Off channel detention storage	Infeasible
23. Remove main stem dams	Infeasible
24. Partial removal of dams	Infeasible
25. Use pipelines from other (unnamed) source	Infeasible
26. Rehab irrigation project – water conservation	Combine with 43 and 107
27. Tie in rural water systems	Infeasible
28. Methane well discharges	Infeasible
29. Build new dam to catch spring flows	Infeasible
30. Build several new reservoirs on lower Yellowstone	Infeasible
31. Pipe from Fort Peck or other upstream sources	Infeasible
32. Reduce Lake Sakakawea water level to increase larval drift time before reservoir	Infeasible
33. Add meander & side channels, reduce slope, lengthen channel for longer drift times	Infeasible
34. Add instream structures to guide larval fish to lengthen channel	Infeasible
35. Construct regional sewage plant; use effluent in irrigation system	Infeasible
36. Pipe from Cartersville Dam	Infeasible
37. Use in-channel infiltration pipes	Rated 5
38. Guide fish with louver system	Infeasible
39. Make hydro facility including larger concrete fishway	Infeasible
40. Pipe municipal water returns from Glendive	Infeasible
41. Pay Glendive for water returns to mitigate caviar loss	Infeasible; beyond study scope
42. Attract fish with light, sounds, or whatever they really like	Infeasible
43. Remove dam, build pumps & wind farm with Pick-Sloan & create trust	Rated 3A – develop
44. Remove dam; move point of diversion upstream	Combine with 110
45. Diversion without dam; with pumping backup	Combine with 43
46. Remove part of dam and convert rest to infiltration gallery	Infeasible
47. Pump to reservoir in winter	Infeasible
48. Widen fishway alternative 1A	Rated 3A – develop
49. Obtain Montana grant to develop pumping power	Combine with 43
50. Establish lots of paddle wheel pumps	Infeasible
51. Use fish ladders	Duplicate
52. Use collapsible dam	Duplicate
53. Floating diversion dam	Duplicate
54. Seasonal push-up dam	Infeasible
55. Remove dam; irrigate only when water high enough to supply head	Infeasible
56. Down canal impoundment to store water with high flows – only divert when high enough to supply head	Infeasible
57. Develop strain of beets requiring no water	Infeasible
58. Use multiple diversions	Rated 5
59. Use Agricultural Department farm bill monies to rehab irrigation system	Infeasible
60. Buy out irrigators to reduce demand	Outside of study scope

Idea	Disposition
61. Use windfarm to pay irrigators to switch to dry land farming	Infeasible
62. Explore drip irrigation	Water conservation issue
63. Explore sealing canal delivery system to reduce eliminate seepage	Water conservation issue
64. Use pipe system to reduce evaporation in delivery system	Water conservation issue
65. Fish ramp	Duplicate
66. Fish tunnel	Infeasible
67. High and low water passage designed into dam	Infeasible
68. 21G to 2AG fish channel	Rated 4
69. Upstream passage designed into bypass screen structure	Infeasible
70. Pump fishway design – false weir	Infeasible
71. Use German retractable dam	Combined with 105
72. Fish catapult	Infeasible
73. Pay fisherman to put fish upstream of dam	Infeasible
74. Rewards for pallid sturgeon caught by paddle fish fishermen	Infeasible
75. Use bascule gate	Duplication
76. Make whitewater river course through project area	Infeasible
77. In-channel turbine to provide power for pumps	Infeasible
78. Build habitat to attract fish	Combine with 94
79. Remove rocks washed downstream; reuse rocks; sell rocks to landscapers on east coast	Infeasible
80. Use fish herding black Labrador retrievers	Infeasible
81. Use rock dikes to let water into canal – but not fish - into canal	Infeasible
82. Use multiple small pump plants close to demand	Rated 3A – develop
83. Use differential gates such as Obermeyer to move thalwag	Duplication
84. Clean up rock debris and breech center of existing dam	Infeasible
85. Reroute Yellowstone to current backchannel to maintain irrigation	Infeasible
86. Use solar power pumps	Infeasible
87. Use sounds and lights to reduce entrainment	Duplication
88. Spawning habitat in canal	Infeasible
89. Add new screens at wastewater sites	Infeasible
90. Raise bed of Yellowstone	Infeasible
91. Install twenty sills (6” to 8” high) to get head	Rated 5
92. Low head hydro plant for supplemental power	Infeasible
93. Increase funding level for pallid sturgeon efforts elsewhere	Infeasible
94. Modify dams to enhance attracting fish	Combine with 48
95. Crossbreed sturgeon with steelhead	Infeasible
96. Do nothing	Rated 3C – develop; rejected during development
97. Concept II, Alternative 1A – riprap fishway around fishway	Rated 4
98. 1B through dam	Rated 4
99. 1B grouted	Rated 4
100. 1C with earthen wall	Rated 4
101. Flume and baffle fishway	Rated 4
102. Denil fish ladder	Rated 5
103. Long low gradient channel	Rated 3A
104. Fish elevators + music	Rated 4
105. Collapsible gates with rock fishway	Rated 3A
106. Provide infiltration gallery	Questionable feasibility
107. Conventional pump plants on Yellowstone	Combine with 43
108. Rock ramp fish passage	Rated 3A
109. Infiltration ponds	Infeasible
110. Upstream diversion point without pumps	Rated 3A

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

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

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

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

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

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

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

Technical Team Recommendations

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

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

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

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

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

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

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

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

Biological Review Team

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

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

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

ESA Modifications - Alternatives Evaluation Matrix

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

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

Legend

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

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

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

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

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

NEPA Initial Screening

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

Public Meeting in Glendive, Montana

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

Table A.1.6 - EA Alternatives and Their Disposition.

Alternative	Disposition
1. No Action	Evaluated in detail as the **No Action Alternative**, as required by NEPA.
2. Rock Ramp	Evaluated in detail as the **Rock Ramp Alternative**.
3. Relocate Diversion Upstream	Eliminated from detailed study. Further hydraulic analysis determined that a diversion dam/weir with rock ramp would be required to provide sufficient head for reliable diversion of water under low flow.

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

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

The screening criteria for alternatives were:

Alternatives Screening Criteria

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

Alternatives Considered But Eliminated

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

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

Alternatives Eliminated After Initial Scoping

Relocate Diversion Upstream Alternative

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

The Value Planning Study (Reclamation 2005) originally recommended further evaluation of this alternative. Because this alternative removed the existing dam, which the Biological Review Team recommended for optimal fish passage, it was presented during public scoping.
The original concept was to move the point of diversion for the canal upstream far enough to allow diversions of water into the canal without a dam/weir. Although no dam would be needed, initial design features included several rock sills in the river channel to prevent head cutting after dam removal, as well as a rock dike field and revetment to stabilize the channel location at the point of diversion. This would reduce the risk of the channel migrating away from the new diversion site.

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

Hydraulic modeling revealed that this alternative would be technically infeasible without a dam/weir to raise and divert water during low flow. Three thousand cfs was set as the minimum flow in the river to evaluate the reliability of alternatives for diverting flow into the canal.

Under minimum flow conditions a 5-6 foot high dam/weir would be required to provide sufficient head for diversion of 1,374 cfs flow into the canal (figure A.1.1). The additional dam/weir would be a fish passage impediment much like the existing dam (although about 5 ft lower) that could be combined with a rock ramp to provide fish passage.

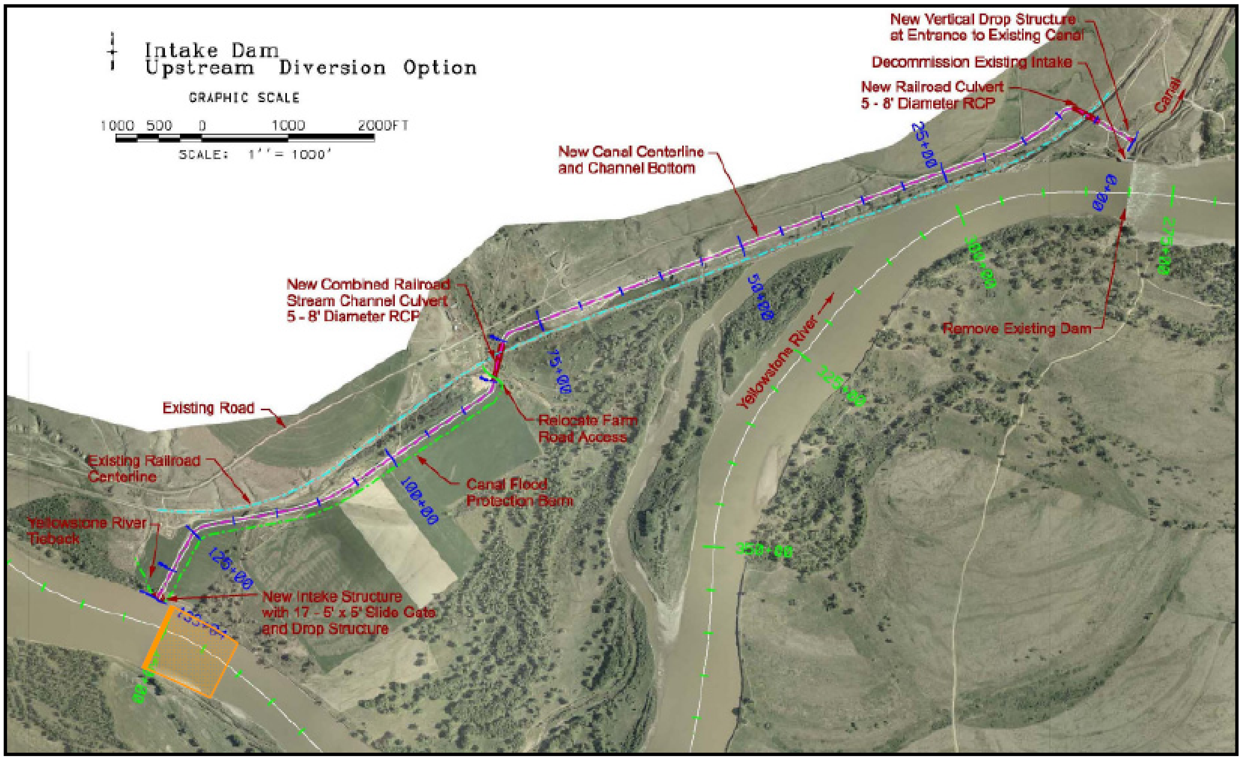

Figure A.1.1 - Relocate Diversion Upstream Alternative With Rock Ramp.

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

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

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

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

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

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

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

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

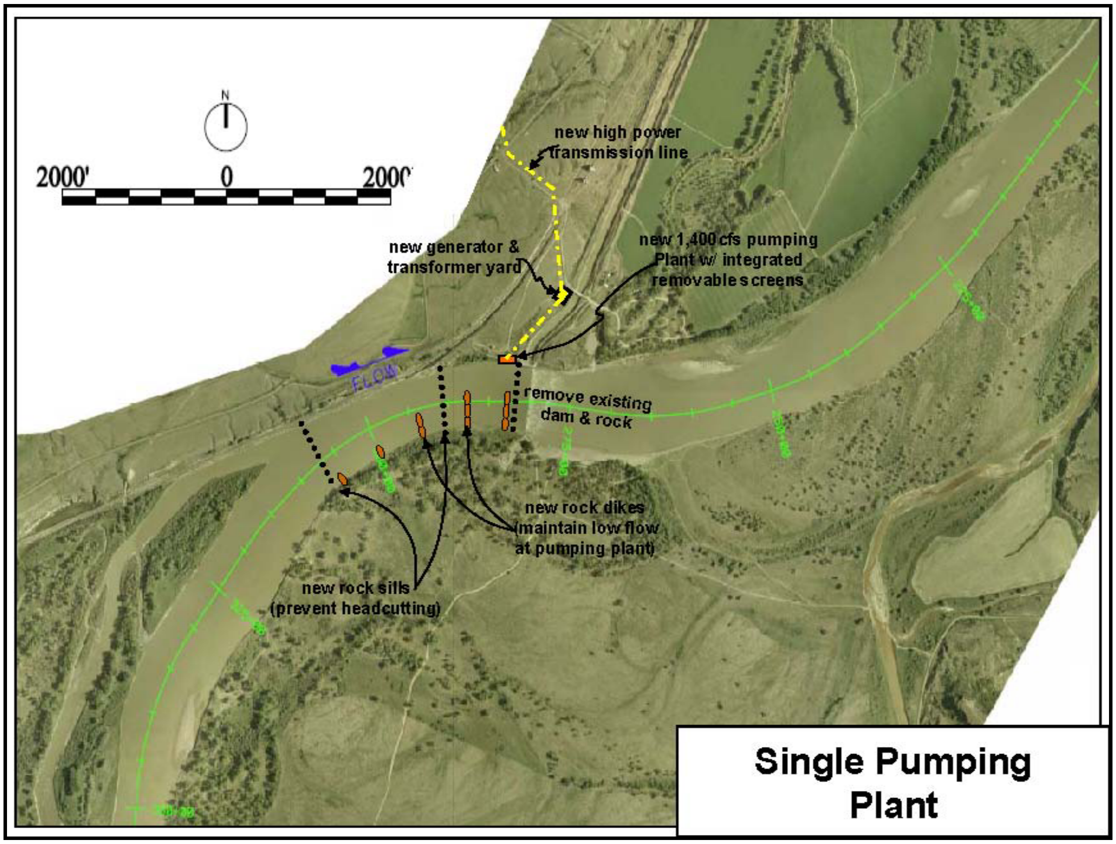

Figure A.1.2 – Single Pumping Plant Alternative Original Concept.

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

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

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

Multiple Pumping Stations Alternative

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

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

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

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

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

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

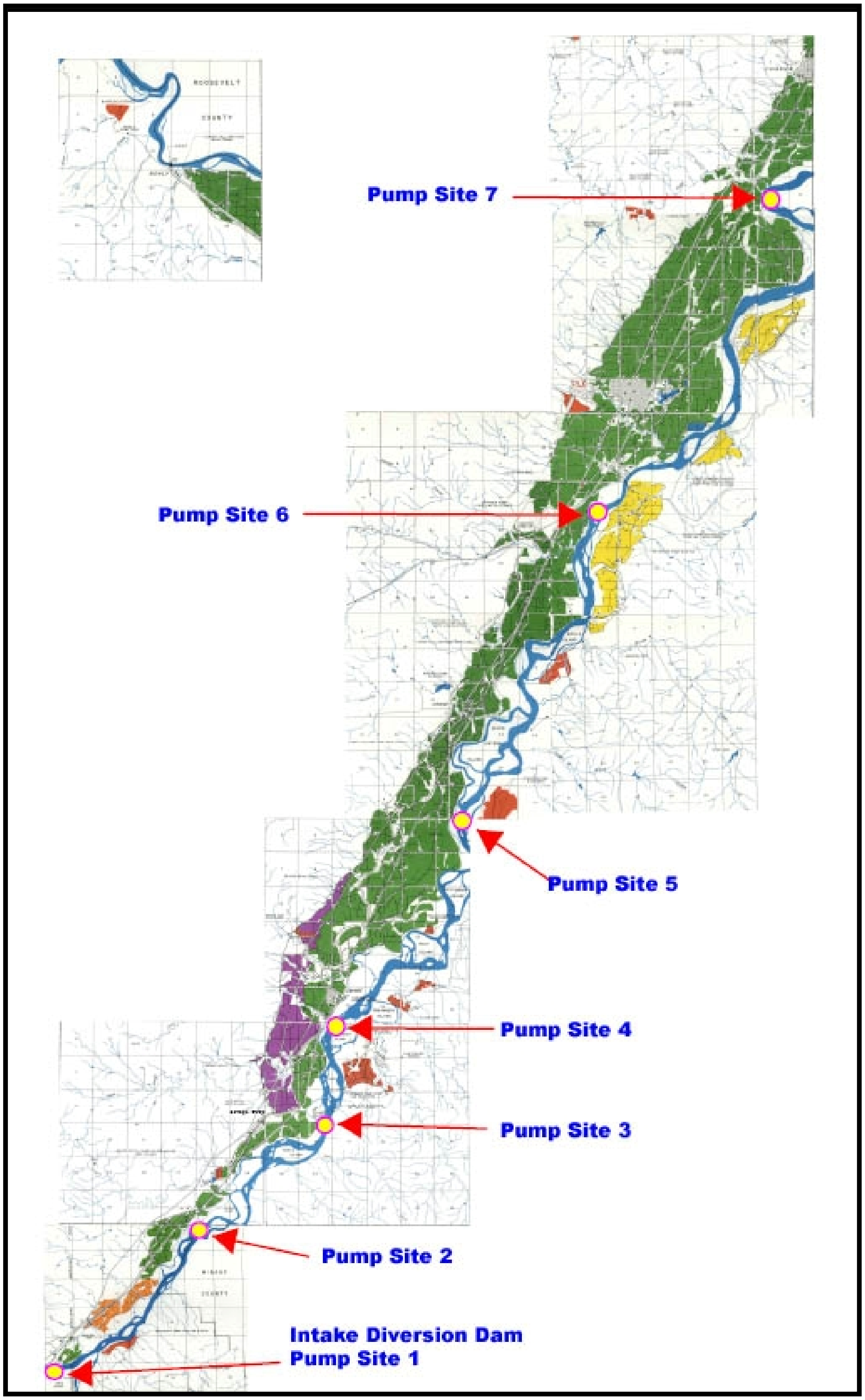

Figure A.1.3 - Proposed Locations of Pump Stations.

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

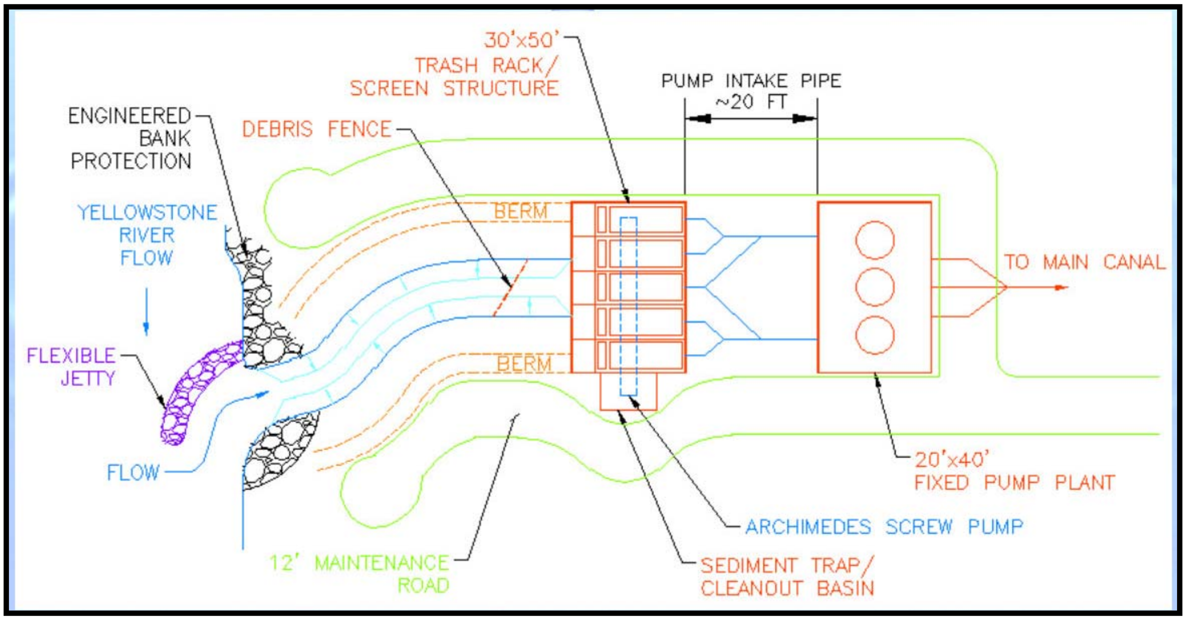

Figure A.1.4 – Conceptual Design of Fixed Pumping Station.

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

Because the irrigation canal system was designed for gravity flow of water primarily from a single water source at Intake, this alternative would require some restructuring of the Lower Yellowstone Project canal system to accommodate a water supply from multiple points along the canal. It is estimated that 12 additional check structures would need to be constructed within the main canal to maintain the water depth and elevations required to deliver water to the lateral canals for distribution to the fields. Since the additional check structures would decrease the velocity of the water in the main canal, additional sediment deposition would be expected in the upper part of the system.

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

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

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

Infiltration Gallery Alternative

Removing Intake Diversion Dam and constructing an infiltration gallery was suggested by EPA, but it was eliminated from further consideration, because this alternative would require at least one and most likely multiple pumping plants, which makes it redundant with the Single Pumping Plant Alternative. In addition, the same reasons for eliminating the Single Pumping Plant Alternative would apply to the Infiltration Gallery Alternative (see page 2-30). For example, power demand would be as high as or higher than the Single Pumping Plant Alternative, but unlike the Single Pumping Plant, back-flushing would also be required. Its only advantage over the Single Pumping Plant Alternative would be elimination of fish screens in a new headworks; however, excavation and construction of the infiltration gallery likely would be as costly and would disturb much more river channel than the Single Pumping Plant Alternative.

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

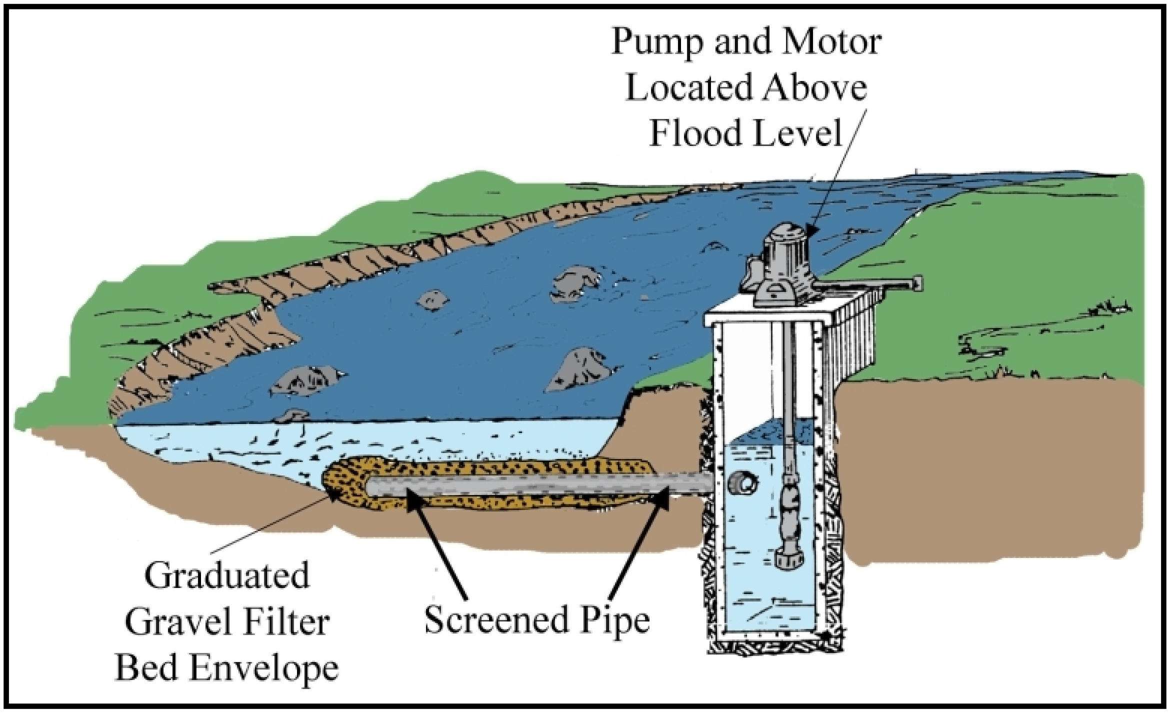

Figure A.1.5 – Conceptual Layout of an Infiltration Gallery.

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

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

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

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

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

V-Shaped Screen Option

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

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

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

Originally this option lacked a trashrack, but on-going informal consultation with the Service resulted in a significant modification to this option prior to public scoping. The Biological Review Team was concerned that large, adult fish entering the canal would be blocked by the trashrack at the upstream end of the fish screen structure (Jordan 2006) These fish would be trapped in an artificial canal environment indefinitely, potentially requiring capture and relocation each fall. In response to this concern, Reclamation designed a trashrack to be placed on the river side of the existing headworks to block adult fish and large debris from entering the canal. The trashrack would be a new concrete structure with panels that could be removed during the winter to avoid ice damage.

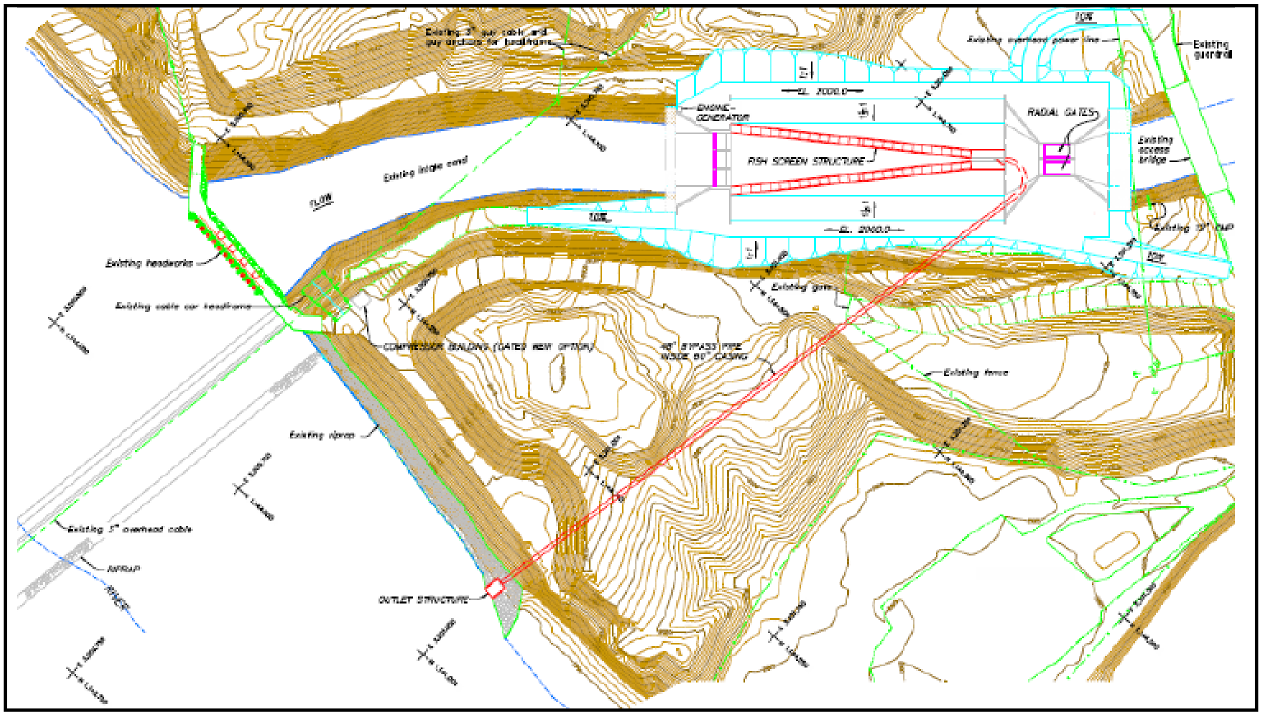

Figure A.1.6 – V-Shaped Fish Screen Option.

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

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

Summary

In 2005 a Reclamation Value Planning Study team initially brainstormed 110 ideas for alternatives and screened these down to 10 (Reclamation 2005). After conceptual development, the Value Planning Study used a “choosing by advantages” system to rank the alternatives and eliminated the 3 with the lowest scores. The Value Planning Study recommended that the Long, Low-Gradient Channel Alternative, Rock Ramp Alternative, Remove Dam and Build Single Pumping Plant Alternative, and the Widen Fishway Alternative be carried forward for further consideration. The Remove Dam and Move Diversion Upstream Alternative, Multiple Pump Stations Alternative, and Collapsible Gates Alternative also were identified for further study.

Later in 2005 Reclamation formed a Technical Team to apply three filters to these 10 alternatives and to recommend which were worthy of further consideration. Reclamation, the Lower Yellowstone Project, State of Montana, The Nature Conservancy, the Corps, and the Service representatives served on the team. The filters were biological, water delivery, and engineering/construction factors. Using these, the Technical Team identified the Rock Ramp, Single Pumping Plant, and Move Diversion Upstream as the most viable ways to provide fish passage. These were further developed from 2005 through 2009. A Biological Review Team of pallid sturgeon experts with the Service made specific recommendations to alternatives throughout development.

When the NEPA process began in 2008 with public scoping, two fish screen options and five alternatives were under consideration. The scoping alternatives included the three identified by the Technical Team plus No Action and Relocate Main Channel, including two types of fish screens. Public scoping identified a new alternative – Multiple Pumping Plants. Screening eliminated the Relocate Diversion Upstream, Single Pumping Plant, and Multiple Pumping Plants Alternatives, and the V-Shaped Screen Option. An Infiltration Gallery Alternative later suggested by EPA was found to be redundant with the Single Pumping Plant and was also eliminated. As a result of this alternative formulation process, the alternatives forwarded for evaluation in the Intake EA were No Action, Relocate Main Channel, and Rock Ramp.

Appendix A.2 – Hydraulics

Introduction

This appendix describes the hydraulic analysis performed to evaluate existing conditions and preliminary alternatives for the proposed Intake Project. Numerous studies performed in the past laid the foundation for the work described in this appendix. Analysis procedures, assumptions, and results are presented, and additional modeling to analyze the alternatives at a conceptual level is summarized.

This document serves as an integrated hydraulics appendix. A number of analyses have been performed in support of the 10% design analysis for a range of alternatives. This appendix contains data from the following former appendixes:

- Appendix C Hydraulics (July 2006)
- Appendix I Additional Ramp Alternative (February 2007)
- Appendix J Channel Relocation (December 2008)
- Unlettered Hydraulics Appendix, Cylindrical Fish Screen and Sediment Sluice Alternatives (January 2008)

This document supersedes these appendixes and includes updated discharges based on the hydrologic analysis described in a Corps hydrology report (Corps 2006), which is included in the Intake EA as a supporting document. Some of the information presented in this document has been superseded (e.g. stepped rock ramp); however, it has been included here to serve as baseline data and for comparison.

Numerous other alternatives have been considered but eliminated. For more information on these alternatives, see Intake EA chapter two or Alternative Formulation, appendix A.1.

Study Purpose

The purpose of the hydraulic analysis was to develop preliminary hydraulic design information for four alternatives:

- Rock Ramp Alternative - Reconfigure the existing Intake Diversion Dam into an engineered rock ramp
- Relocate Diversion Upstream Alternative - Relocate the intake diversion upstream to a location where gravity diversion would not require a dam
- Pumping Plant(s) Alternatives - Construction of a single large pumping plant or multiple small pumping plants at Intake, MT, including removal of the existing dam
- Relocate Main Channel - Relocate the main channel of the Yellowstone River to bypass the existing dam and extend the diversion canal upstream.

Study Scope

Analysis was performed at a conceptual level to examine alternative feasibility and refine cost estimates. Future detailed design analysis is required to further define project features and thoroughly evaluate alternative feasibility.

Past Studies

This study has a narrow hydraulic scope that relies on previous evaluations. Numerous past studies have been performed to evaluate many different alternatives for providing fish passage at the Intake Diversion Dam. A few of the recent studies with additional information include the Intake Diversion Dam, Yellowstone River, Montana, Fish Protection and Passage Concept Study Report (Reclamation 2000), the Lower Yellowstone River Intake Dam Fish Passage Alternatives Analysis (Corps 2002), the Intake Diversion Dam, Fish Protection and Passage Concept Study Report II (Reclamation 2004), and the Draft Biological Assessment: Future Operation of the Lower Yellowstone Project with Proposed Conservation Measures (Reclamation 2005).

Intake Diversion Dam Existing Conditions

Evaluation and analysis was performed to review and update existing conditions. A plan view of the Intake Diversion Dam and Yellowstone River vicinity is shown in plate A.2.1.

Intake Diversion Dam was originally constructed as a rock-filled timber crib weir with a height of 12 ft. The dam spans across the Yellowstone River channel for a width of 700 ft. The dam extends about 135 ft longitudinally along the channel and consists of a 1 vertical on 2 horizontal (1:2) upstream slope, a 15-ft wide crest, and a varying degree downstream slope. Since the construction of the dam, the structure has required frequent repair to maintain the upstream Yellowstone River water surface elevation required for irrigation flow diversion. In the current condition, the dam crest elevation varies as ice and flood flows progressively displace riprap material from the crest. Updated survey data of the dam crest and vicinity was not available. Previous survey data indicated a range of 2 ft across the crest from elevation 1987 to 1989 ft. Current practice is to maintain the rock crest a minimum of 1 ft above the wooden structure to provide enough head for the maximum diversion rate of about 1,400 cfs.

Dam Maintenance

Significant repair has occurred several times following major flood and/or ice events. Over the years, large quantities of rock have been added to the dam to replace rock displaced by the river. Major structure repair has also occurred, most recently in the 1970s. A cableway that crosses the Yellowstone River along the crest of the dam is used to replace shifted rock and maintain the crest elevation (see Intake EA chapter two, No Action Alternative). Rock extends downstream of the dam in a scattered rock rubble field over 300 ft on the left bank (north, intake structure side) to about 150 ft on the right bank. On an as-needed basis, 300 to 1200 cubic yards of large quarried rock is placed to maintain the dam crest (Reclamation 2005:7). The maintenance is usually annually, varying with conditions. Drought and mild winters reduce crest damage. Using the cableway, the largest rock that can be placed is about 1 cubic yard or about a 3’ by 3’ boulder.

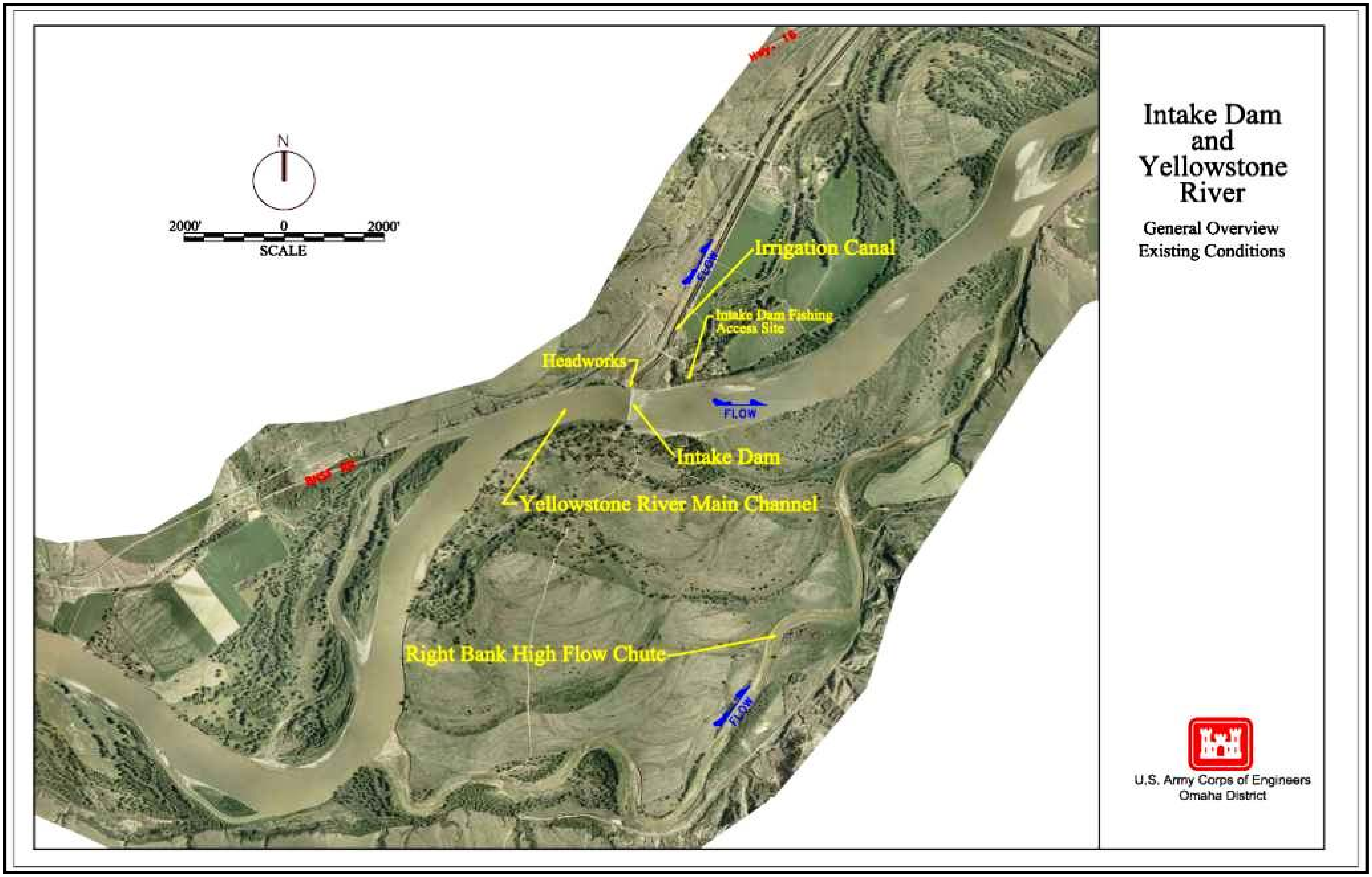

Plate A.2.1 – Intake Diversion Dam and Yellowstone River Vicinity Map.

Typical practice is to take rock with a quarry run gradation, place the large rocks across the crest, and then use smaller rocks to fill in around the large rock. Rock is often taken from a nearby quarry with quality that varies from durable to fractured. A photo from the site that was taken during a low period in the early 2000's illustrates the rock crest and downstream rubble field in figure A.2.1. Figure A.2.2 illustrates the replacement of dam crest rock.

Figure A.2.1 - Intake Diversion Dam at Low Flow.

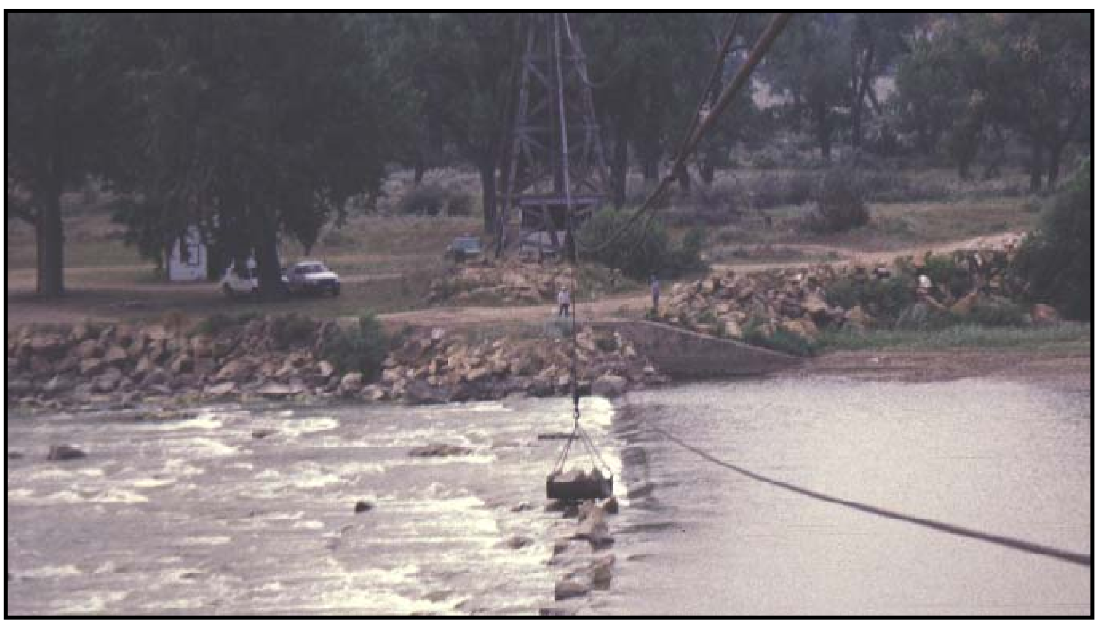

Figure A.2.2 - Intake Diversion Dam Replacing Crest Rock.

Yellowstone River Hydrology

Yellowstone River flow values were evaluated during this study and are reported in the Intake EA supporting document, Corps (2006). Flow frequency and flow duration analysis considered both the Sidney and Glendive gage record and examined the impact of Yellowtail Dam on results. Refer to the Corps (2006) hydrology report for a complete discussion of analysis methods and results. Peak flow values used in this study are based on winter discharges and are in table A.2.1, while Flow-Duration values used are in table A.2.2.

Table A.2.1 - Peak Winter Discharges at Glendive, Montana (MT) Gage.

		Discharge*	
Exceedance Probability	Recurrence Interval	Computed Probability	Expected Probability **
	(years)	(cfs)	(cfs)
0.5	2	14,900	14900
0.1	10	43,100	44600
0.05	20	61,500	65200
0.02	50	94,600	105400
0.01	100	128,000	148000
0.002	500	249,000	323000

* Based on Bulletin 17b analysis

** For comparison purposes only. This study uses computed values.

Table A.2.2 - Flow Duration Values at Sidney, MT, Gage.

	Discharge (cfs)												
Percent Time Flow Equaled or Exceeded	Annual	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1	65,500	19,800	12,300	11,300	13,500	22,900	50,500	38,100	53,200	93,000	73,200	25,400	17,900
50	8,460	8,710	8,080	7,100	6,600	7,400	8,720	8,470	14,800	30,700	17,100	7,080	6,660
80	5,640	6,010	5,590	5,020	4,800	4,910	6,230	6,130	9,770	18,700	7,780	3,980	4,320
90	4,530	5,120	4,790	4,210	4,110	4,490	5,160	5,470	7,560	14,900	5,730	2,710	3,600
95	3,800	4,360	4,160	3,520	3,210	4,180	4,200	5,000	6,230	12,400	4,930	1,770	3,060
99	2,130	3,710	2,230	2,130	2,160	2,990	3,110	3,850	4,530	8,570	3,590	1,390	2,020

Survey Data

LiDAR topographic data, previously collected for the Yellowstone River Corridor Study, were used for this study. The constructed HEC-RAS model used the LiDAR data for the channel banks and floodplain. Bathymetric survey data were also collected to define the channel. All survey data used in the HEC-RAS model are in the following coordinate system:

Horizontal: Montana State Plane NAD 83
Vertical: NAVD 1988

The LiDAR survey data were of sufficient accuracy to generate 2-ft contours.

The bathymetric data were collected by the USGS in June and August of 2007 in the form of cross-sections. Cross sections for the HEC-RAS model were taken only at surveyed locations to avoid using interpolated data. The area defined as the "intense mapping area" extended from

1500 ft upstream from the Intake Diversion Dam to 3000 ft downstream. Within the intense mapping area, bathymetric data were collected along cross-sections at a spacing of 50 ft. In addition to the intense mapping area, cross-sections were surveyed upstream, downstream, and in the right bank chute. Thirteen cross-sections were surveyed upstream from the intense mapping area over a distance of approximately 16,000 ft. Twelve cross-sections were surveyed downstream over a distance of approximately 19,000 ft. Twelve cross-sections were surveyed on the right chute which is approximately 24,500 ft long. The surveyed sections can be seen on plate A.2.2.

Diversion Headworks

The existing headworks for the irrigation diversion is a concrete structure with 11 5-ft diameter slide gates. The face of the headworks structure is approximately 164 ft long. Wingwalls extend back into the bank on either side of the face approximately 84 ft at a 45 degree angle.

Existing Conditions HEC-RAS Model

The Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 4.0 dated March 2008 was used to model the system. The HEC-RAS software package was developed for one-dimensional steady and unsteady flow river hydraulic calculations. Both sub- and super-critical flow regimes can be evaluated with HEC-RAS.

Model Stationing

An HEC-RAS model was constructed in 2006 prior to collection of the bathymetric data. To be consistent with the previously constructed model, the same centerline was used for this model. Model extents begin at station 0 approximately 28,000 ft downstream of the existing Intake Diversion Dam.

Model Roughness

The HEC-RAS model uses a Manning roughness value of 0.035 for channel regions and 0.050 for overbank regions for the main channel. For the right chute, roughness values of 0.040 and 0.050 were used for the channel and overbanks, respectively.

The roughness parameters established for the model were similar to the previous modeling effort.

Intake Diversion Dam Crest

The Intake Diversion Dam crest was modeled within HEC-RAS using the inline weir option. Modeling parameters within the HEC-RAS model are summarized in table A.2.3.

Table A.2.3 - Intake Diversion Dam Crest HEC-RAS Data.

HEC-RAS Parameters		Weir Crest	
Yellowstone River Crest Station	280+22	Station	Elevation
Discharge Coefficient	2.7	(ft)	(ft NAVD88)
Width	15 ft	0	1987
		30	1987
		130	1988
		430	1989
		700	1989

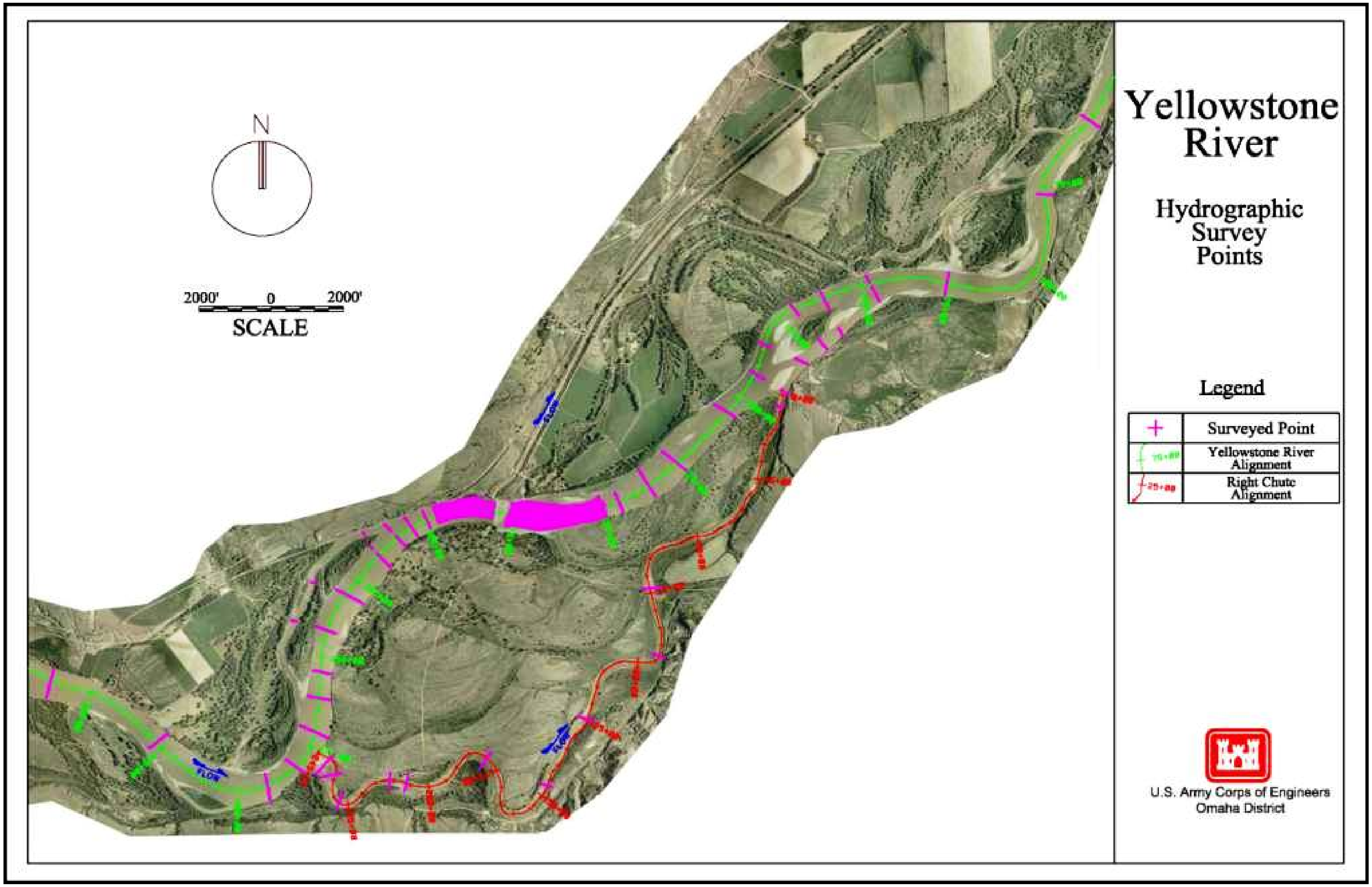

Plate A.2.2 – Surveyed Cross Sections.

Calibration

Available calibration data consisted of the following:

- Discharge and water surface elevation measurements upstream and downstream of the dam. The USGS collected these data four times during 2008.
- Water's edge information from land survey data gathered during August 2007 by the USGS
- Edge of water data from the LiDAR survey performed in September 2004
- Previously constructed BOR HEC-RAS model that was calibrated to measured water surfaces (actual calibration data were not available)

Initial evaluation of the available calibration data appeared to yield conflicting results for the measured data. However, after additional analysis, some of the differences were rectified. Photographs showing the dam crest in different years support the conclusion that the crest elevation and configuration were altered (assumedly from high flows or ice) between November 2006 and August 2008 (see figures A.2.3 and A.2.4). Figures A.2.3 and A.2.4 show the dam crest from approximately the same location during similar discharges (≈ 5800-6000 cfs). The photographs show the change in crest configuration as well as the change in water surface behind the dam as evident from the water surface compared to the trash rack timbers.

Figure A.2.3 - Dam Crest 2 November 2006.

Figure A.2.4 - Dam Crest 25 August 2008.

The calibration data used in this study are summarized in table A.2.4. Rating curves showing computed versus measured water surfaces are shown in figure A.2.5.

Right Bank Chute

The new HEC-RAS model includes the overbank flow area and the right bank chute. The right bank chute allows flow to bypass Intake Diversion Dam and access the southern floodplain. The chute exits the Yellowstone River about 9,500 ft upstream of the dam near station 375+00. The chute re-enters the Yellowstone River about 8,500 ft downstream of the dam near station 195+00. Total chute length is about 24,500 ft. Flow area was not added to the chute, as the channel was not flowing at the time of the LiDAR survey. The chute channel section has a 100 – 200 ft bottom width. At the time of the site visit (23-24 May 2006), the Yellowstone River at Glendive USGS gage flow varied from 26,600 to 29,600 cfs. Chute flow seemed to initiate at about that level. During the time of the site visit, estimated chute flow was about 300 - 400 cfs.

The initial model included an upstream chute invert elevation of 1995.0. Initial HEC-RAS computations determined a chute flow of about 960 cfs with a Yellowstone River total flow of 27,000 cfs. Based on the site observation of the flow split, the invert elevation of the right bank chute cross-section located just downstream at the Yellowstone River junction was raised to an elevation of 1997.8. As a result, the HEC-RAS model computed right bank chute was reduced to approximately 400 cfs. Given the accuracy of the LiDAR data set and lack of below water survey information, the adjustment seemed reasonable. The HEC-RAS estimated flow split is shown in table A.2.5.

Table A.2.4 - Calibration Data.

Site Location	Date	Data Source	Measured or estimated discharge *	Measured Water Surface Elevation
			(cfs)	(ft NAVD88)
Yellowstone River above Intake (?HEC-RAS RS 28400)	6/18/2008	USGS (ND office) Surveys during sediment sampling effort	29,400	1995.38
	6/25/2008		51,800	1997.32
	7/9/2008		47,200	1996.66
	8/27/2008		5,890	1991.19
	11/1/2006	USGS (MT office) "Land Surveys"	5,900	1992.75
	11/2/2006		5,800	1992.44
	11/16/2006		6,560	1992.87
	September 2004	LiDAR Survey	4,200	1988.79
Yellowstone River below Intake (?HEC-RAS RS 27500)	6/17/2008	USGS (ND office) Surveys during sediment sampling effort	30,800	1990.16
	6/24/2008		49,600	1991.96
	7/8/2008		46,500	1991.82
	8/26/2008		4,690	1985.66
	10/31/2006	USGS (MT office) "Land Surveys"	6,050	1986.12
	11/1/2006		5,900	1986.06
	11/14/2006		7,340	1986.56
	8/7/2007		2,650	1985.12
	September 2004	LiDAR Survey	3,400	1984.28
Yellowstone River Diversion Canal	6/19/2008	USGS (ND office) Surveys during sediment sampling effort	1,130	1988.53
	6/26/2008		1,310	1989.30
	7/10/2008		1,350	1989.30
	8/28/2008		1,050	1988.46

* Measured discharges are associated with USGS surveys during sediment sampling. During land surveys and LIDAR data collection, discharges are estimated from Glendive and Sidney gage data.

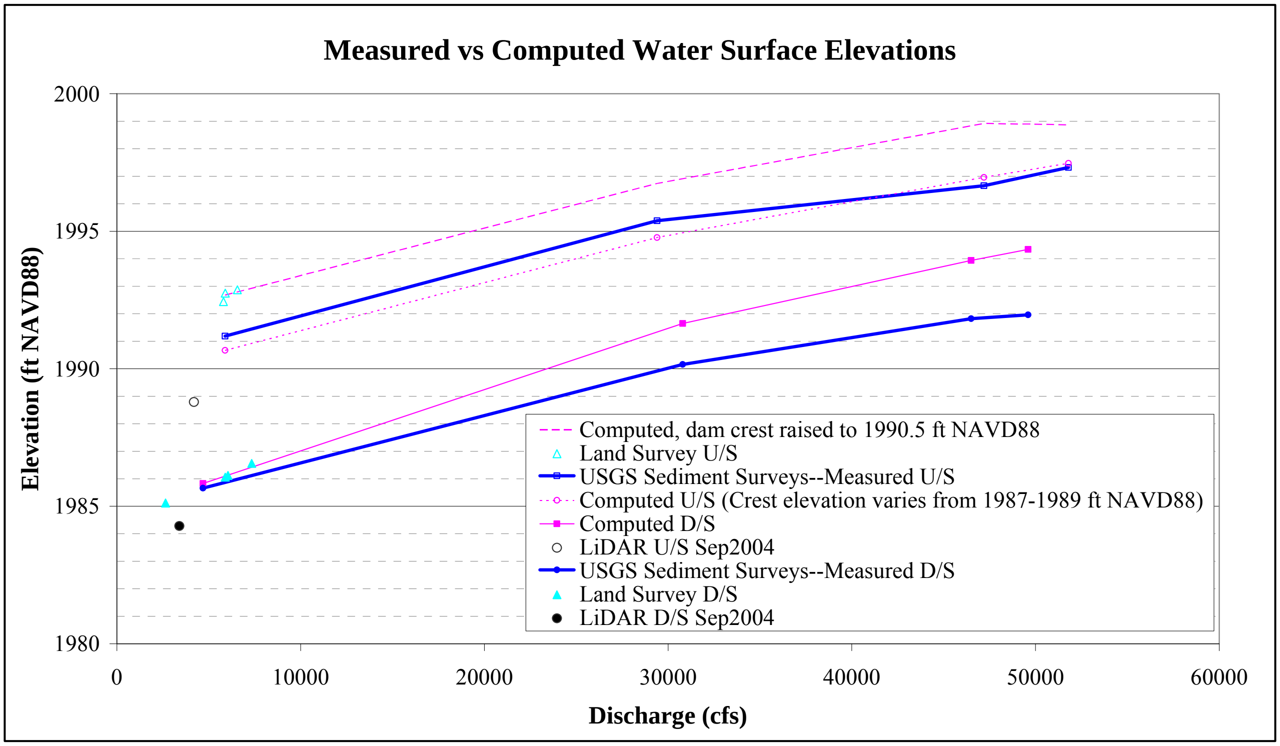

Figure A.2.5 - Calibration Rating Curves.

Table A.2.5 - Yellowstone River vs. Right Bank Chute Flow Split.

Total Flow (cfs)	Yellowstone River flow (cfs)	Chute Flow (cfs)	Chute % of Total Flow
10,000	10,000	0	0.0%
20,000	20,000	0	0.0%
27,000	26,605	395	1.5%
40,000	38,342	1,658	4.1%
60,000	56,055	3,946	6.6%
80,000	73,849	6,151	7.7%
100,000	92,149	7,851	7.9%
128,000	118,100	9,900	7.7%
160,000	147,341	12,659	7.9%

Intake Diversion Dam Water Surface Impact

The new HEC-RAS model was used to compute rating curves upstream and downstream of the dam. Figure A.2.6 illustrates the rating curves upstream and downstream of the dam.

Sediment Transport

Since the construction of Intake Diversion Dam, sediment transported as suspended load and bed load have been impeded, re-directed, or removed from the river system. Many of the suspended sediments in the water column above the dam are transported into the intake canal or carried over the dam. A fraction of these sediments settle from the water column to the river bed above the dam forming a delta (see Intake EA, chapter three, figure 3.6). A schematic illustrating typical river response to dam construction is illustrated in figure A.2.7. Since Intake Diversion Dam has been in place for over 100 years, the river response to this low head dam is expected to have reached equilibrium.

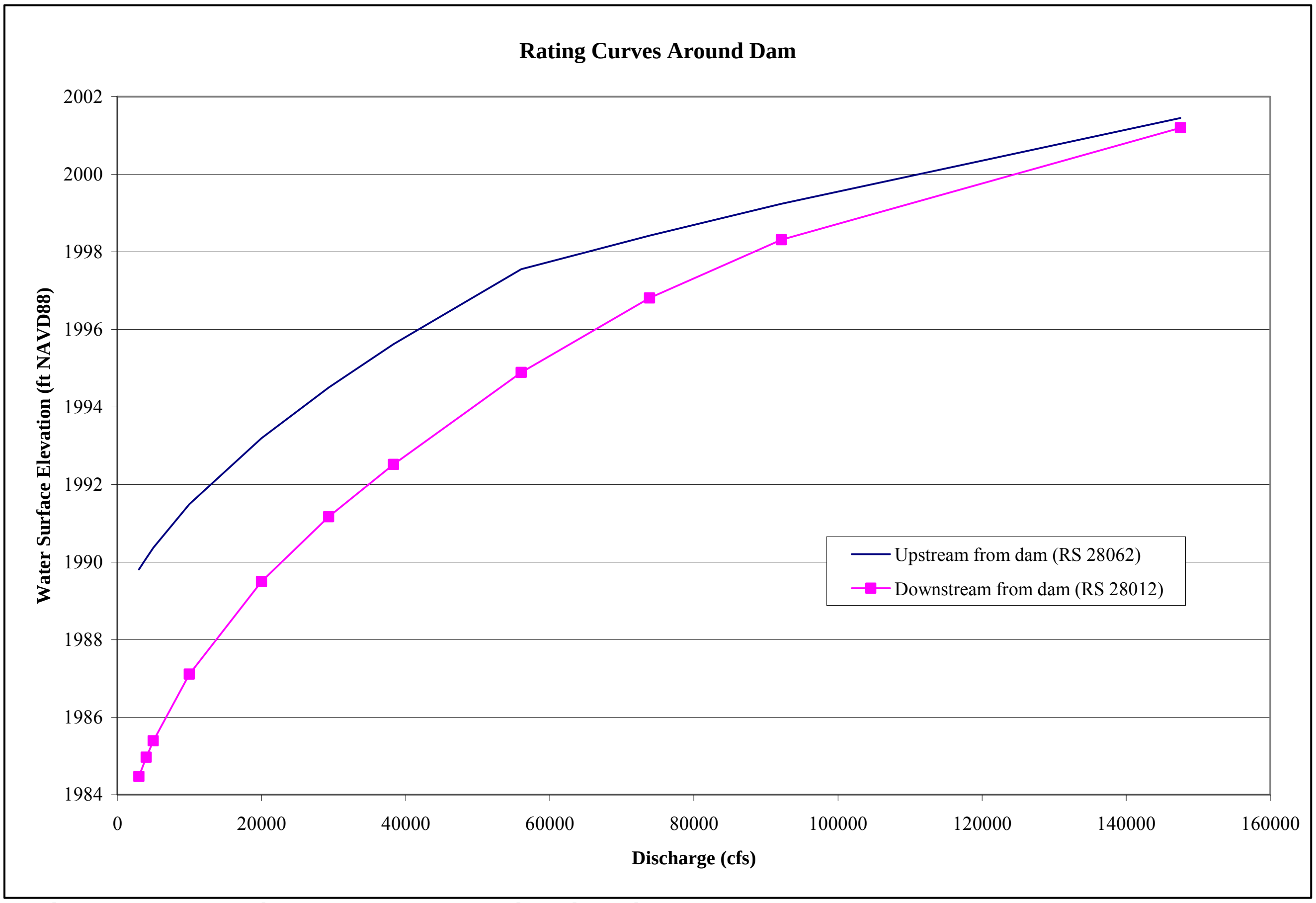

Figure A.2.6 - Rating Curves near Intake Diversion Dam.

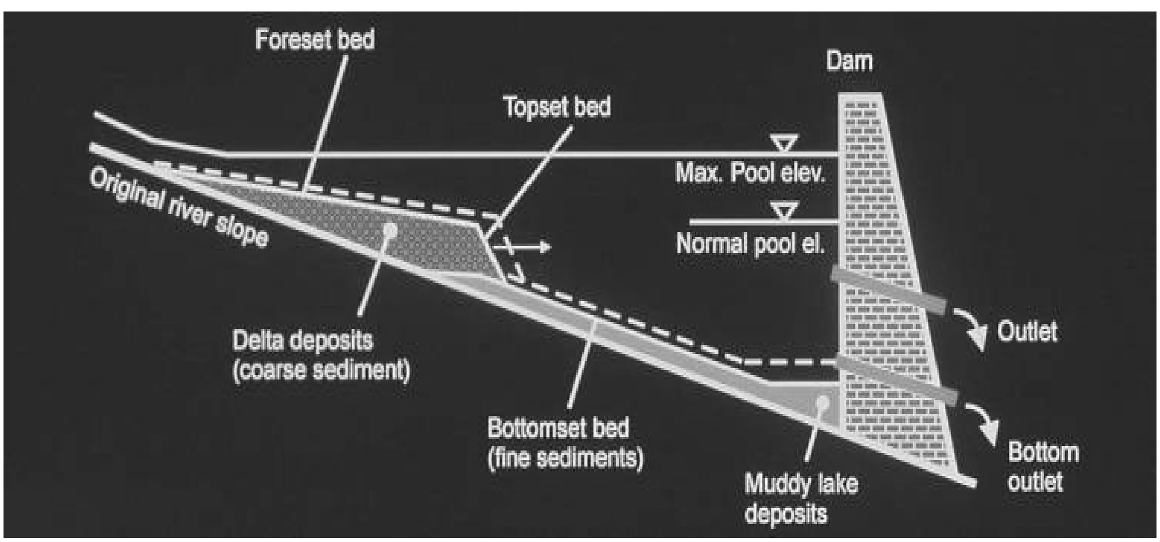

Figure A.2.7 Theoretical Delta Formation in Reservoirs

Most of the bed load material in the river is retained in deltaic formations above the dam due to a reduction in flow velocity caused by the backwater effect of the dam. At high discharges, some bed load would transition to suspended load and would be distributed into the canal and over the dam. The delta formation above the dam may change slightly in response to the current river flow regime. However, since the river has adjusted to the dam during the last 100 years, these small adjustments are likely temporary and similar to the dynamic nature of the Yellowstone River.

A sediment data assessment was performed using the available information from the nearest stream gage station operated by the USGS and also limited samples collected specifically for this evaluation in the summer of 2008. Data resources for the reach are limited. The purpose of the sediment assessment was to perform a reconnaissance level assessment to evaluate sediment movement in the dam vicinity. The assessment focused primarily on the sampling plan enacted in 2008 to obtain a snapshot of sediment movement and distribution in the area adjacent to the dam

Sediment Data Assessment

In the proximity of Intake Diversion Dam, sediment and flow data is limited to the USGS gage on the Yellowstone at Sidney, MT, (41.9 miles downriver) and a sampling program undertaken in the vicinity of the dam in 2008.

The USGS gage at Sidney, MT, provides suspended sediment concentrations since 1965. Figure A.2.8 shows the sediment transport correlation for the entire history of the gage. Figure A.2.9 shows only the sediment transport correlation from 1965 to 1989, and figure A.2.10 shows the same for 1990 to 2007.

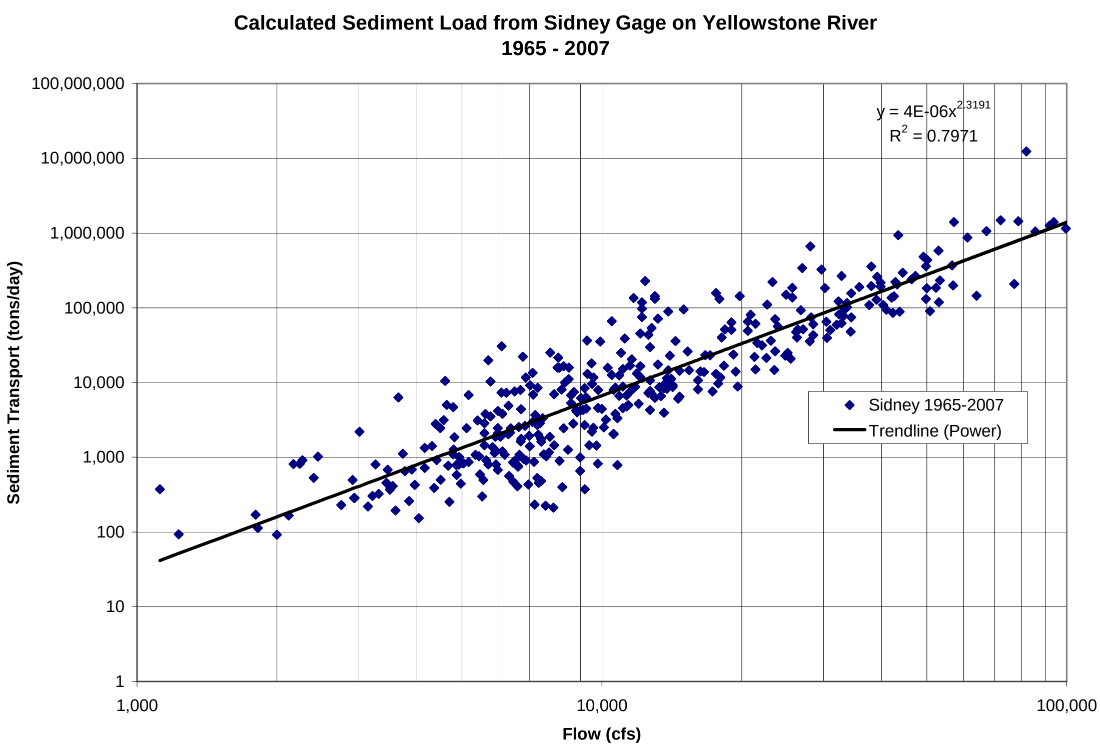

Figure A.2.8 - Measured Suspended Sediment Load at Sidney, MT, 1965-2007.

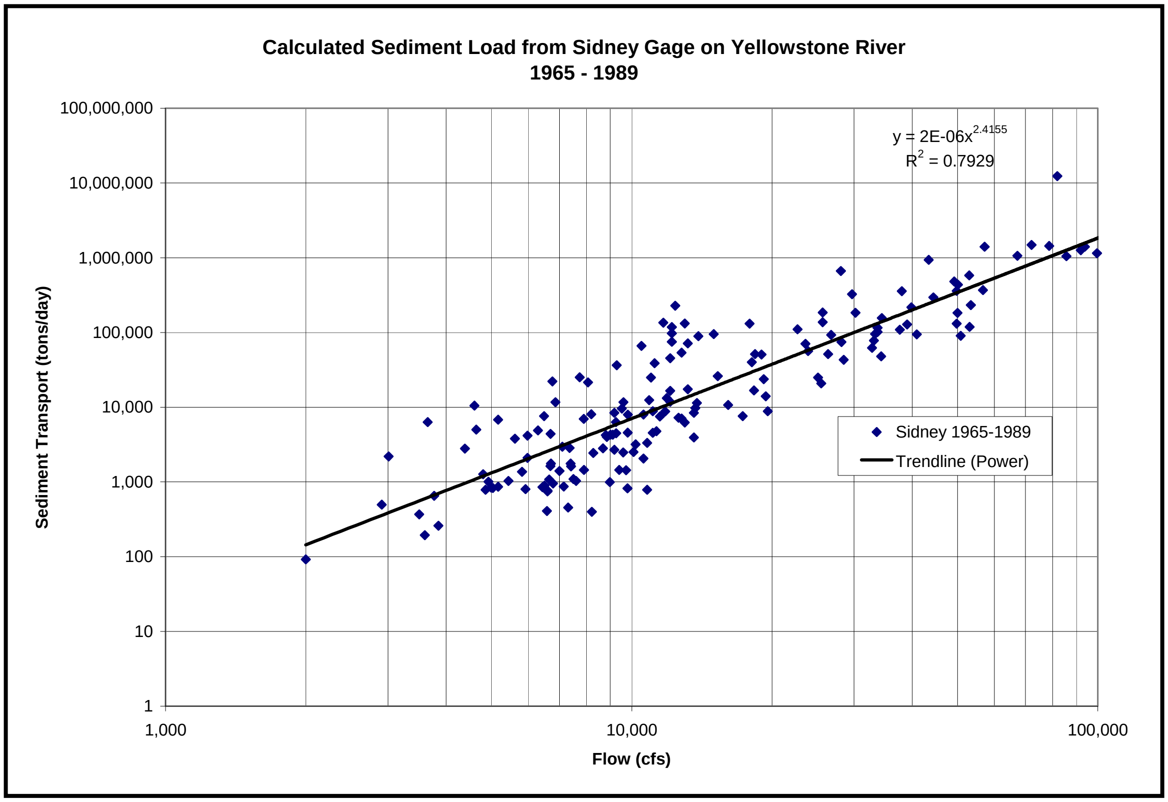

Figure A.2.9 - Measured Suspended Sediment Load at Sidney, MT, 1965-1989.

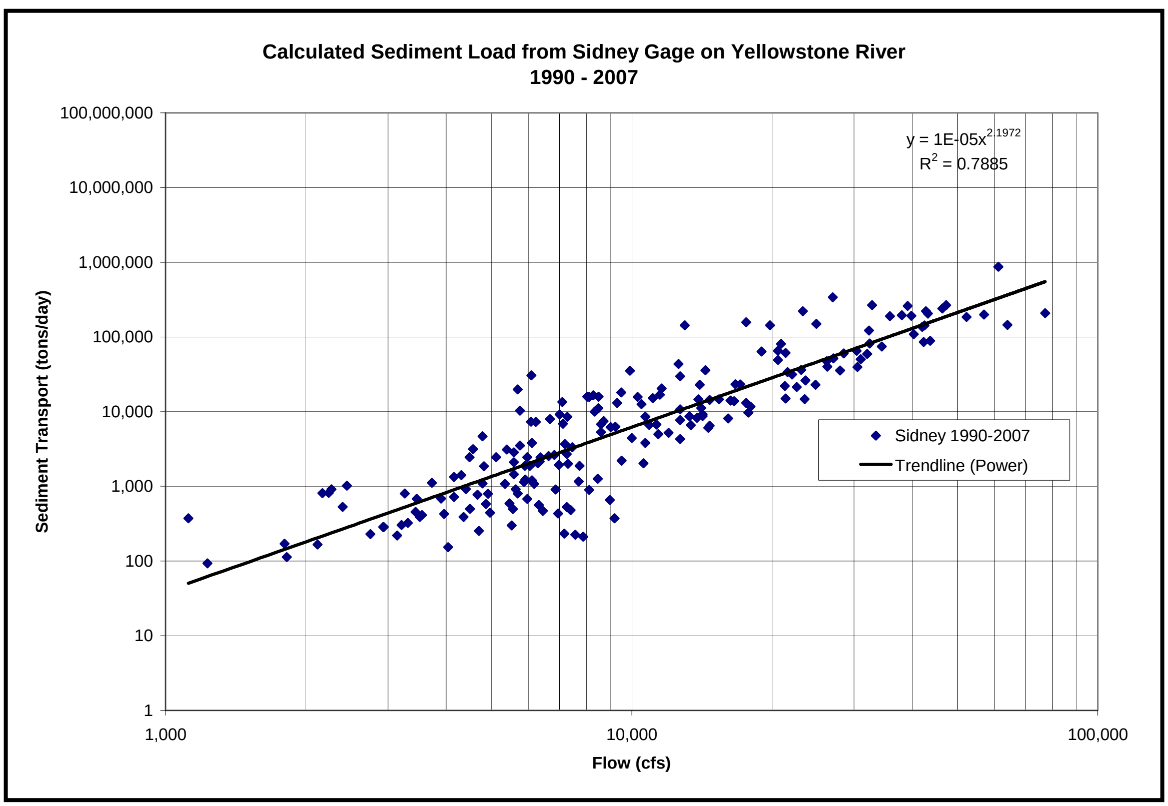

Figure A.2.10 - Measured Suspended Sediment Load at Sidney, MT, 1990-2007.

The reduction in sediment transport for a corresponding discharge in the recent years may be attributable to numerous factors. Coarsening of the available material for transport, additional sinks for finer suspended sediments, changes in duration of the transport events, and reduction in flow velocity for a given discharge may impact transport. The reduction in fine particles due to diversion at Intake Diversion Dam may play a role in this change.

Suspended sediment samples were collected at the Sidney gage for the majority of the same time period. Figures A.2.11 and A.2.12 represent the particle size distributions for the same time periods as above.

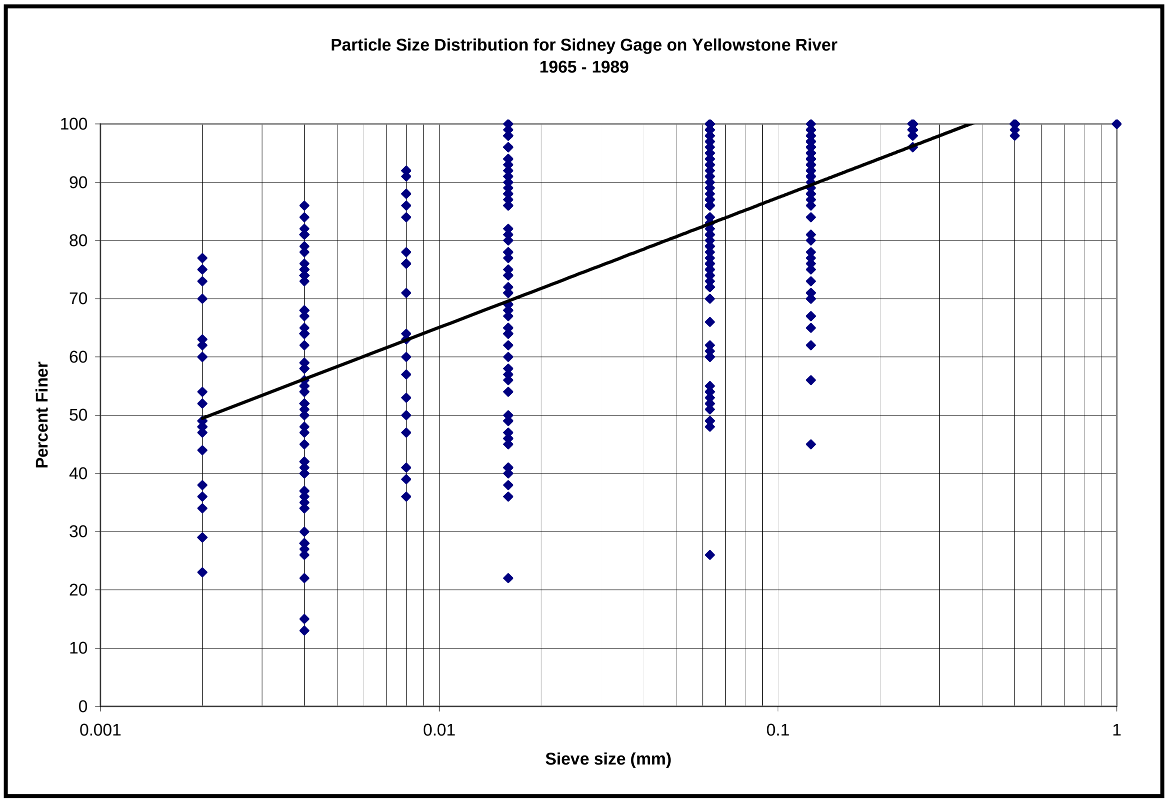

Figure A.2.11 - Suspended Sediment Particle Size Distribution at Sidney, MT, 1965-1989.

To provide increased knowledge of sedimentation processes local to the dam, the USGS undertook a sampling program during the summer of 2008 in an attempt to identify the distribution of sediments between the areas above and below the dam and within the irrigation canal downstream of the diversion point from the Yellowstone River. For each sampling event, suspended sediment concentration and bed samples were collected. Figures A.2.13 - A.2.15 summarize the calculated sediment transport at each of the measured locations.

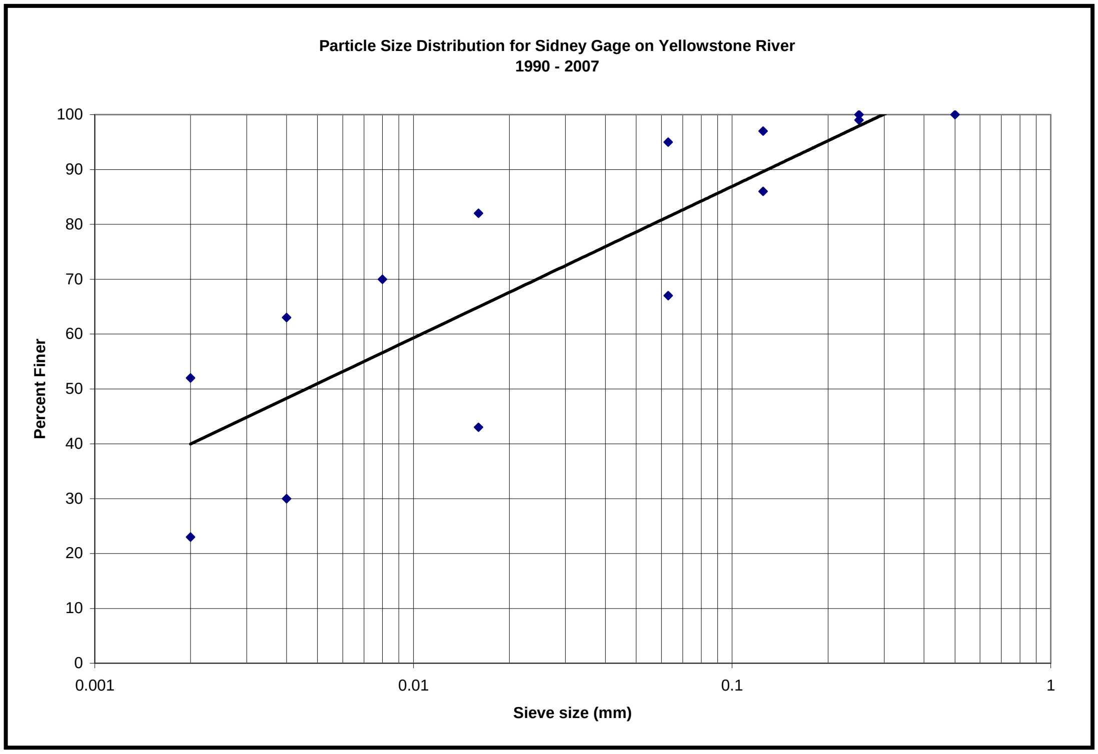

Figure A.2.12 - Suspended Sediment Particle Size Distribution at Sidney, MT, 1990-2007.

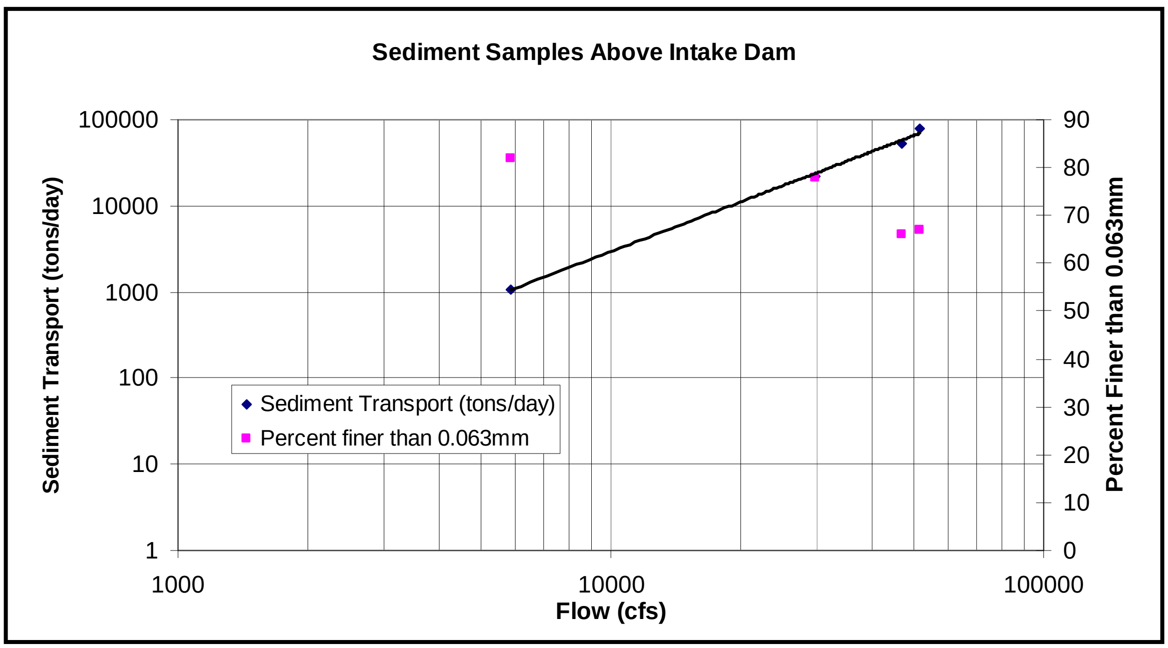

Figure A.2.13 - Measured Sediment Transport above Intake Diversion Dam.

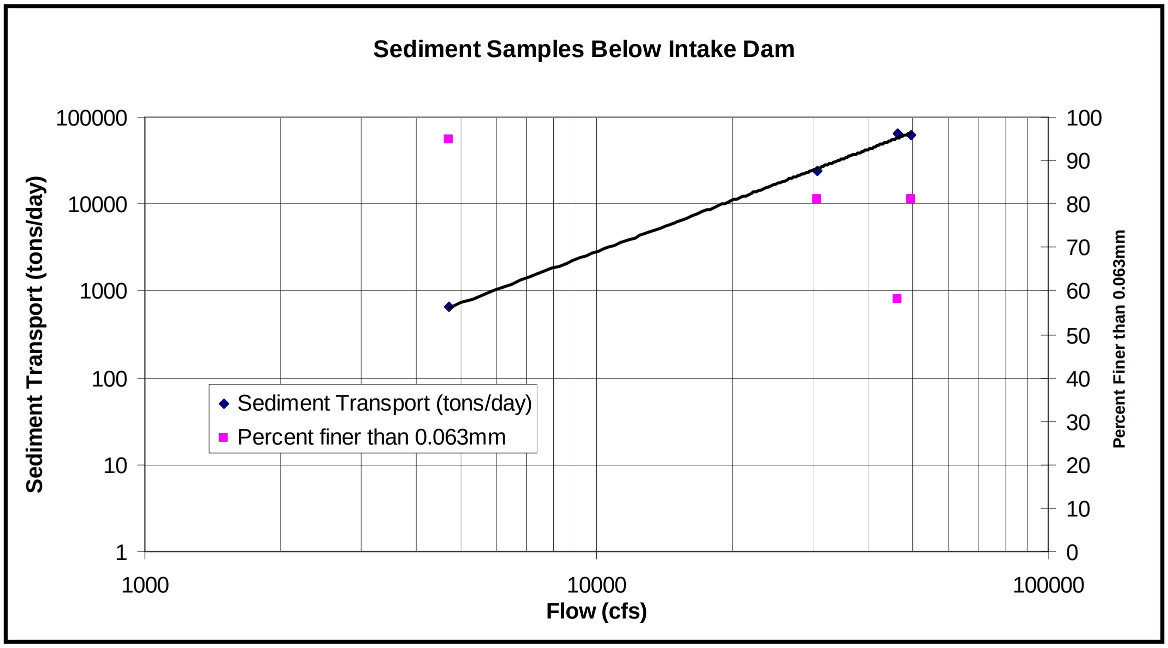

Figure A.2.14 - Measured Sediment Transport Below Intake Diversion Dam.

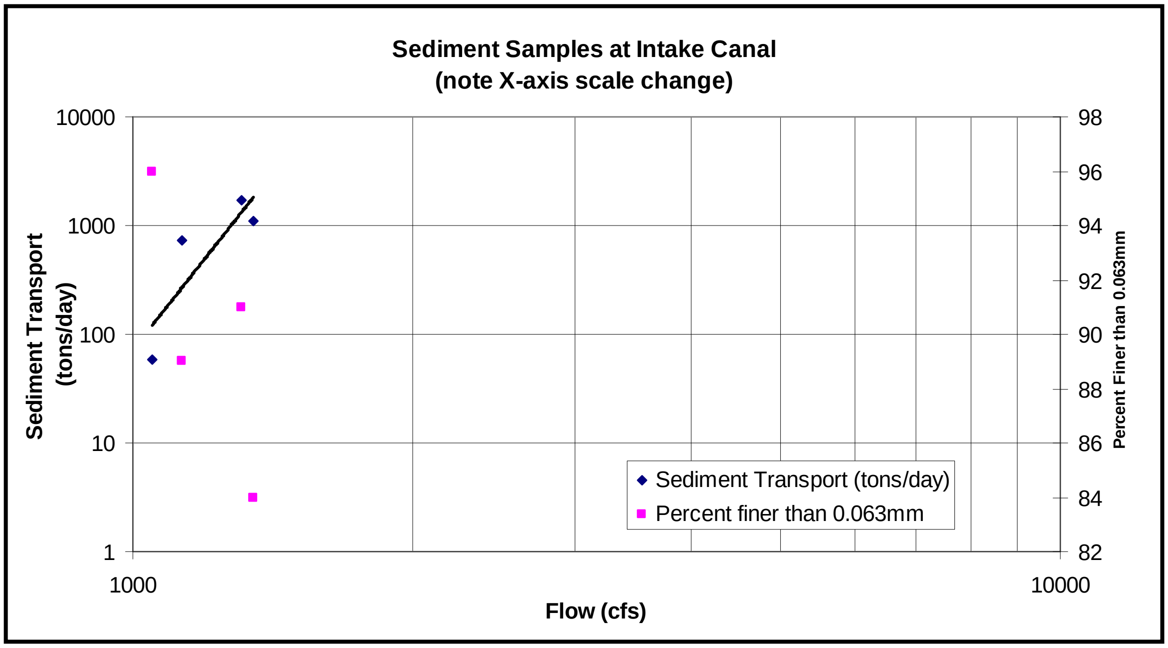

Figure A.2.15 - Measured Sediment Samples at Intake Canal.

The highest discharges into the canal coincide with the highest flows in the river. While this is the case, with limited data it is difficult to determine the correlation between increased sediment load in the river and the corresponding sediment load in the canal. Increased sediment transport is seen in the canal at increased flows, but there is no way to directly know if this is a result of increased river bed load. The increased load may be only attributable to the increased flow, not the increased sediment source.

It would be expected that for any single sampling event, the flow above the dam would equal the sum of the flows from the intake canal and the river downstream of the dam for a system in relative equilibrium. For these sampling events, the summed flows are within five percent of the above dam measurement. The subtraction of approximately 1000 tons/day of sediment into the intake canal does not fully account for the measured change in Yellowstone River transport to from upstream to below the dam. Even so, the values are similar enough that very little change in the extent of the delta deposition upstream of the dam would be expected in the future.

Bed load samples collected from the areas above, below, and in the intake main canal are displayed in figures A.2.16 - A.2.18.

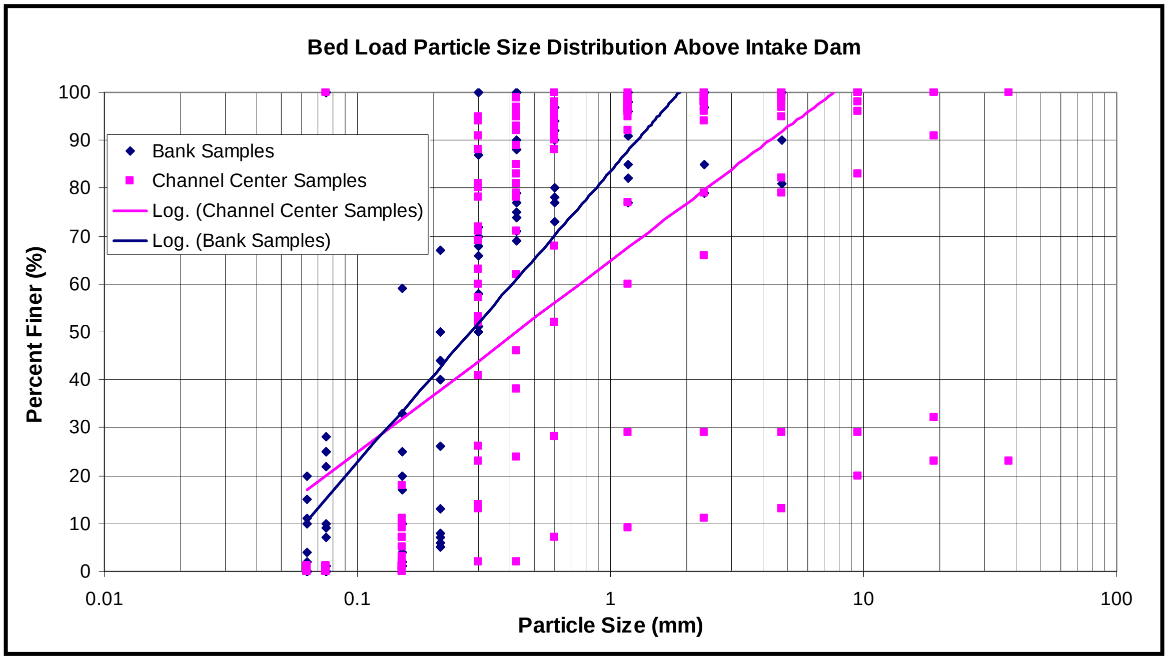

Figure A.2.16 - Bed Load Sediment Particle Size Distribution Above Intake Diversion Dam 2008

The distribution is skewed towards large particle sizes by two samples that appear to be gravel and larger rock. Both samples were taken during the same sampling event and may not be representative of the bed load above the dam as extremely high velocities would be necessary to move this material as part of the bed load.

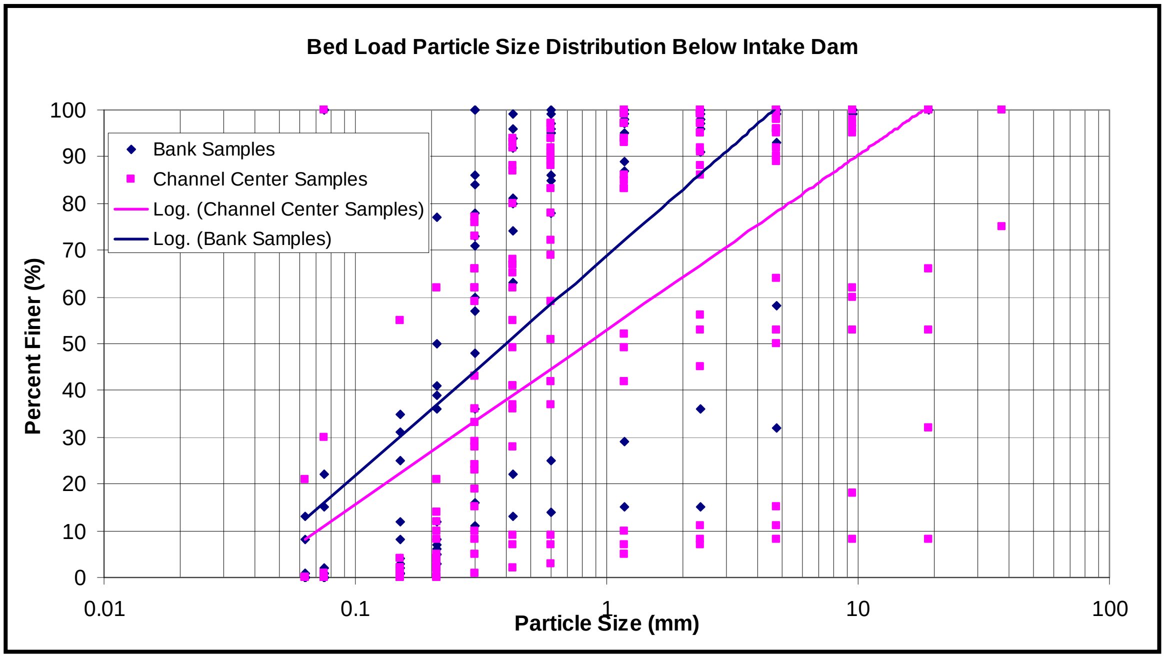

Figure A.2.17 - Bed Load Sediment Particle Size Distribution Below Intake Diversion Dam 2008

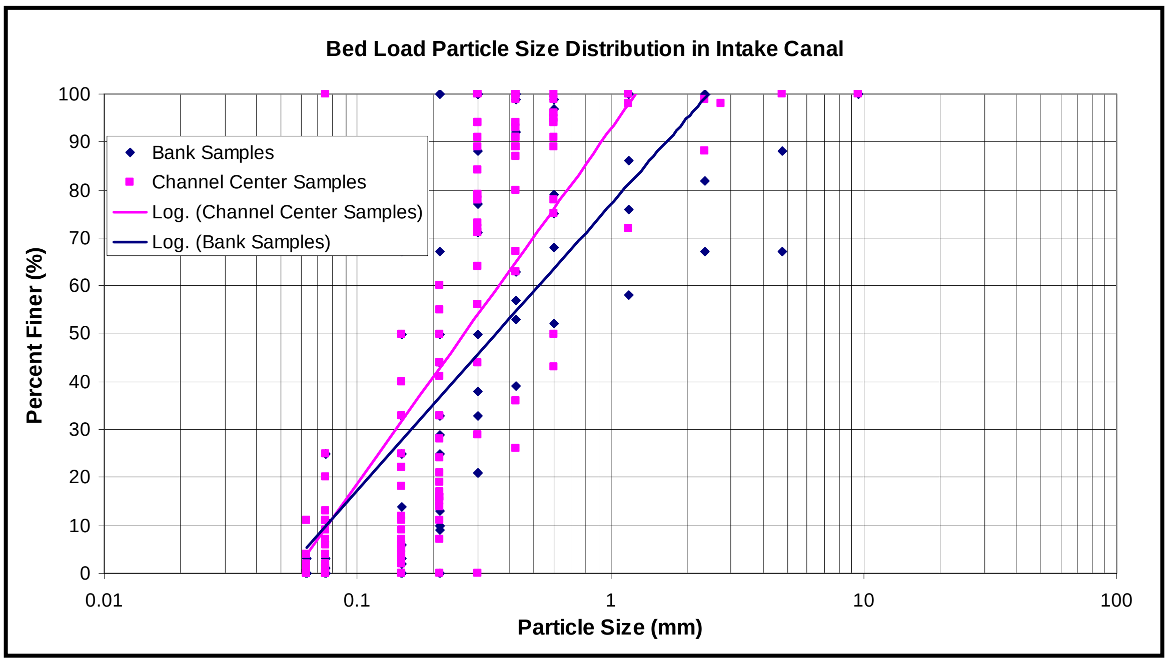

Figure A.2.18 - Bed Load Sediment Particle Size Distribution at Intake Canal 2008.

Each set of samples was plotted as two subsets. The near bank samples are the two samples closest to each bank, and the channel center samples includes all samples not used in the near bank samples subset. The bed load particle size distributions for the areas above and below the dam and in the canal show finer sediments being transported closer to the banks, with coarser materials moving along the bed in the center of the channel. This result fits well with the theoretical concept that bed load becomes coarser with increased flow velocity.

In addition to the USGS sampling during 2008, Corps collected bed and bank material samples in the vicinity of the dam. These samples are intended to provide information on the makeup of the delta sediment and give an estimate of its extents. Ten bed material samples were collected. They range from almost five miles above the structure to just over three miles below it. Seven bar samples were collected and three bank samples were collected. The bank material was identified as highly homogeneous. The samples collected on each bar were similar on the respective bar but varied somewhat between bars. With only two bank samples collected above the dam and one below, no concrete determinations can be made. From the one sample below the dam, it appears that is has a finer material makeup than the samples above. There may be many reasons for this; one that is likely is that the catchment of coarser material above the dam is due to lower velocities during high flow events caused by the backwater effect of the structure.

Figures A.2.19 and A.2.20 display the particle size distribution of the bar samples collected above and below the structure during 2008.

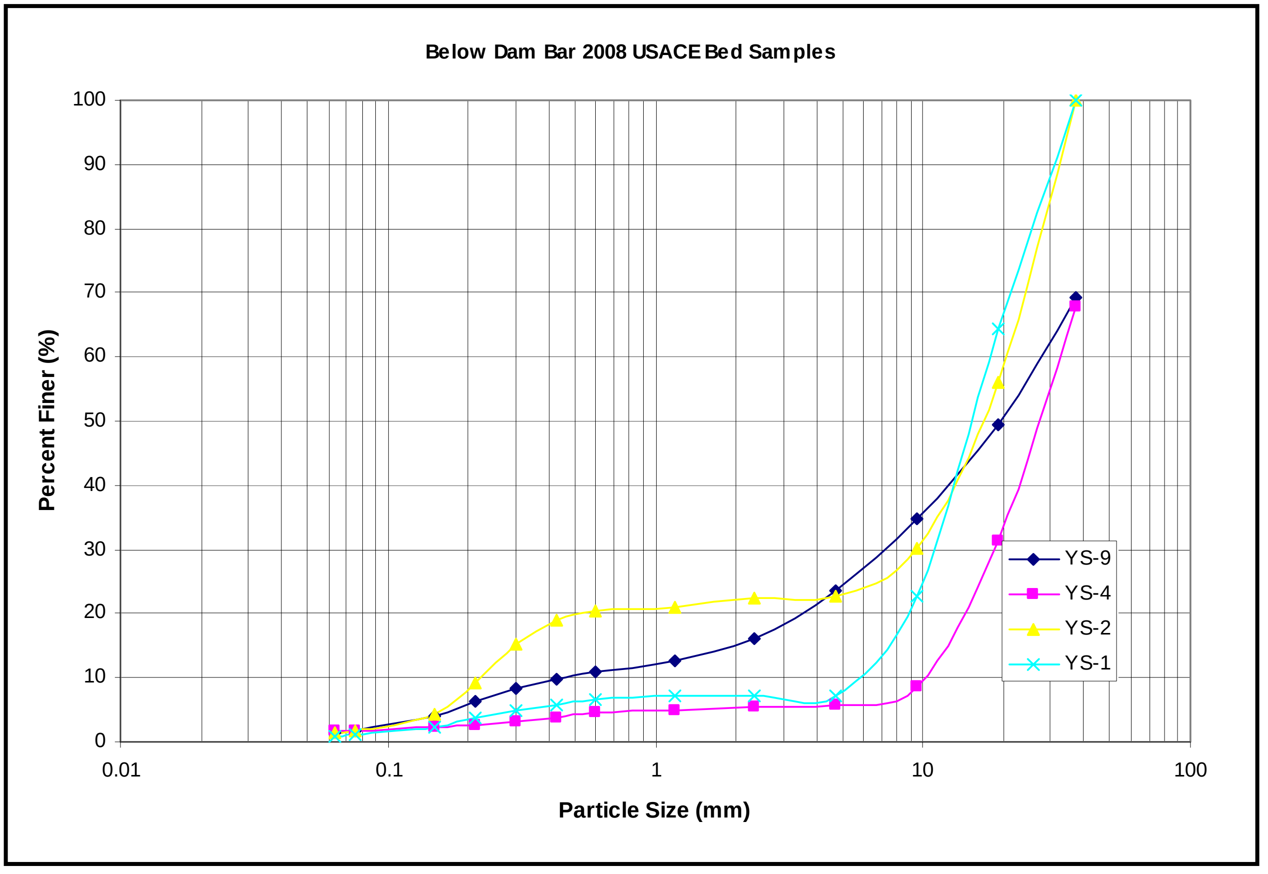

Figure A.2.19 - Bar Samples Below Intake Diversion Dam 2008.

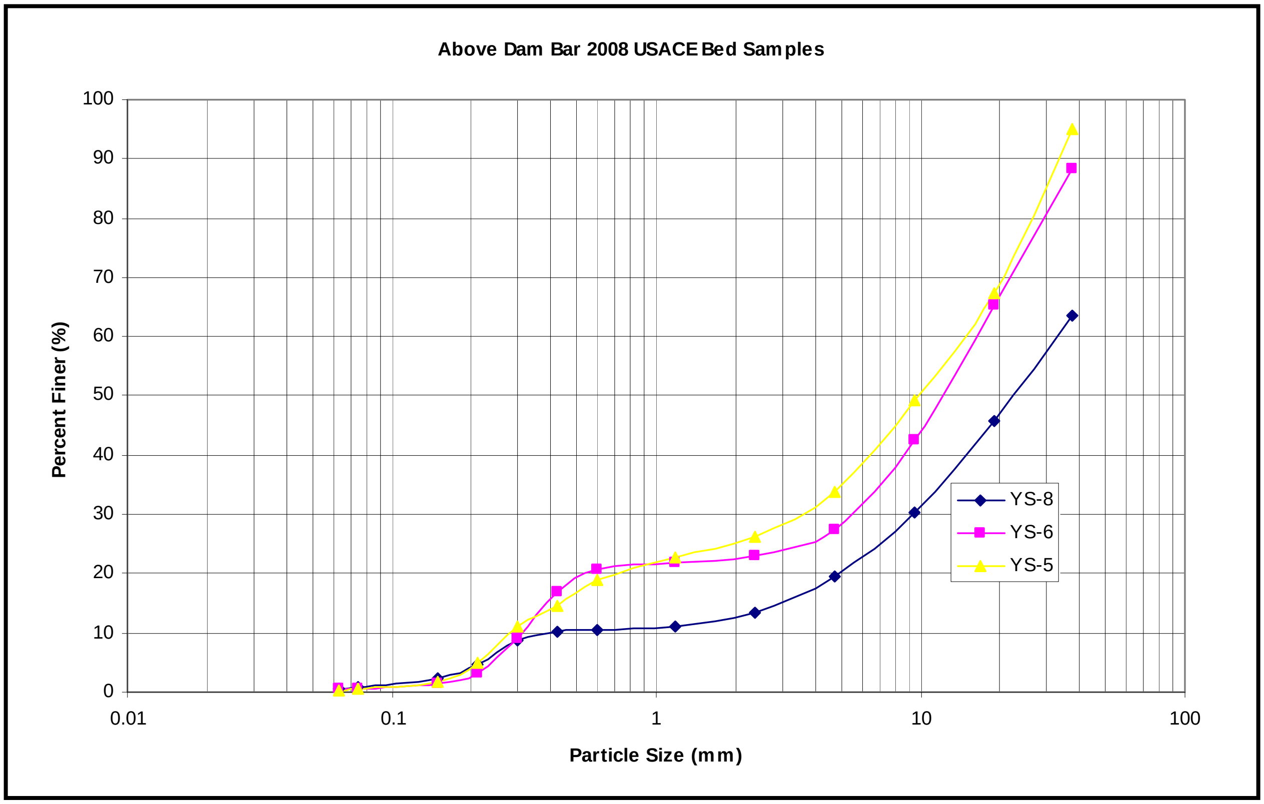

Figure A.2.20 - Bar Samples Above Intake Diversion Dam 2008.

The above sample particle size distribution shows that there is some coarsening of the bars below the dam. Approximately 40% of particles are finer than 10 mm above the dam compared to only 20% below the dam. This finer material may be trapped in the banks during high water events, deposited to the bed due to a drop in velocity cause by the backwater effect of the dam, or sent down the intake canal in the top of the water column.

A Wohlman pebble count was conducted at the same location as bar sample YS-9, approximately one half mile below the dam. Two separate counts were conducted with similar results. The counts showed a significant number of coarse gravel through small cobble rocks. The D_{50} for the hand sample was approximately 50mm. Most of these larger cobbles were the expected saucer shape, indicating hydraulic shaping. No sharp, jagged cobbles or gravel were noted.

Figures A.2.21 and A.2.22 compare the bank and bar samples above and below the dam.

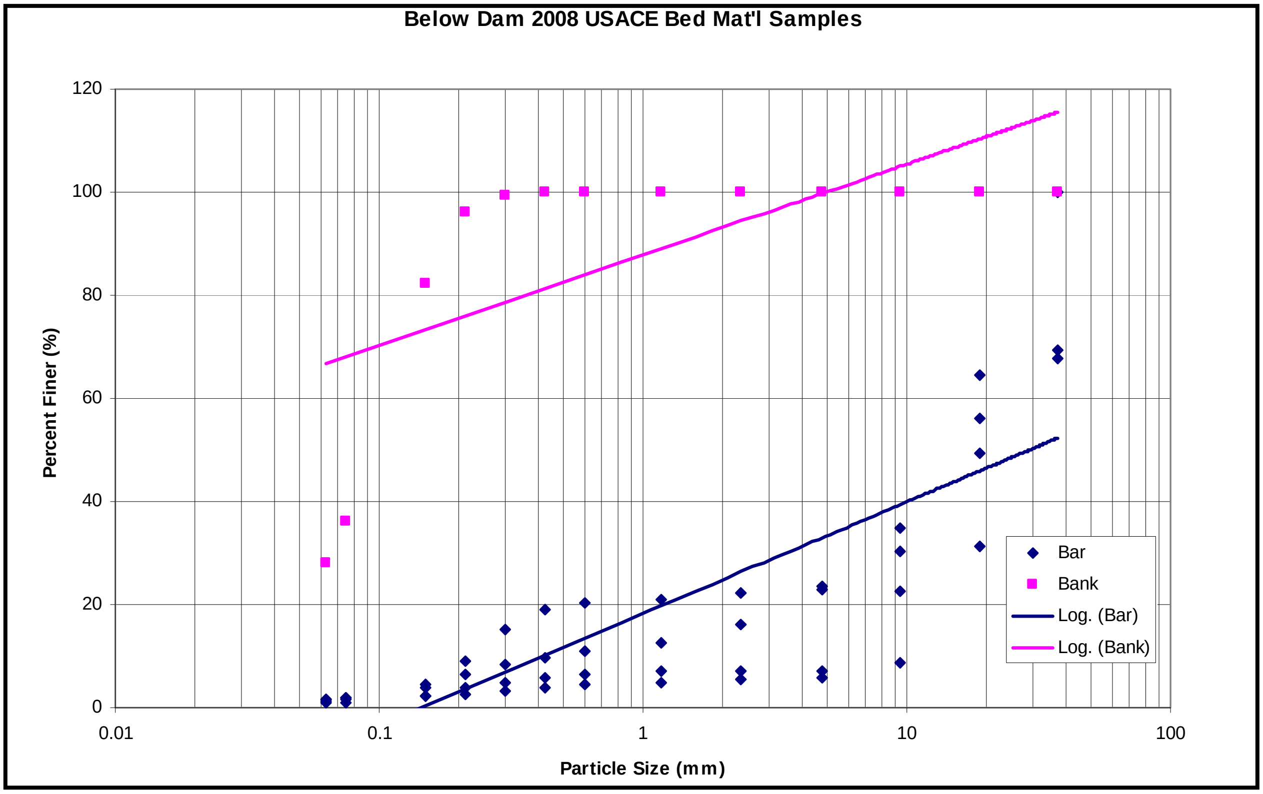

Figure A.2.21 - Bar and Bank Samples Below Intake Diversion Dam 2008.

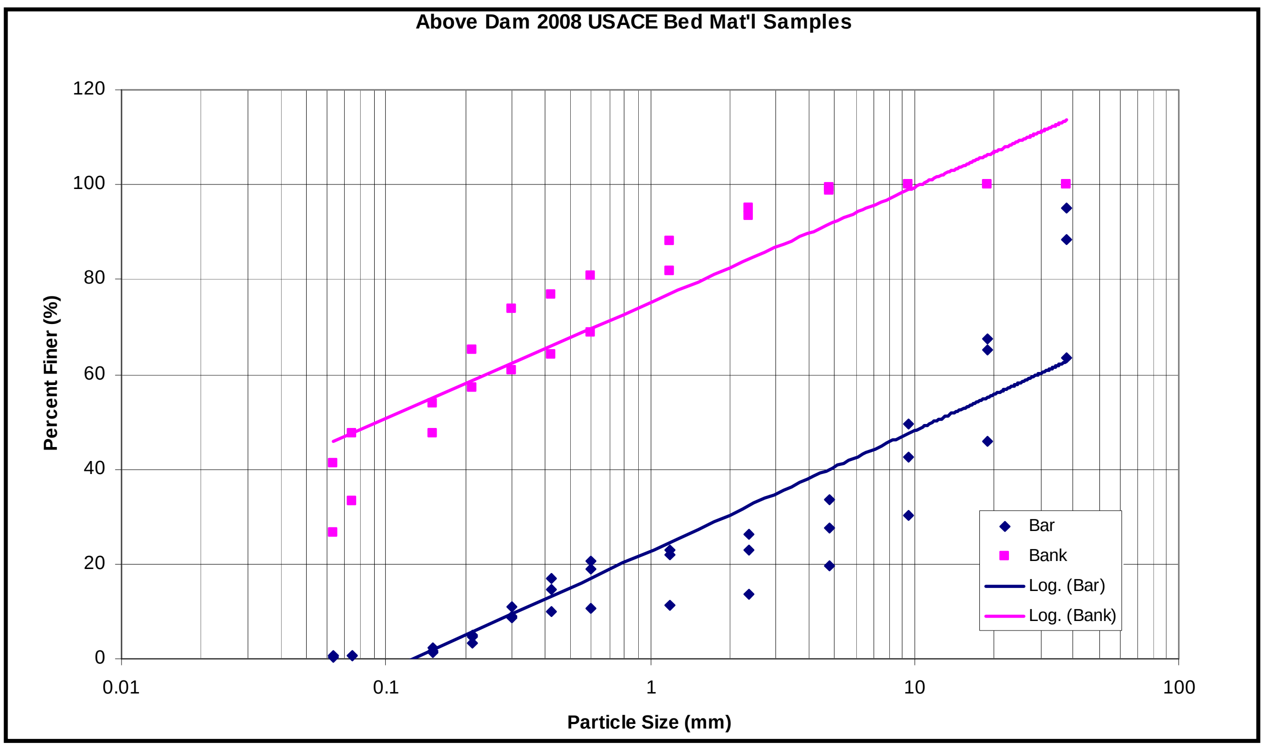

Figure A.2.22 - Bar and Bank Samples Above Intake Diversion Dam 2008.

Sediment Data Comparisons

Sediment transport directly below the dam is measured in an area that has experienced channel armoring. Armoring is the prolonged degradation and coarsening of the bed sediment (Vanoni 2006). As such, in the absence of extreme flows, these coarser bed materials are not available for transport. This can be seen by comparing the transport below the dam to that at the Sidney, MT, gage. The transport is approximately 7,500 tons/day at Sidney compared with 3,000 tons/day below the dam for a corresponding flow of 10,000 cfs. At higher flows of 50,000 cfs the Sidney data shows approximately three times the transport when compared to below the dam. Caution should be used when interpreting these results as sediment transport is extremely episodic and event dependent. The wide variation in sediment load is illustrated by the data shown in figure A.2.8 where the sediment load can vary by a factor of 10 for the same river flow. In summary, evaluation of the sediment load information determined:

- Sediment load measured upstream of the dam is slightly higher than downstream of the dam, with 2008 measured values ranging from nearly equal to approximately 20% higher.
- Bed and bank particle size distributions are coarser below the dam, indicating the retention of finer sediments in the dam backwater area. Some fine sediments were likely transported with the intake canal flows.
- Sediment transport occurs within the canal. Measured loads vary with discharge but are significant. The canal sediment transport for a given flow is about 2-5% when compared to the total Yellowstone River sediment load measured above the dam.
- Projecting over a full season of canal irrigation flows by assuming 1200 cfs for 4 months, the measured canal sediment transport of 800 tons per day corresponds to a sediment volume of about 96,000 tons. Using a density of 95 lb/ft^3, this equates to approximately 46 acre-feet per season. The limited information available regarding canal maintenance indicates that most of this material does not deposit within the canal. It is likely that material is deposited within the irrigated farm fields or carried with return flows to the Yellowstone River.
- Measured sediment transport rates downstream at Sidney are generally higher than those at Intake Diversion Dam. Further investigation would be required to evaluate differences. However, further design efforts should consider that Sidney data are not representative of conditions at Intake Diversion Dam.

Unfortunately a direct comparison between particle size distributions at the dam and Sidney is not possible. This is due to bed load data at the dam, and suspended load data at Sidney.

Direct comparisons can be made between the three locations near Intake Diversion Dam. Figures A.2.16 - A.2.18 presented the bed load particle size distribution around the dam. In all three locations, the bed load is finer near the banks than in the higher velocity center channel.

A comparison of the bed material particle size indicators can be used to identify differences in the size distributions. The D_{50} particle size is the median diameter where 50% of the sediment is finer (Yang 2003). For samples above the dam the D_{50} for the channel center is approximately 0.41 mm, and 0.26 mm for the near bank samples based on the power function trendline that represents the distribution. Below the dam, these values are 0.80 mm and 0.40 mm respectively. This indicated a significant increase in the coarseness of the bed load below the dam. Reasons for this could include an increase in turbulent flow and limited amounts of fine material to be moved due to armoring. This increase in D_{50} is observed even as total transport of suspended load decreases below the dam, as seen in figure A.2.14. This is also expected since coarser materials at similar discharges transition between suspended and bed load.

In the intake canal the D_{50} values are 0.25 mm for the center channel and 0.35 mm for the banks. These results show that there is fine to medium sand moving as bed load in the intake canal. These results show coarser material at the banks of the intake chute, but the difference between the distribution trend lines is very small. Both of these values classify the D_{50} as medium sand. Three of the four samples in the intake canal exhibited distribution trends similar to above and below the dam. The fourth, at low flow in late August 2008 show a strong trend in the opposite direction, with the banks having more coarse material than the channel. The exact reason behind this sample result is unknown. Removal of this sample from the plot results in D_{50} values for banks and channel being nearly identical. In summary, evaluation of the sediment size information determined:

- Size distribution between the areas upstream of the dam, in the canal, and downstream of the dam is typical of river response to a structure such as Intake Diversion Dam. In general, the bed load material in the center of the channel is coarser than the material near the banks.
- Bed load material size below the dam is the coarsest, with a D_{50} of 0.8 mm.
- Bed load material above the dam is slightly smaller, with a D_{50} of 0.4 mm.
- Bed load material in the canal is the smallest, with a D_{50} of 0.25 mm.

The comparison of the measured data indicates that the Sidney, MT, gage on the Yellowstone River may not be a reliable surrogate for the sediment transport processed happening directly below Intake Diversion Dam. A longer period of data collection and analysis would be required to fully evaluate the relationship.

Deltaic Sediments and Geographic Extents

Limited channel geometry data is available for the current river orientation and dam operation. To determine the volume of sediment deposited in the delta, knowledge of the channel geometry before the construction of the dam would be necessary. In lieu of such data, an estimation of the delta extents was made. Surveys collected in the dam vicinity in 2007 were evaluated. Bathymetric data were gathered around the dam and upstream. Due to dangerous survey conditions, no data is available from the near dam region. Evaluation of the data indicates a scour hole that occurs on the left bank or outside of the bend upstream of the dam. As previously discussed in the sediment data assessment, this has probably occurred due to the entrainment of sediments into the canal. Surveys also indicate that a significant amount of sediment has been deposited upstream of the dam.

Since construction, the bed immediately upstream of Intake Diversion Dam has aggraded while forming a delta behind the impoundment. Historical data is not sufficient to accurately assess the amount of sediment that has been trapped, but the amount can be estimated comparing current surveys with a projected bed that would simulate the initial conditions before the dam was placed.

To estimate the sediment deposition volume, two surfaces representing trapezoidal channels with 2:1 side slopes were projected upstream from the dam using a representative channel width of 700 feet. The projected section width corresponds to the channel width at Intake Diversion Dam. Adjacent areas indicate that a greater channel width may be more representative of the Yellowstone River. All projections assumed an initial invert elevation of 1980 feet at the dam to represent the base bed elevation after dam removal. Surfaces were projected at two bed slopes to provide lower and upper bounds for the volume estimation based upon values that represent naturally occurring bed slopes in the region. The upper bound estimation was projected upstream at a slope of 0.0005 ft/ft. The lower bound estimation was projected upstream at a value of 0.00085 ft/ft.

The shape of the projected channel excavation compared to the current bed elevation is shown on 4 different cross-sections in figure A.2.23. A plan view of the section location is shown on figure A.2.24. The first three cross-sections display the build up of sediments behind the dam. The cross-section at Station 7+70 shows that there has not been much deposition adjacent to the headworks structure. This is likely caused by increased velocities due to interactions with the diversion and a lower crest elevation at the left edge of the dam which attracts higher velocity flows to the structure. By Station 14+500 the surfaces have intersected the existing ground. The effects of deposition begin to dissipate between Station 10+000 and 15+000 using this estimation. Evaluation results are summarized as:

- Results determined a range of 3.0 to 4.7 million cubic yards of material that would be mobilized following dam removal. Using an estimated sediment unit weight value of 95 lb/cu ft, the material volume corresponds to a range of 3.8 to 6 million tons.
- For comparison purposes, the Yellowstone River at Sidney is estimated to have moved approximately 900,000 tons from May 1 through August 30 in 2007 as suspended load. Additional material would move as bed load, increasing total load to approximately one million tons. Therefore, the deposited material is four to six times the Yellowstone River suspended load during the 4 month peak flow period.
- As has been seen in recent dam removals, deltaic sediments may move from their current locations fairly quickly, but would require a longer time to move farther through the Yellowstone River and into the Missouri River.
- The deposition zone extends to about 10,000 to 15,000 feet upstream of the dam. Bar samples collected up to 20,000+ feet above the dam
- Maximum depths vary throughout the deposition zone with many areas exceeding 10 feet in depth.
- A greater channel width would increase volume estimates. This is likely to occur as banks become unstable.
- Results are based on a reconnaissance level evaluation. A detailed sediment transport and stability analysis would be required to more accurately estimate material volume and transport.

(Cross sections oriented looking upstream)

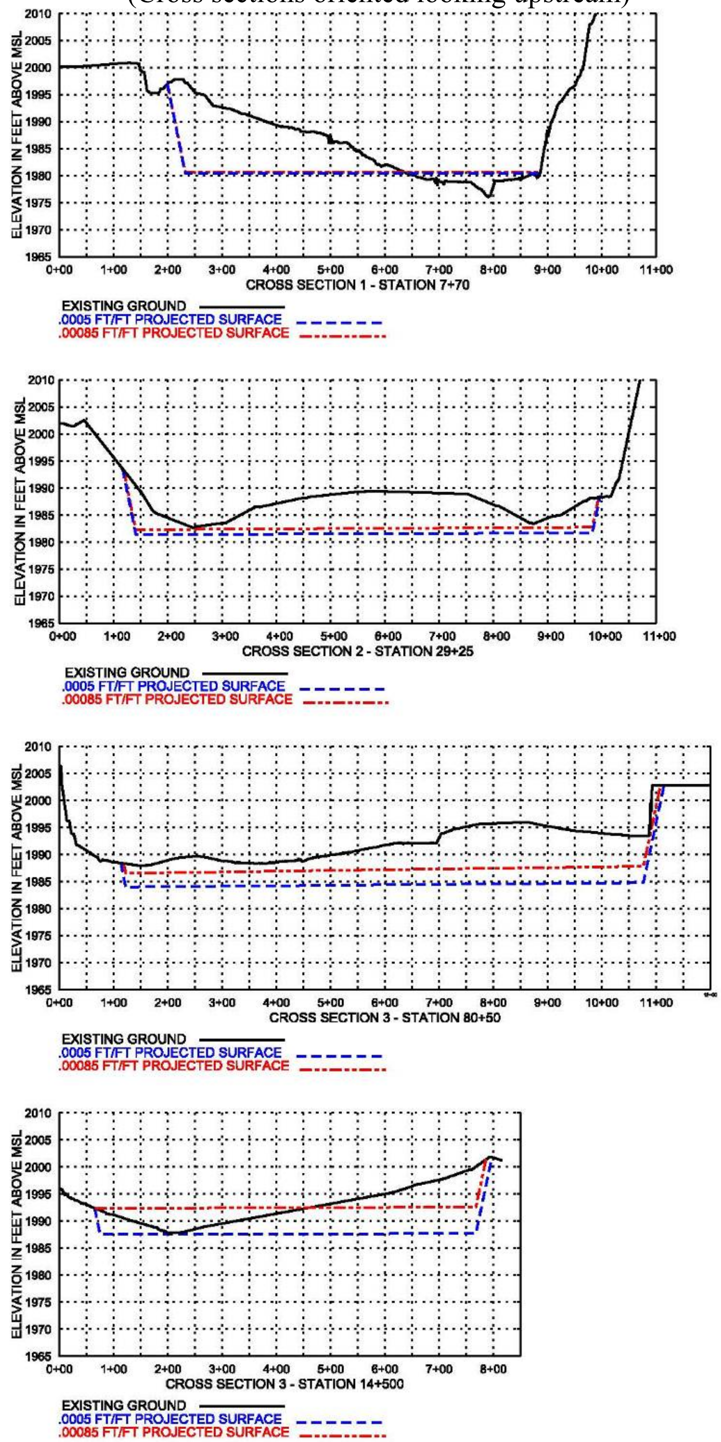

Figure A.2.23 - Projected Channel Cross-sections for Deposition Estimates.

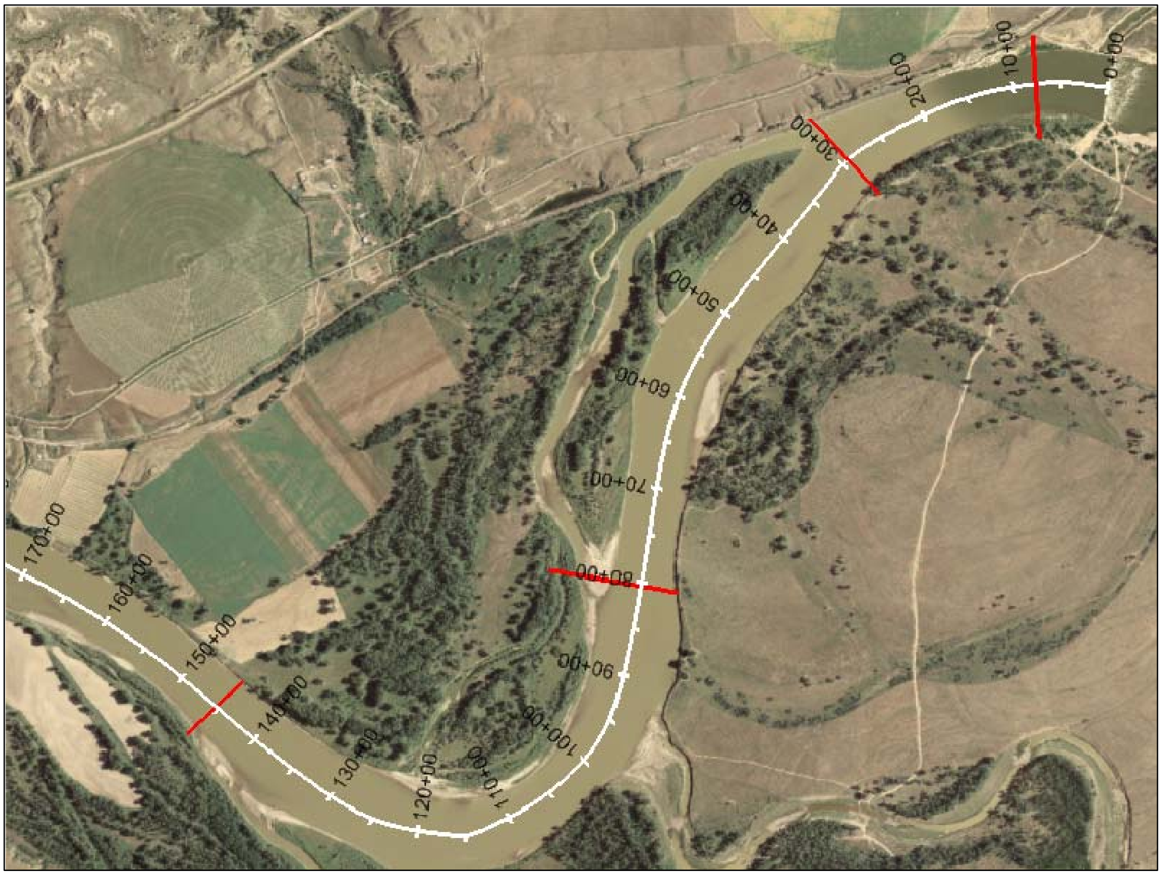

Figure A.2.24 - Section Locations for Deposition Estimates.

Irrigation Canal Maintenance

Informal communication with the Irrigation District indicates maintenance activities have been conducted on a five to 10 year interval. Routine O&M of the dam and headworks is conducted by the Lower Yellowstone Project, Board of Control (Board of Control). The ice and trash deflectors on the headworks are replaced as needed, and the cableway is used to replace rock at the diversion dam. Some accelerated maintenance and replacement likely would occur over time. The Board of Control expects to repair concrete at the entrance to the high-pressure gates and projecting piers and would attempt to repair three bays every other year until completed. The north cableway tower probably would be renovated in the next 10 years. The south tower was renovated in 1999. It is anticipated that the cableway drums would be reconditioned or replaced in the next 5 years.

According to the Board of Control, rock has been added to the crest of the diversion dam nearly every year of the dam's existence. The reason rock is added is to elevate the water surface at least 12" above the existing crest, maintain a full canal, and protect the downstream face of the diversion dam from erosion. The annual quantity of rock added depends on river events, high water, and ice movement and varies from 500 - 7,000 tons, with the average being approximately 2,500 tons.

Rock is placed on the diversion dam usually in late July or early August when main canal flows are normally affected by seasonal low flow. Rock is stockpiled at the diversion dam, taken from the stockpile with a loader, dumped into a skid, and hauled across the river and dumped in the river by an overhead cableway. A portable hydraulic pump unit provides power to operate the cableway. The cableway spans about 900 ft and is suspended between two wooden towers. Rock is quarried from private land about 2 miles southeast of the diversion dam and hauled and stockpiled near the right abutment. Rock is excavated from a sloping base below vertical rock outcrops. It is separated from other material with a hydraulic hoe, sorted, and placed on two small trucks and stockpiled at Intake Diversion Dam.

Diversion of irrigation water traditionally starts May 1 and continues until October 1; however, climatic conditions can begin the season 2 weeks earlier or extend it by 2 weeks. Diversions range from 600 – 1,380 cfs. The higher diversions occur for about 50% of the irrigation season and continue as late as the first week of September. Diversions are regulated with 11 high pressure, unscreened gates. Gates are adjusted daily in response to fluctuations in river flow and irrigation demand.

Maintenance of the headworks structure includes repair and rehabilitation of gates and lifting devices, power unit, deck, wooden debris and ice deflector, concrete surfaces, and security features. A major maintenance activity involves removing lodged trees and limbs from the riverside of the high pressure gates. This maintenance is conducted every year prior to adding rock to the dam. A pontoon boat is positioned near the debris, and grab hooks are used to pull lodged materials from the debris and ice deflectors mounted on the gate bays. Workers use chain saws to cut debris into smaller pieces. A power winch on top of the structure assists in raising submerged trees and limbs to the surface.

The 12”x12" timbers covering the headworks are replaced about every 15 years. Deteriorating concrete, which is subject to aging, freeze-thawing, and eroding, is repaired annually. At the end of each irrigation season, the main canal is dewatered.

The cost estimate for O&M of the existing Intake Diversion Dam, headworks, and first mile of the main canal would be $139,281 annually. This would include $40,875 for the diversion dam, $31,563 for the headworks, $1,133 for the main canal, and $65,710 for diversion dam rehabilitation. Both the main canal and dam would be repaired every 12 years.

Alternatives

Four primary alternatives are reviewed in this section: Rock Ramp, Relocate Diversion Upstream, Pumping Plant(s), and Relocate Main Channel. Essentially all four of the primary alternatives could be varied to produce multiple sub-alternatives. However, a detailed evaluation of all potential variations was not within the scope of this report. Two sub-alternatives are presented for the rock ramp (stepped and constant slope) and both a single pumping plant and multiple pumping plants are discussed. Variations on the Relocate Main Channel Alternative are limitless and would be evaluated further in final design if that alternative is selected.

A general overview of all the alternatives presented below can be seen in plate A.2.3.

Rock Ramp

The rock ramp alternative consists of constructing a rock ramp downstream of the existing Intake Diversion Dam structure. Constructing the rock ramp would maintain the existing Yellowstone River stage-flow relationship such that diversion with the same canal intake is feasible. The ramp is constructed by adding material on the downstream side of the existing structure.

It should be noted that the original design of the rock ramp included “steps” with between 0.5 and 1 ft of drop. The current version of the rock ramp design is flat with a constant slope. However, both ramp types are presented here for comparison.

Stepped Rock Ramp

Highlights of the ramp project and analysis are as follows:

- Install concrete cap on existing dam and maintain existing intake for diversion.
- Construct sloping rock ramp downstream of the dam crest.
- Design ramp to be suitable for fish passage with diverse flow depths and velocities. A range of ramp slopes was evaluated. Review boulder spacing and configuration.
- Review ice impacts to the ramp stability.
- Ramp design is conceptual with sufficient detail to evaluate feasibility and to prepare cost estimates.
- Review available ramp design criteria and site specifics to develop guidance for refined design.
- Numerous examples of rock ramps are available. However, an installation on a duplicate river to the Yellowstone River with similar flow, unit discharge, drop height, sediment transport, substrate, section, slope, and other physical parameters was not located.
- Note that the rock ramp evaluation was completed before the hydrographic survey data were available. Because this evaluation is at a conceptual level, the analysis was not updated with the new survey data.

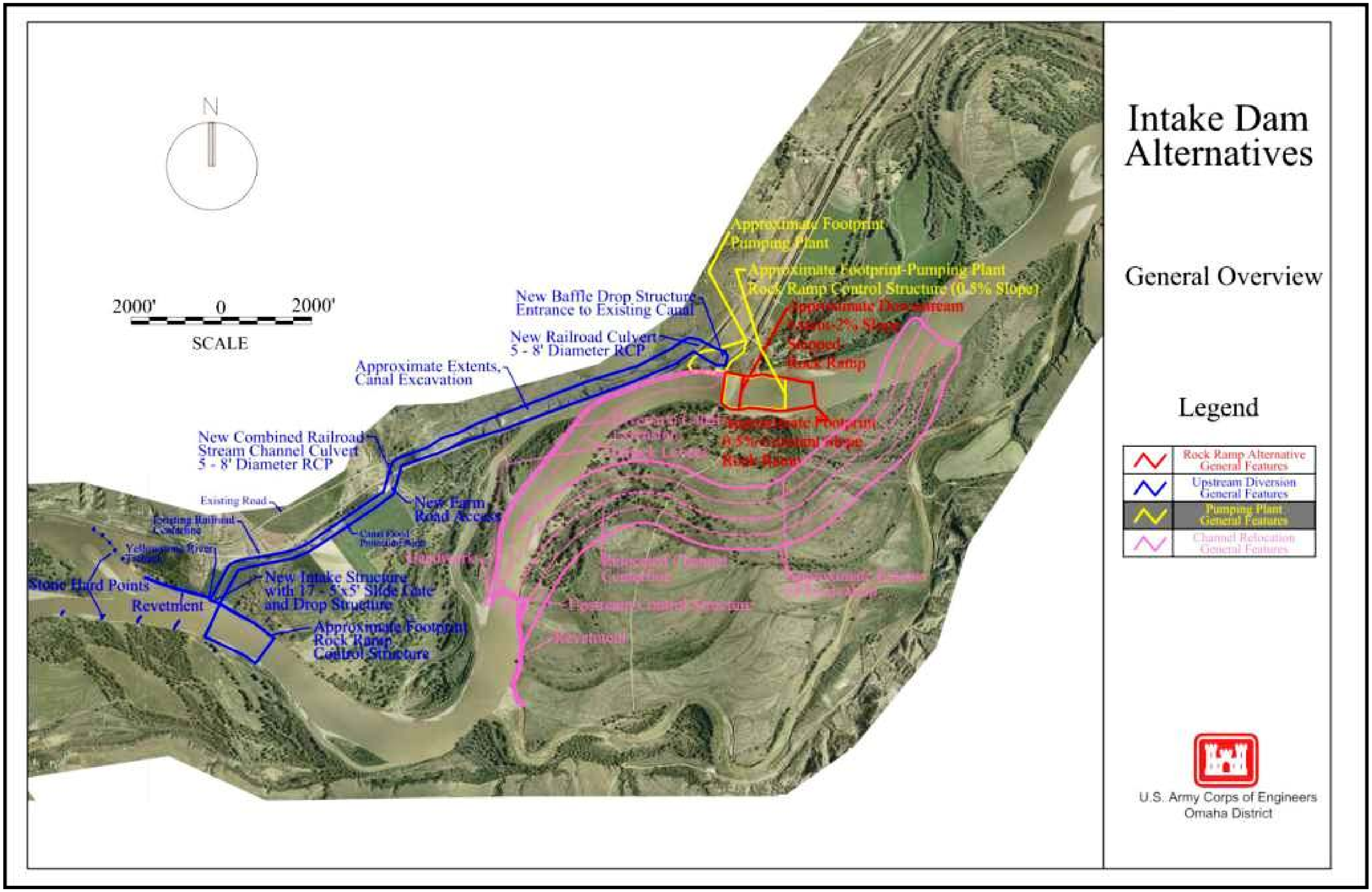

Plate A.2.3 – Alternatives General Overview.

Stepped Ramp Layout A series of slopes and drop heights were tried with the ramp in an attempt to minimize peak flow velocity and the corresponding rock size. Slopes of 5%, 3.33%, and 2% were all evaluated. Drop heights of 0.5 ft and 1 ft were also checked. Installed ramps on the Red River of the North and guidance developed by Luther Aadland of the Minnesota Department of Natural Resources (Buesing 2006 and Breining 2003) used a 1 ft drop. Compared to the Intake Diversion Dam application, the Red River ramps are a similar drop height and slightly lower unit discharge. Design and analysis results are summarized as follows:

- *Top of Ramp* Current elevation varies from 1987 to 1989; assume new dam crest is at elevation 1989. Placing the dam crest at 1989 would provide sufficient head for the existing intake structure. NOTE: To facilitate fish passage and maintain flow distribution, an uneven crest with possibly natural rock set in the crest concrete is probably required. These details will be determined in final design.

- *Toe of Ramp* Elevation 1980 (based on the old channel surveys of limited detail in the near dam vicinity). A tie-in slope of 3H on 1V or similar for rock ramp stability should be used to reach the bottom of the scour hole located downstream of the dam. According to the old survey data, the elevation 1980 is about 400 ft from the dam.

- Approximate Ramp Center Bottom Width – 550 ft

- *Ramp Shape* Ramp is "U" shaped, although unbalanced to maintain the main flow channel along the irrigation intake bank. The ramp shape should be optimized to provide the maximum depth-velocity diversity in detailed design. Due to the width of the river, it is anticipated that a significant portion of the center ramp would be relatively flat. A conceptual ramp layout is illustrated in plate A.2.4. Ramp details are shown in table A.2.6. A typical ramp profile is shown in figure A.2.25.

Table A.2.6 - Ramp Layout for Various Slopes.

Alternative	Ramp Length (ft)	Length Between Steps (ft)	Number of Boulder Rows
5% Slope, 1 ft drop	180	20	9
5% Slope, 0.5 ft drop	180	10	18
3.33% Slope, 1 ft drop	270	30	9
2% Slope, 1 ft drop	450	20	9
2% Slope, 0.5 ft drop	450	10	18

Ramp Step and Boulder Layout Guidance A 4' minimum diameter boulder is placed to form each "step" in the above profile. The boulders are not solid but would block the bulk of the flow. The boulders would be offset a little from each other to allow fish passage between boulders and give staggered resting pools. The boulder would be 0.5' to 1' above grade on the upstream side. The boulder crown would be 1' to 2' above the grade of the downstream pool. A conceptual layout of the ramp boulders is shown in figure A.2.26.

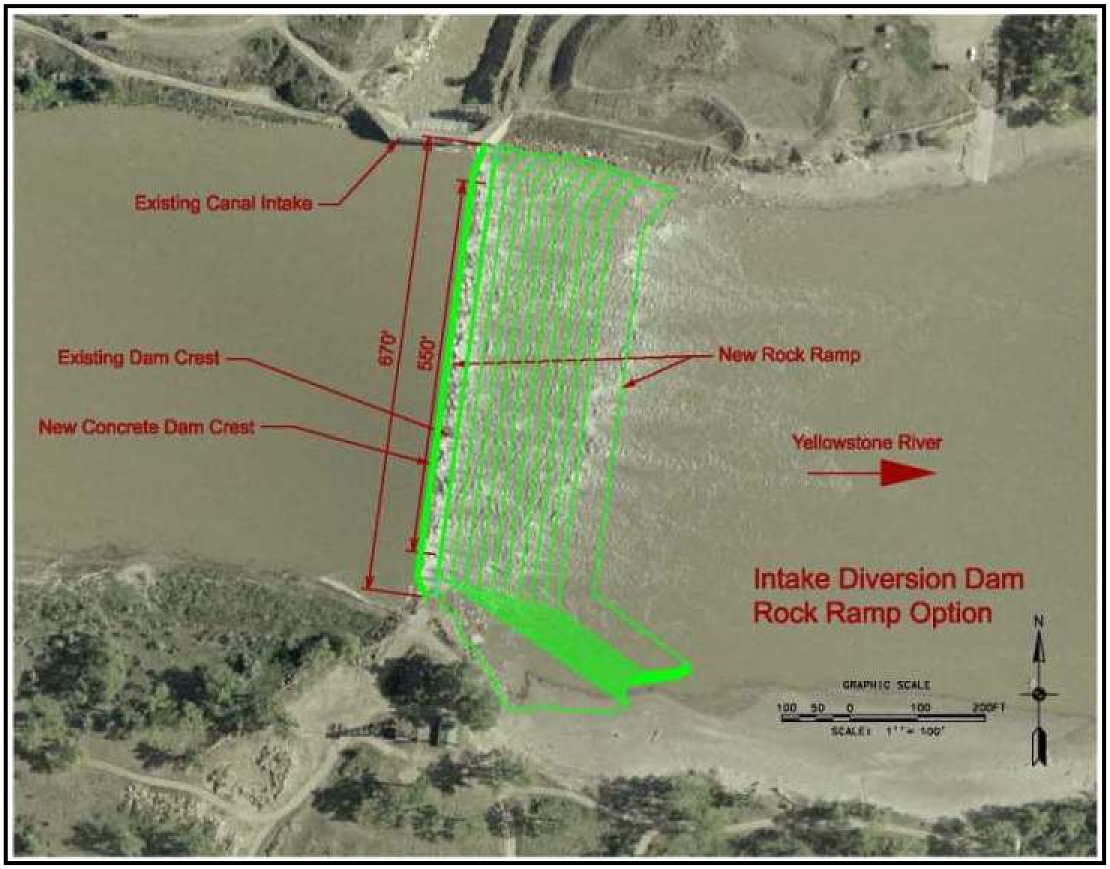

Plate A.2.4 – Stepped Ramp Layout.

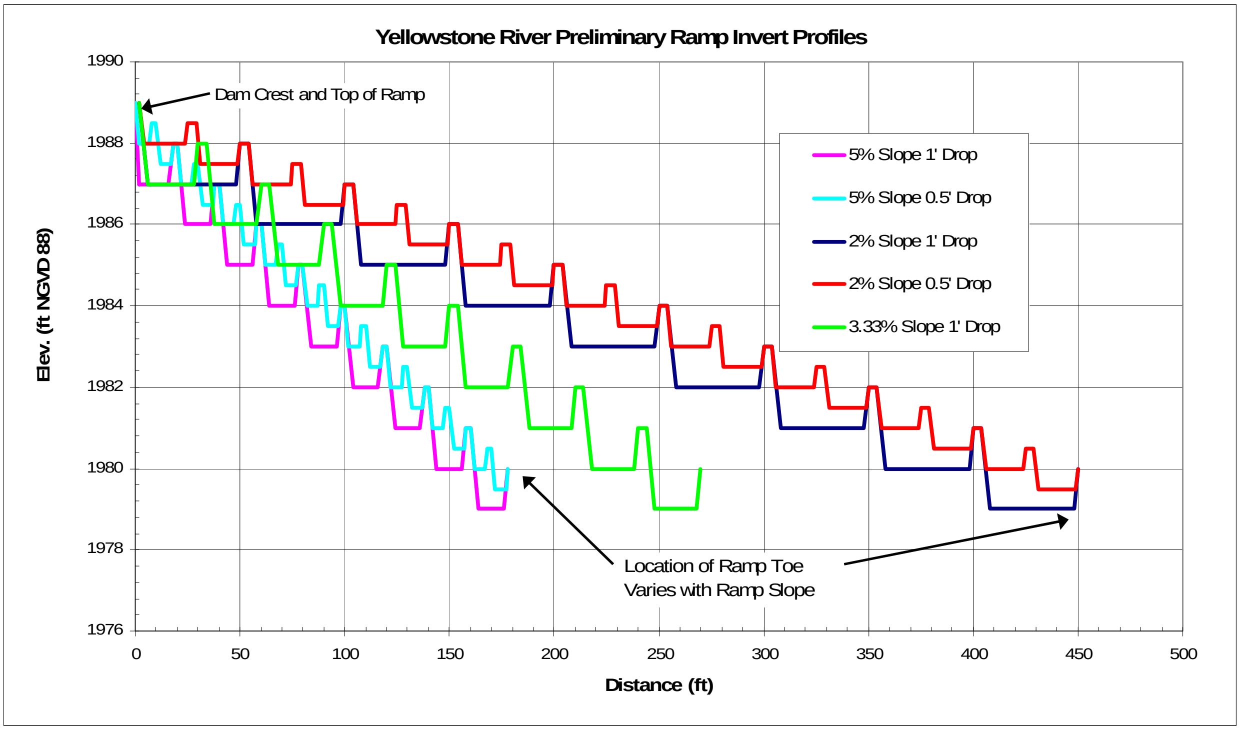

Figure A.2.25 - Stepped Ramp Invert Profiles.

- The ramp is formed by constructing a series of steps. Large boulders form perpendicular vanes that are used to anchor the steps; smaller rock is used to form the base of the steps.
- Fish passage is achieved passing through the large boulder vanes.
- Gaps in the boulders are staggered and variable to achieve velocity diversity for a range of flows.
- The large boulders should protrude about 1 ft above the ramp slope where the boulder vanes are perpendicular to the channel centerline.
- The large boulders should protrude 2 ft above the slope at the channel edges and transition between the two.
- Along a vane, the boulders at the channel edge should be 2 ft higher in actual elevation than the boulders perpendicular to the channel centerline. This would require that the base rockfill also have a limited transverse slope.
- Ramp boulder anchoring must be sufficient to resist ice forces and 100-year event flow forces.

HEC-RAS Rock Ramp Model The existing condition HEC-RAS model developed in 2006 was used to add a rock ramp and compute flow velocity. Since HEC-RAS is a one dimensional model, accurately evaluating the flow turbulence and velocity variation in both the horizontal and vertical directions is not possible. However, the HEC-RAS model can be used to produce reasonable estimates of average velocity and depth on the ramp and is suitable for use with comparing ramp conditions for various geometries.

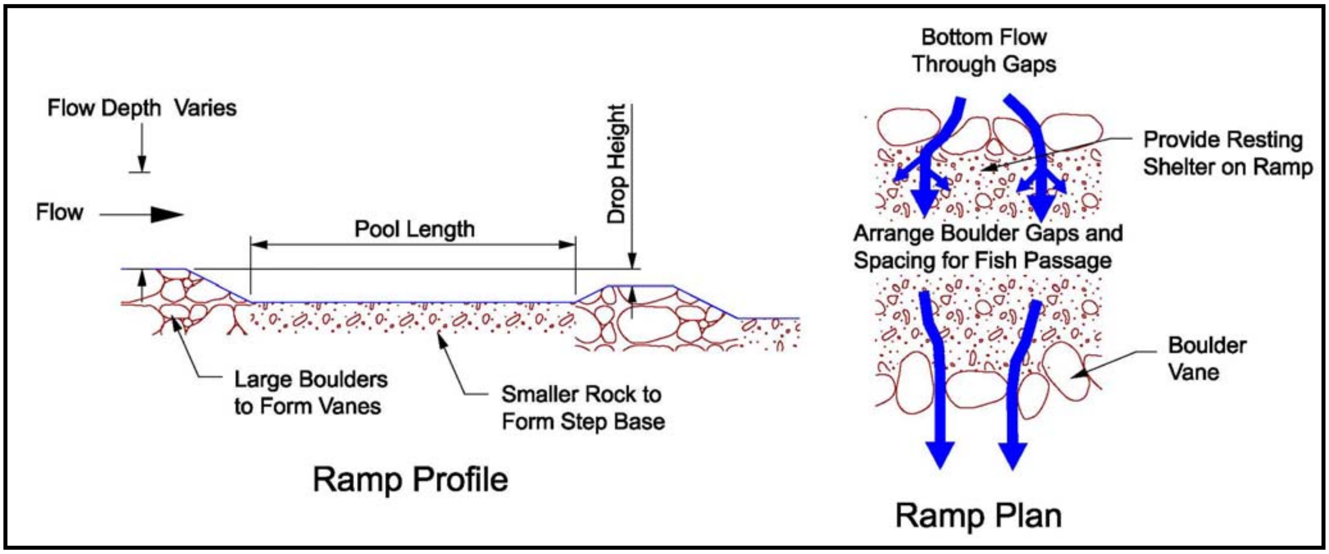

Figure A.2.26 - Conceptual Ramp Plan and Profile.

Model Roughness The rock ramp is expected to have higher roughness values compared to the existing channel due to the rock size and turbulence within the ramp flow. However, overestimating the roughness will cause the model to underestimate the flow velocity. Consequently, ramp stability would be overestimated. Guidance available relates rock size to roughness using the Strickler method (Corps 1994, eq. 5-2). Computations determined a roughness value of 0.036 for 24 inch D_{100} and 0.042 for 48 inch D_{100} size rock. Since lower roughness values would result in the maximum velocity, a conservatively low roughness value of 0.036 was used for the entire ramp.

Model Geometry Grading plans were not available for the proposed ramp configuration. Therefore, the channel modification option was used within HEC-RAS to generate different slope alternatives. The channel improvement option is limited to simple channels, so the complex shape of the ramp could not be completely modeled. For the conceptual analysis, a center channel section of 560 ft, compared to an existing dam width of 700 ft, was assumed. This bottom width was selected as reasonable for the existing site to reflect flow area and concentration on the ramp.

HEC-RAS Model Results Computation results from the HEC-RAS model were used to evaluate the maximum rock size required for stability. Interpretation of computed results is summarized as follows:

1) Results showed only a small change between the different alternatives when comparing velocity at similar ramp elevation location. Modeling the ramp with HEC-RAS may be of limited accuracy for absolute values but relative comparison between locations should be useful. An HEC-RAS output plot of computed water surface elevation for the 5% slope with 1 ft drop is shown in figure A.2.27. Computed velocity range is shown in figure A.2.28 for the 5% slope with 1 ft drop.

2) Results did show that the 1 ft step drop appears to be a little superior to the 0.5 ft drop. The smaller drop has similar velocities at the step compared to the 1 ft drop. However, the smaller drop has short resting areas with twice as many turbulent zones over the ramp length.

3) Computations determined that ramp velocity peaks for flow rates of 80,000 to 100,000 cfs. For larger flow events, tailwater conditions reduce computed flow velocity. Computations determined that critical depth occurs at the ramp crest for all flows below 80,000 cfs.

4) Reducing the ramp slope from 5% to 2% had a marginal effect on average flow velocity with a decrease of less than 1 ft/sec. From a fish passage aspect, the flatter slope serves to lengthen the high velocity and turbulent zone and may not be preferable. However, the flatter slope may indicate a wider range vertical velocity distribution that corresponds to a lower near bottom velocity within the ramp.

5) Computed rock size decreases in the direction of flow down the ramp. It is necessary to provide a concrete cap on the existing structure for upper ramp stability; this would also help with ice forces.

6) The maximum velocity is located at the crest of each boulder row. The minimum velocity occurs within the pool section located between the boulder steps.

7) Flow velocity difference between the two slopes is lower than expected. The ramp slope reduction from 5% to 2% would be expected to cause some decrease in ramp velocity and turbulence. Differences at the higher flows would probably be much greater but the impact of the floodplain and chute flow offsets the slope change. At the lower flows, although the ramp invert slope is changing, the energy grade slope is very similar between the different ramp slopes. Figure A.2.29 compares the ramp velocity profile at 100,000 cfs for various ramp geometries. The plot illustrates the difference between the 1 ft and the 0.5 ft drop heights. Figure A.2.30 compares the relative velocity difference on the ramp for the 5% slope and 2% slope at different flows using the 1’ drop height. Both figures must be interpreted with caution.

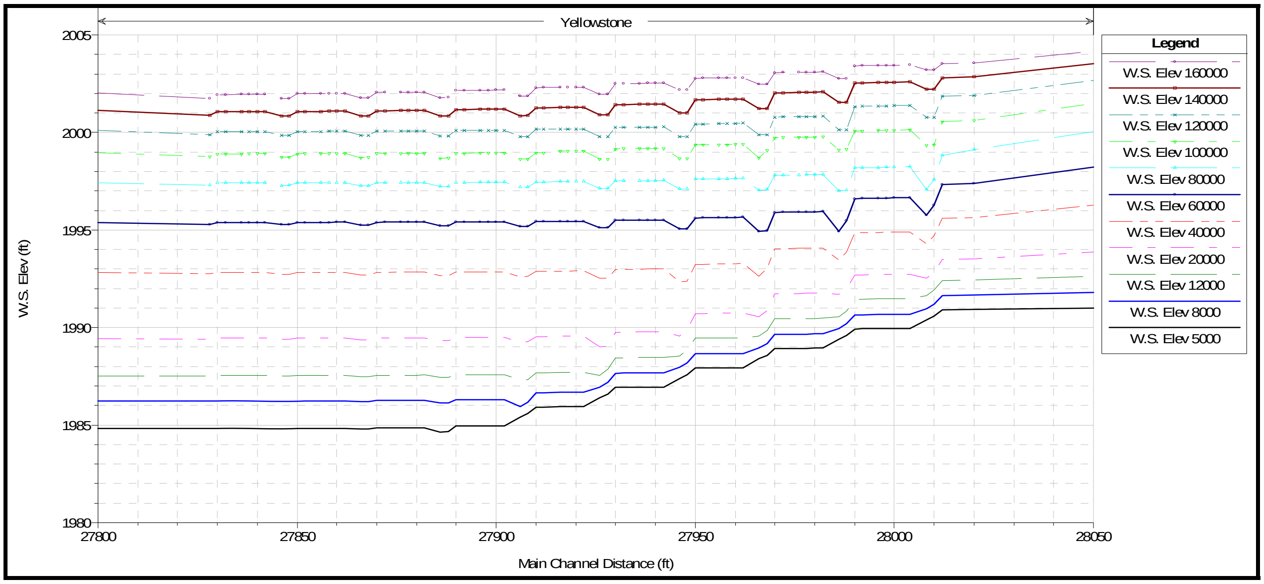

Figure A.2.27 - Computed Water Surface Elevation – 5% Slope Ramp, 1-ft Drop.

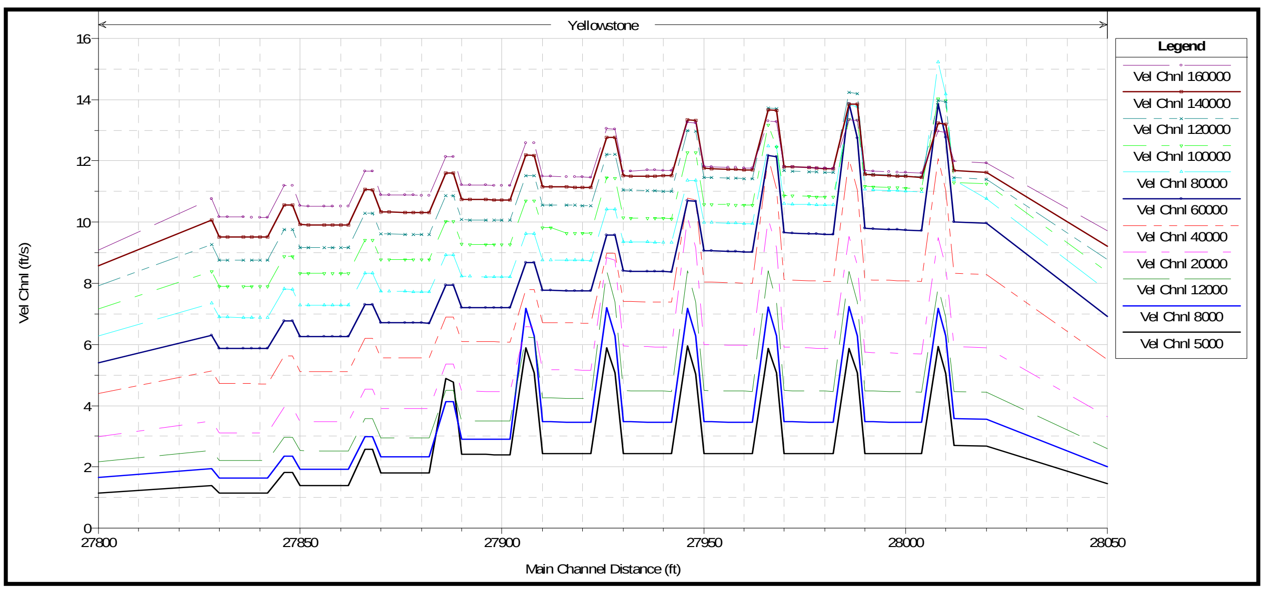

Figure A.2.28 - Computed Flow Velocity – 5% Slope Ramp, 1-ft Drop.

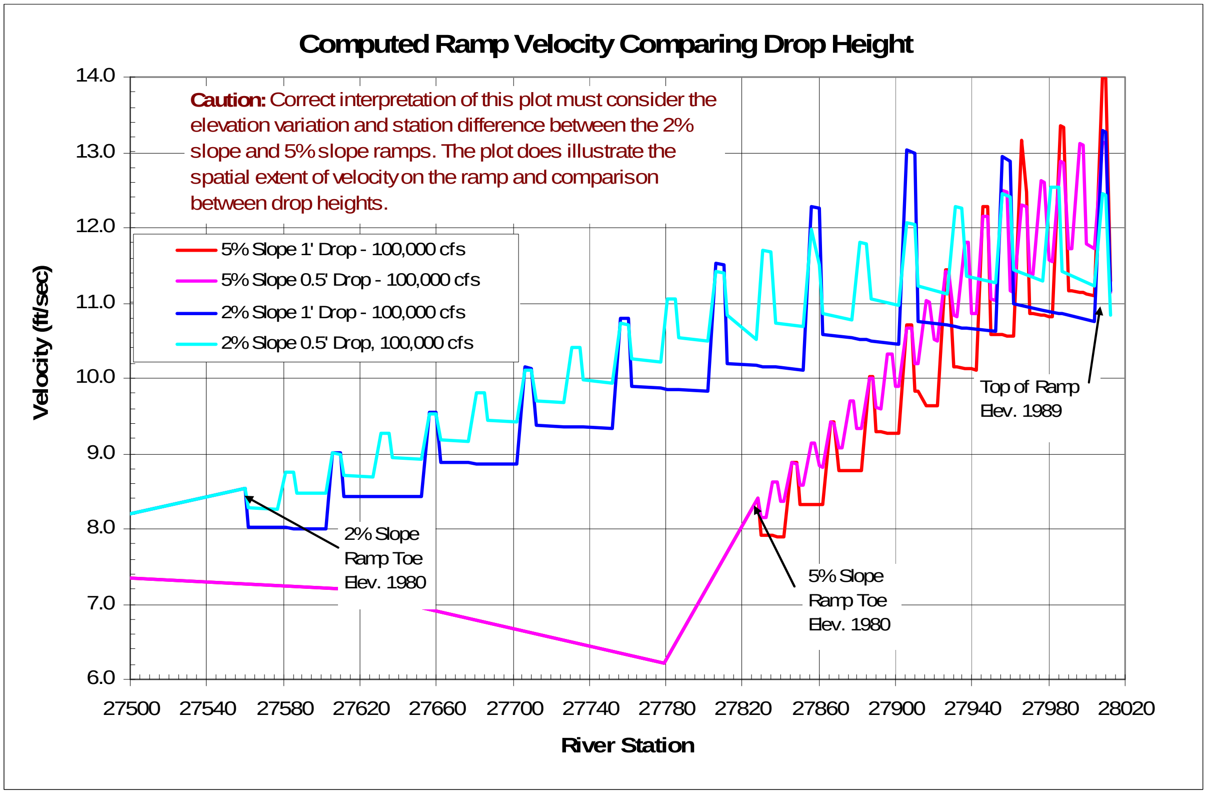

Figure A.2.29 - Computed Flow Velocity Comparing Drop Height.

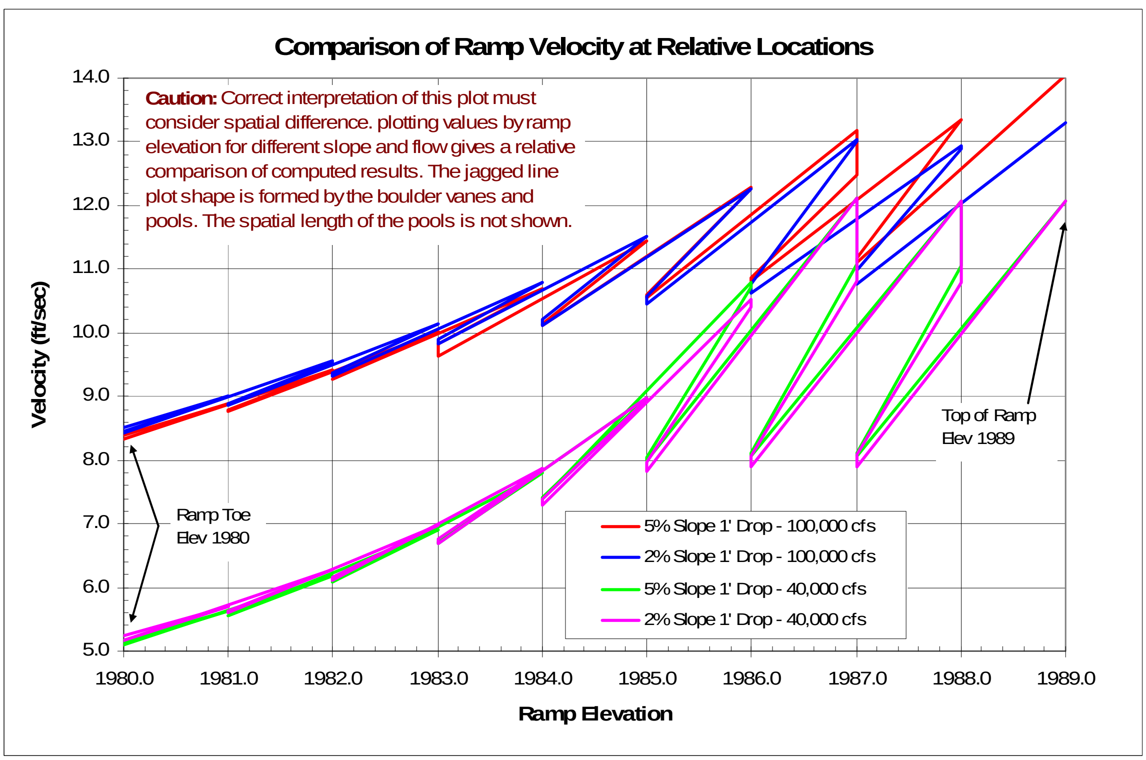

Figure A.2.30 - Comparison of Ramp Velocity at Relative Locations.

Stable Rock Size for Ramp Stable rock size was evaluated using ramp flow velocities computed with the HEC-RAS model. A comparison of results from different flow events and locations on the ramp is shown in the below tables. The critical threshold for the initiation of motion is often expressed as critical shear stress which relates the initiation of material movement to material size, flow depth, and slope. Additional empirical methods for evaluating material movement are also available.

For the conceptual analysis, stable rock size was computed using the flow velocity and the turbulent method presented by Ishbash on HDC Sheet 712-1 (WES 1988). Additional computations were performed using the steep slope riprap equation in EM 1110-2-1601 (Corps 1994, eq. 3-5). Stable rock size computations demonstrate that very large rock is required for ramp stability. In addition, it is doubtful that all rock on the ramp would be stable for extreme events. Results from the Ishbash computation method using HEC-RAS results for a range of flows and ramp slope are shown in table A.2.7.

Table A.2.7 - HEC-RAS Rock Ramp Stability Computations.
Yellowstone River - 160,000 cfs Total Flow

Ramp Position		5% Slope, 1 ft drop	5% Slope, 0.5 ft drop	3.33% Slope, 1 ft drop	2% Slope, 1 ft drop	2% Slope, 0.5 ft drop
Top	Comp. Veloc. (ft/sec)	13.0	12.6	12.8	12.4	11.9
	Stable Rock Size D_{50} (ft)	*2.14*	*2.03*	*2.10*	*1.96*	*1.81*
Elev 1988 Step Center	Comp. Veloc. (ft/sec)	11.7	12.0	11.6	11.4	11.5
	Stable Rock Size D_{50} (ft)	*1.74*	*1.83*	*1.72*	*1.66*	*1.67*
Elev 1988 Boulder	Comp. Veloc. (ft/sec)	13.3	12.7	13.0	12.7	12.1
	Stable Rock Size D_{50} (ft)	*2.27*	*2.07*	*2.16*	*2.05*	*1.87*
Elev 1987 Step Center	Comp. Veloc. (ft/sec)	11.8	12.0	11.6	11.5	11.6
	Stable Rock Size D_{50} (ft)	*1.78*	*1.85*	*1.73*	*1.69*	*1.71*
Elev 1987 Boulder	Comp. Veloc. (ft/sec)	13.3	12.9	13.2	13.0	12.3
	Stable Rock Size D_{50} (ft)	*2.26*	*2.12*	*2.23*	*2.15*	*1.94*
Elev 1986 Step Center	Comp. Veloc. (ft/sec)	11.8	12.2	11.8	11.6	11.8
	Stable Rock Size D_{50} (ft)	*1.78*	*1.88*	*1.77*	*1.72*	*1.77*
Elev 1986 Boulder	Comp. Veloc. (ft/sec)	13.3	12.8	13.2	13.0	12.6
	Stable Rock Size D_{50} (ft)	*2.25*	*2.10*	*2.23*	*2.15*	*2.02*
Elev 1985 Step Center	Comp. Veloc. (ft/sec)	11.7	11.9	11.7	11.6	11.8
	Stable Rock Size D_{50} (ft)	*1.74*	*1.82*	*1.74*	*1.72*	*1.78*
Elev 1985 Boulder	Comp. Veloc. (ft/sec)	13.1	12.7	13.1	13.0	12.5
	Stable Rock Size D_{50} (ft)	*2.17*	*2.06*	*2.17*	*2.16*	*2.00*
Elev 1984 Step Center	Comp. Veloc. (ft/sec)	11.5	11.8	11.6	11.5	11.8
	Stable Rock Size D_{50} (ft)	*1.69*	*1.79*	*1.70*	*1.70*	*1.77*
Elev 1984 Boulder	Comp. Veloc. (ft/sec)	12.6	12.5	12.7	12.7	12.5
	Stable Rock Size D_{50} (ft)	*2.02*	*1.99*	*2.06*	*2.07*	*1.99*

Table A.2.7 - HEC-RAS Rock Ramp Stability Computations (continued)

Yellowstone River - 100,000 cfs Total Flow

Ramp Position		5% Slope, 1 ft drop	5% Slope, 0.5 ft drop	3.33% Slope, 1 ft drop	2% Slope, 1 ft drop	2% Slope, 0.5 ft drop
Top	Comp. Veloc. (ft/sec)	14.0	13.2	13.8	13.3	12.5
	Stable Rock Size D_{50} (ft)	*2.52*	*2.21*	*2.45*	*2.26*	*1.98*
Elev 1988 Step Center	Comp. Veloc. (ft/sec)	11.2	11.7	11.1	10.9	11.3
	Stable Rock Size D_{50} (ft)	*1.59*	*1.75*	*1.57*	*1.52*	*1.63*
Elev 1988 Boulder	Comp. Veloc. (ft/sec)	13.4	12.9	13.3	13.0	12.5
	Stable Rock Size D_{50} (ft)	*2.28*	*2.12*	*2.25*	*2.14*	*1.98*
Elev 1987 Step Center	Comp. Veloc. (ft/sec)	10.9	11.4	10.8	10.7	11.1
	Stable Rock Size D_{50} (ft)	*1.50*	*1.65*	*1.50*	*1.46*	*1.58*
Elev 1987 Boulder	Comp. Veloc. (ft/sec)	13.2	12.3	13.2	13.0	12.1
	Stable Rock Size D_{50} (ft)	*2.21*	*1.93*	*2.22*	*2.17*	*1.86*
Elev 1986 Step Center	Comp. Veloc. (ft/sec)	10.6	11.0	10.6	10.5	10.8
	Stable Rock Size D_{50} (ft)	*1.43*	*1.55*	*1.43*	*1.42*	*1.48*
Elev 1986 Boulder	Comp. Veloc. (ft/sec)	12.3	12.2	12.3	12.3	12.0
	Stable Rock Size D_{50} (ft)	*1.93*	*1.89*	*1.94*	*1.92*	*1.83*
Elev 1985 Step Center	Comp. Veloc. (ft/sec)	10.1	10.8	10.2	10.2	10.5
	Stable Rock Size D_{50} (ft)	*1.31*	*1.49*	*1.32*	*1.32*	*1.41*
Elev 1985 Boulder	Comp. Veloc. (ft/sec)	11.5	11.4	11.5	11.5	11.4
	Stable Rock Size D_{50} (ft)	*1.67*	*1.66*	*1.69*	*1.69*	*1.66*
Elev 1984 Step Center	Comp. Veloc. (ft/sec)	9.8	10.2	9.9	9.9	10.2
	Stable Rock Size D_{50} (ft)	*1.23*	*1.33*	*1.24*	*1.24*	*1.33*
Elev 1984 Boulder	Comp. Veloc. (ft/sec)	10.7	10.7	10.8	10.8	10.7
	Stable Rock Size D_{50} (ft)	*1.46*	*1.45*	*1.48*	*1.49*	*1.47*

Yellowstone River - 60,000 cfs Total Flow

Ramp Position		5% Slope, 1 ft drop	5% Slope, 0.5 ft drop	3.33% Slope, 1 ft drop	2% Slope, 1 ft drop	2% Slope, 0.5 ft drop
Top	Comp. Veloc. (ft/sec)	13.9	13.1	13.9	13.9	12.3
	Stable Rock Size D_{50} (ft)	*2.45*	*2.18*	*2.45*	*2.45*	*1.93*
Elev 1988 Step Center	Comp. Veloc. (ft/sec)	9.8	10.7	9.7	9.7	10.3
	Stable Rock Size D_{50} (ft)	*1.22*	*1.45*	*1.21*	*1.20*	*1.35*
Elev 1988 Boulder	Comp. Veloc. (ft/sec)	13.9	12.7	13.8	13.2	12.0
	Stable Rock Size D_{50} (ft)	*2.46*	*2.06*	*2.42*	*2.21*	*1.83*
Elev 1987 Step Center	Comp. Veloc. (ft/sec)	9.6	10.3	9.6	9.5	9.9
	Stable Rock Size D_{50} (ft)	*1.19*	*1.35*	*1.17*	*1.14*	*1.26*
Elev 1987 Boulder	Comp. Veloc. (ft/sec)	12.2	11.6	12.0	11.8	11.2
	Stable Rock Size D_{50} (ft)	*1.89*	*1.73*	*1.85*	*1.78*	*1.61*
Elev 1986 Step Center	Comp. Veloc. (ft/sec)	9.1	9.6	9.0	9.0	9.4
	Stable Rock Size D_{50} (ft)	*1.05*	*1.17*	*1.04*	*1.03*	*1.13*
Elev 1986 Boulder	Comp. Veloc. (ft/sec)	10.7	10.5	10.7	10.6	10.3
	Stable Rock Size D_{50} (ft)	*1.46*	*1.41*	*1.45*	*1.44*	*1.36*
Elev 1985 Step Center	Comp. Veloc. (ft/sec)	8.4	8.8	8.4	8.4	8.8
	Stable Rock Size D_{50} (ft)	*0.90*	*1.00*	*0.90*	*0.90*	*0.98*
Elev 1985 Boulder	Comp. Veloc. (ft/sec)	9.6	9.5	9.6	9.6	9.5
	Stable Rock Size D_{50} (ft)	*1.17*	*1.15*	*1.17*	*1.18*	*1.14*
Elev 1984 Step Center	Comp. Veloc. (ft/sec)	7.8	8.1	7.8	7.8	8.2
	Stable Rock Size D_{50} (ft)	*0.77*	*0.85*	*0.77*	*0.78*	*0.85*
Elev 1984 Boulder	Comp. Veloc. (ft/sec)	8.7	8.6	8.7	8.8	8.7
	Stable Rock Size D_{50} (ft)	*0.96*	*0.95*	*0.97*	*0.98*	*0.96*

A second method was also used to evaluate stable rock size for the conceptual analysis. This method uses the steep slope equation presented within EM 1110-2-1601 (Corps 1994, eq. 3-5). This method computes stable rock size based on unit discharge and slope. Results from those computations are shown in table A.2.8.

Table A.2.8 - Steep Slope Rock Ramp Stability Computations.

Design Flow (cfs)	Bottom width (ft)	Unit q (cfs/ft)	Flow Factor q * 1.25	Design Slope (ft/ft)	COE D_{30} (ft)	Est. D_{50} (ft)
60,000	550	109	136	0.050	3.08	3.70
100,000	550	182	227	0.050	4.33	5.19
160,000	550	291	364	0.050	5.92	7.11
60,000	550	109	136	0.020	1.85	2.22
100,000	550	182	227	0.020	2.60	3.12
160,000	550	291	364	0.020	3.56	4.27
60,000	700	86	107	0.050	2.62	3.15
100,000	700	143	179	0.050	3.69	4.42
160,000	700	229	286	0.050	5.04	6.05
60,000	700	86	107	0.020	1.58	1.89
100,000	700	143	179	0.020	2.22	2.66
160,000	700	229	286	0.020	3.03	3.64

Rock size computed with the steep slope equation determined an even larger rock required for stability than the Ishbash method using the HEC-RAS velocity. Results are tabulated for both 5% and 2% slope and two bottom widths. It should be noted that the steep slope method ignores the energy dissipation provided by the individual steps on the ramp.

Recommended Rock Size Based on the computation results, a rock size in excess of 4 ft is recommended for the ramp boulders. Constructing the entire ramp from 4 ft boulders is probably cost prohibitive. Computed rock size is based on average HEC-RAS model average flow velocity and a vertical velocity distribution is expected within the pool section of the ramp. Based on the analysis, a rock size of 2 ft is recommended for the remainder of the ramp. Using the Ishbash method and HEC-RAS computed velocity; the determined D_{50} rock size for 100,000 cfs flow was about 1.5 ft. Stability for the 2 ft diameter rock is questionable for flow events in excess of 60,000 cfs. Future efforts will revise the rock size required for stability. However, it is likely that entire ramp stability for events in the critical flow range before the ramp begins to submerge (roughly flow greater than 80,000 - 100,000 cfs) is not feasible without using rock approaching 3 ft diameter for the entire upper portion of the ramp. Referring to the flow frequency analysis, 100,000 cfs is approximately a 50-year event.

Ramp Ice Stability Based on the ice analysis conducted by CRREL (App. D), the boulder size required for ice stability is estimated to be in the range of 4-6 ft diameter. This correlates fairly well with dam project history, where the larger rocks placed are on the order of 3 ft diameter. As the maintenance record shows, the dam crest riprap has been moved by ice and high flow conditions. Use of natural rock boulders or a simulated rock formed with concrete would provide stability for the boulder steps. In between the steps, loose rock riprap of a much smaller diameter is proposed. Ice damage may occur to portions of the ramp with the smaller rock. Ramp ice stability is summarized as follows:

- CRREL analysis determined a boulder size required for stability of 4-6 ft diameter.
- Natural rock boulders or simulated rock boulders would be placed to form the boulder steps that conform to the recommended size.
- A concrete cap would be placed on the existing dam to resist ice forces. The cap is required to resist ice loads as calculated in the structural analysis contained within Appendix A-.
- Ice forces on the ramp would be mitigated by the upstream concrete crest. The crest should break up the ice floe into much smaller fragments.
- Smaller rock would be used to form the ramp bottom between the boulders. The smaller rock is integral to achieving fish passage. Some ice damage may occur to this portion of the ramp. The boulder rows should serve to shield the bottom portion of the ramp. In addition, flow depths that transport the ice sheets should keep the ice above the ramp bottom and reduce damage potential.

Ramp Fish Passage Related to Relevant Pallid Sturgeon Swim Guidance Design swim guidance for the Pallid Sturgeon is available from documented laboratory testing. Test results were reviewed for conclusions specific to rock ramp navigability. The report *Assessment of Behavior and Swimming Ability of Yellowstone River Sturgeon for Design of Fish Passage Devices*, by White and Mefford, 2002 (Corps 2002, App. A) included tests conducted to evaluate the behavioral response of adult shovelnose sturgeon to velocity, substrate, horizontal turbulence, vertical turbulence, and three prototype fishways. Relevant conclusions are:

- Sturgeon successfully negotiated the range of average velocities tested (0.8-6.0 ft/sec) over all substrates (smooth, fine sand, coarse sand, gravel, and cobble).
- As substrate increased, movement success declines but small sample size precluded definitive conclusions.
- Sturgeon were able to negotiate horizontal and vertical eddies. However, larger eddies tended to cause delays. Asymmetrical eddies were also noted to be problematic for passage.
- Fishway tests indicated that the rock fishway passage success was much improved.

A second report *Preliminary Comparison of Pallid and Shovelnose Sturgeon for Swimming Ability and Use of Fish Passage Structure, Kynard, 2002* (Corps 2002, App. B) gathered information in an experimental flume on the swimming ability and behavior of pallid sturgeon in two different flow regimes, laminar and a complex turbulent flow created by a structure. Relevant conclusions are:

- Pallid sturgeon demonstrated the swimming ability to navigate complex currents in a side-baffle fish ladder at 6% slope and should be able to swim upstream in complex flows in other passage situation, like rock ramps, as along as velocities are appropriate.
- Pallid and shovelnose sturgeon swam through the side-baffle section off the bottom, passing quickly through 65 cm/sec (2.1 ft/sec) velocity in only 1-2 sec using about two tailbeats/sec.
- Current velocity in fish ladders or rock ramps that enable fish to swim in the prolonged mode, and do not require the burst swim mode, seems preferable for these species.

Relevant pallid sturgeon fish passage criteria from previous studies (Corps 2002: Appendix A, B) does not include maximum velocity criteria. However, the computed average velocities determined with the HEC-RAS model are high enough to be concerning for flows in excess of 40,000 cfs for the upper portion of the ramp. Interpretation of results should consider that the ramp geometry is variable and these results are not reflected in the HEC-RAS computations. Flow duration data (Corps 2006: table B-3) indicates that the percent of time that a flow of 40,000 cfs is equaled or exceeded in June is about 30%. For all other months, the percent of time decreases to about 5% or less.

While velocity and turbulence in the ramp center may be excessive for high flows, the sloping ramp and U shape should provide a portion of the ramp that is amenable to fish passage. In addition, computed velocities are average. Actual velocity would vary both horizontally across the ramp and vertically within the water column. Future design will determine velocity variation within the ramp. Given the computed high velocities for the upper portion of the ramp, it seems probable that fish passage success for high flow events may be less than desirable.

Comparing the computed results for the 0.5' drop height and the 1.0' drop height, it appears that the larger drop height is preferable. Average velocity at the boulder crest is similar for both drop heights. From a fish passage aspect, the flatter slope doubles the number of drop and serves to lengthen the high velocity and turbulent zone and may not be preferable.

The required rock size for ramp stability is in the 2 – 3 ft diameter range with greater than 4 ft diameter rock used for the boulder vanes. Previous studies indicated that substrate may impact fish passage success. It is probable that Yellowstone River sediment load would naturally fill the rock ramp voids with small cobbles and normal bed load. The smaller material would become mobile during large flows.

Future Design Efforts Future design efforts are required to further evaluate ramp components. Recommended design components include a two-dimensional computational model and a physical model. The preliminary concept is that the physical model would be constructed in a flume to represent a short ramp width. Variable slopes would be evaluated in the flume. Boulder placement adjustment could also be checked. The physical model would illustrate velocity variation/depth down the ramp both horizontally and vertically. The two-dimensional model would be constructed of the entire ramp area and include a segment upstream and downstream of the ramp. A two-dimensional model would be constructed of both existing and refined conditions. The two-dimensional model would illustrate depth averaged velocity magnitude and direction throughout the area. The physical and numerical modeling results can be used to refine ramp design features. Specific items are as follows:

- Use a physical model to calibrate depth averaged two-dimensional model results. Results from both models can be used jointly to develop a comprehensive view of flow parameters and verify results.
- Construct a two-dimensional model of both existing and ramp conditions. Compare results to verify fish passage improvement.
- Compare ramp velocities with relevant pallid sturgeon swim guidance. Evaluate substrate effect on ramp fish passage success. Revise ramp geometry as necessary to optimize fish passage.
- Evaluate velocity magnitude distribution through the ramp.
- Evaluate flow velocity through the boulder gaps to aid with design.
- Design the ramp crest with a variable elevation and structure to facilitate fish passage.
- Evaluate the impact of step length and drop height on ramp velocity/depth.

- Evaluate ramp curvature and transverse slope on the boulder vanes.
- Evaluate for a range of flow conditions to optimize boulder placement for pools and gaps.
- Evaluate flow parameters at the intake structure.
- Evaluate flow parameters at the base of the ramp and energy dissipation requirements.
- Revise ramp rock stability estimate based on computed results. Ramp geometry and rock components may require revision to provide required stability.

Ramp Summary The analysis performed is a conceptual design to evaluate feasibility of the rock ramp. The analysis compared basic ramp geometry and identified several design restrictions that need to be further evaluated. Results are summarized as follows:

- All computed velocities are average velocities. Actual velocity would vary considerably both horizontally across the ramp and vertically within the water column.
- Relevant pallid sturgeon guidance indicated that sturgeon successfully negotiated the range of average velocities tested from 0.8 to 6.0 ft/sec. Computation results determined average flow velocities at the crest in excess of 10 ft/sec for flows in excess of 40,000 cfs. Proper design of the resting pools and boulder vanes are critical to optimize fish passage success. Given the computed high velocities for the upper portion of the ramp, it seems probable that fish passage success for high flow events may be less than desirable. Flow duration data indicates that these flows are equaled or exceeded in June about 30% of the time.
- Results determined high velocities at the ramp crest. To facilitate fish passage and maintain flow distribution, an uneven crest with possibly natural rock set in the crest concrete is probably required. These details will be determined in final design.
- The performed analysis used HEC-RAS to evaluate ramp flow parameters. Both a physical and two-dimensional model is recommended for future design efforts to determine ramp geometry.
- Analysis evaluated ramps with a slope between 2% and 5%. Computed flow velocities in the HEC-RAS model did not vary that much for the different slopes. It is expected that a refined analysis using both physical and two-dimensional models would better illustrate the ramp stability and fish passage advantages between different ramp slopes and pool length. Due to the change in ramp size, a significant cost difference is expected for the two slopes.
- Large rock is required to provide ramp stability. Previous studies indicated that substrate may impact ramp fish passage success.
- Given the large boulder size, it may be more economical to use the 1’ drop and a flatter ramp slope (longer ramp). This would reduce the number of boulder rows. The ramp slope could be adjusted to optimize for the boulder size that is economically available and also refined to consider constructability.
- Computed results show that the 100-yr event requires a very large rock size with a D_{50} of over 2.6 ft for the 100-year event at the top of the ramp. Below elevation 1984, the stable rock size has a D_{50} of 1.1 ft. This still equates to a D_{100} of 24 to 27 inches. For the 10-year event, the lower half of the chute has a stable rock size of about 18 – 21 inches. Future efforts will revise the rock size required for stability. However, it is likely that entire ramp stability for larger flow events is not feasible.
- A boulder size of 4-6 ft is required on the ramp. The base rock D_{100} of less than 24 inches for the ramp is recommended. Analysis determined that this rock is likely not stable for events greater than 50-year near the top of the ramp. The interface of the concrete cap and ramp was not evaluated with HEC-RAS and will provide stability in this location.

- A concrete cap provides stability for the upper portion of the ramp and protects against ice damage. To facilitate fish passage and maintain flow distribution, an uneven crest with possibly natural rock set in the crest concrete is probably required.
- The right bank floodplain currently conveys a limited amount of flow. An excavated bypass on the right bank could be used to reduce the ramp unit discharge for extreme events and reduce the maximum ramp flow to enhance ramp stability.

Constant Slope Rock Ramp

The purpose of this section is to provide results from the preliminary design of additional rock ramp alternatives. Following completion of the *Lower Yellowstone Project Fish Passage and Screening, Preliminary Design Report, Intake Diversion Dam, July 2006* (Corps 2006), a review conference was held between the Reclamation, Omaha District, USGS, and State of Montana Department of Fish, Wildlife & Parks. Following this conference, Reclamation requested evaluation of rock ramp alternatives consisting of a 1% and 0.5% flat slope that did not include any steps for comparison against other rock ramp alternatives. This section presents the analysis procedures, assumptions, and results for these two additional alternatives.

Study Purpose The purpose of the hydraulic analysis was to develop preliminary hydraulic design information for two additional alternatives consisting of building a flat ramp at a constant slope from the existing dam crest of 0.5% or 1%. These alternatives would retain the existing dam and intake structure.

Study Scope Analysis was performed at a conceptual level to examine alternative feasibility and refine cost estimates. At the time this analysis was completed, bathymetric survey data were not available. Because of the conceptual nature of the analysis, the evaluation was not updated when the bathymetric data became available. The lack of updated Yellowstone River survey data in the model limits the accuracy of the performed analysis. Future detailed design analysis is required to further define project features and thoroughly evaluate alternative feasibility.

Hydraulic Design Analysis The Rock Ramp Alternative consists of constructing a rock ramp downstream of the existing Intake Diversion Dam structure. Constructing the rock ramp would maintain the existing Yellowstone River stage-flow relationship such that diversion with the same canal intake would be feasible. The ramp would be constructed by adding material on the downstream side of the existing structure. Highlights of the ramp project and analysis are as follows:

- Install concrete cap on existing dam and maintain existing intake for diversion.
- Construct sloping rock ramp downstream of the dam crest.
- The rock ramp would be at a constant slope without boulder steps. Two slopes were evaluated consisting of 0.5% and 1%.
- Review ice impacts to the ramp stability.
- Ramp design is conceptual with sufficient detail to evaluate feasibility and to prepare cost estimates.
- Review available ramp design criteria and site specifics to develop guidance for refined design.

- Numerous examples of rock ramps are available. However, an installation on a duplicate river to the Yellowstone River with similar flow, unit discharge, drop height, sediment transport, substrate, section, slope, and other physical parameters was not located.

Constant Slope Ramp Layout

Using the previously determined project stationing, the downstream end of the ramp crest is set at elevation 1989 and station 279+86. Current dam crest elevation varies from 1987 to 1989. The design assumed the new dam crest is at elevation 1989. Placing the dam crest at 1989 would provide sufficient head for the existing intake structure. The ramp downstream toe elevation was assumed as 1979 based on the limited Yellowstone River invert data. For the 1% and 0.5% slope, this results in a ramp length of 1000 and 2000 ft, respectively. The ramp is trapezoidal shaped with the main channel section at a flat invert elevation. The existing river banks form the side slopes. The ramp shape should be optimized to provide the maximum depth-velocity diversity in detailed design. Due to the width of the river, it is anticipated that a significant portion of the center ramp would be relatively flat. A profile comparison with the stepped ramp profiles is shown in figure A.2.31. A conceptual ramp layout is illustrated in plate A.2.5.

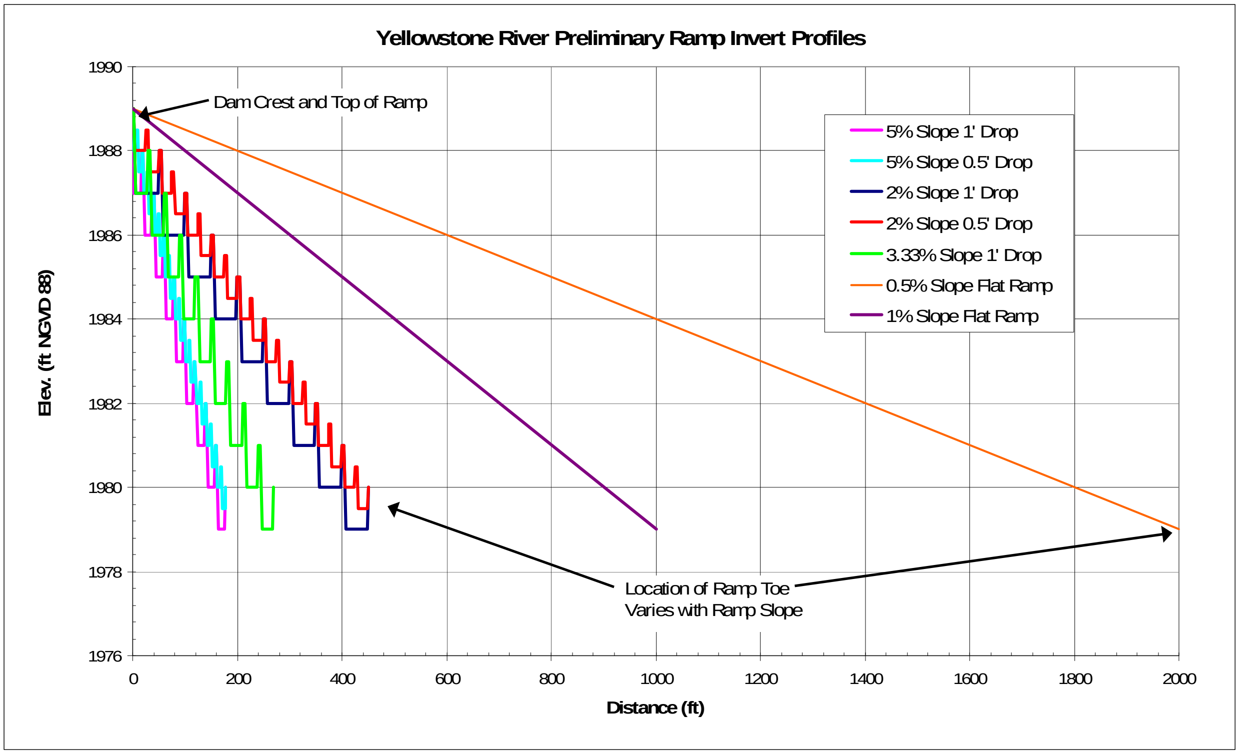

Figure A.2.31 - Constant Slope Ramp vs. Stepped Ramp-Profiles.

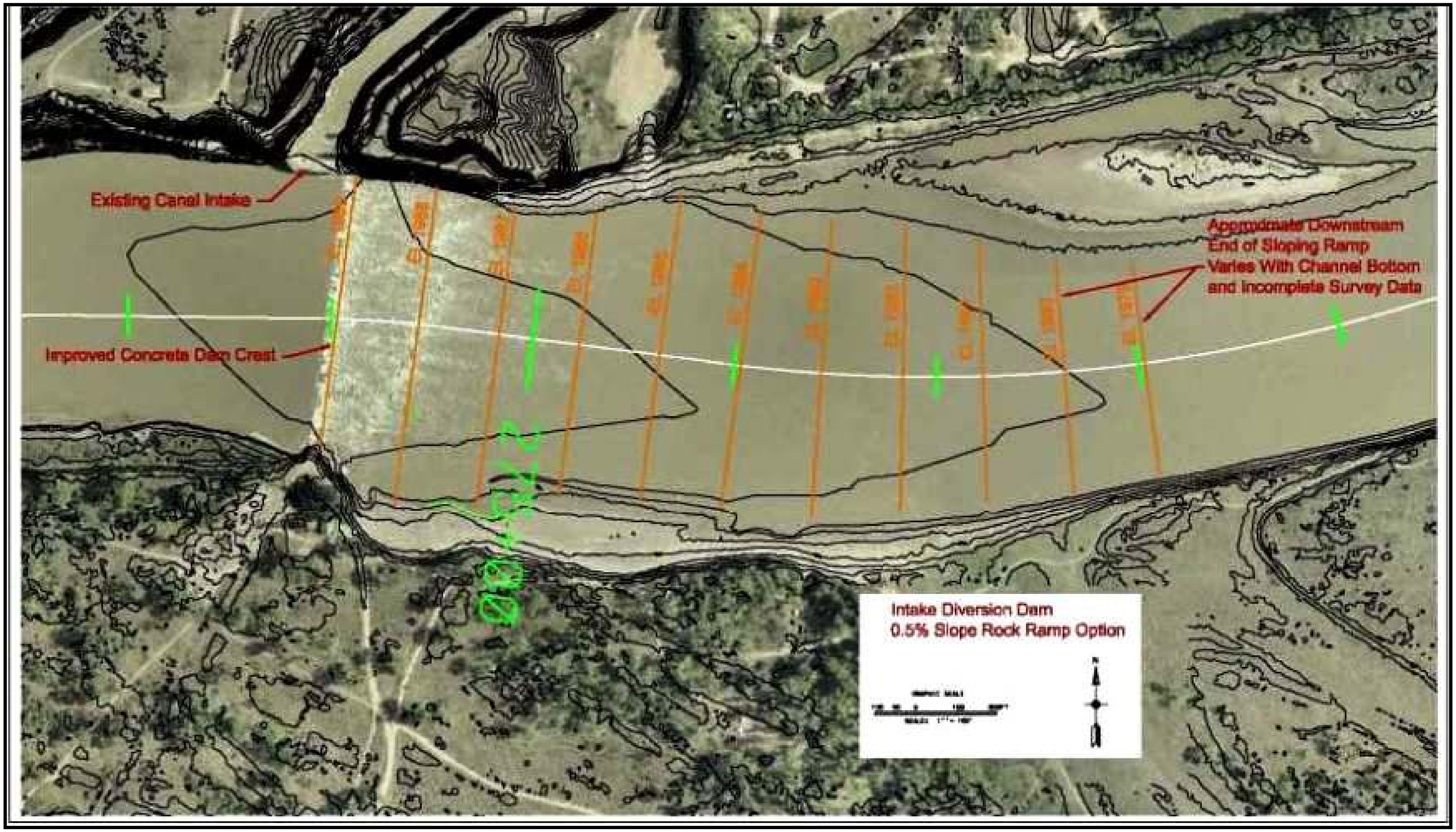

Plate A.2.5 – Constant Slope Ramp Layout.

Ramp Boulders The flat ramp alternative does not include boulders as an integral design component. Boulders could be inserted if required to add depth diversity and fish friendly habitat.

Normal Depth Comparison Evaluation of the two flat ramp alternatives was initially performed using a normal depth analysis. The analysis was performed to evaluate the impact on computed flow depth and velocity for both roughness and slope. Channel computations are based on normal depth using the Manning equation and the continuity equation (Chow 1959:128 and 129) which are:

$$V = \frac{1.49 * R^{2/3} * S^{1/2}}{n}$$

$$Q = VA$$

Where V = flow velocity (ft/sec)
R = hydraulic radius (ft)
S = energy slope (ft/ft)
n = Mannings roughness coefficient (minimum and maximum)
Q = flow rate (cfs)
A = flow area (sq ft)

Computations assumed a 600 ft bottom width channel and 2H on 1V side slopes. The confined channel ignores the substantial floodplain flow during high flow events. Previous analysis (see section 2.6) determined that right bank floodplain flow initiates at about 25,000 to 30,000 cfs Yellowstone River flow. Normal depth evaluation results are illustrated figures A.2.32 and A.2.33.

Normal depth computations are conceptual to illustrate impacts that may result from changing slope and roughness. Due to backwater impacts normal depth may not occur on the ramp. Computation results indicate that both roughness and slope are important parameters that have significant impact on flow depth and velocity for flows in excess of 15,000 cfs. For example, at a flow rate of 20,000 cfs, the computed velocity increases by about 1.8 ft/sec when the slope increases from 0.5% to 1% and increases by about 2.2 ft/sec when the roughness reduces from 0.045 to 0.028.

HEC-RAS Rock Ramp Model The previously constructed existing condition HEC-RAS model was used to add a rock ramp and compute flow velocity. Since HEC-RAS is a one dimensional model, accurately evaluating the flow turbulence and velocity variation in both the horizontal and vertical directions is not possible. However, the HEC-RAS model can be used to produce reasonable estimates of average velocity and depth on the ramp and is suitable for use with comparing ramp conditions for various geometries.

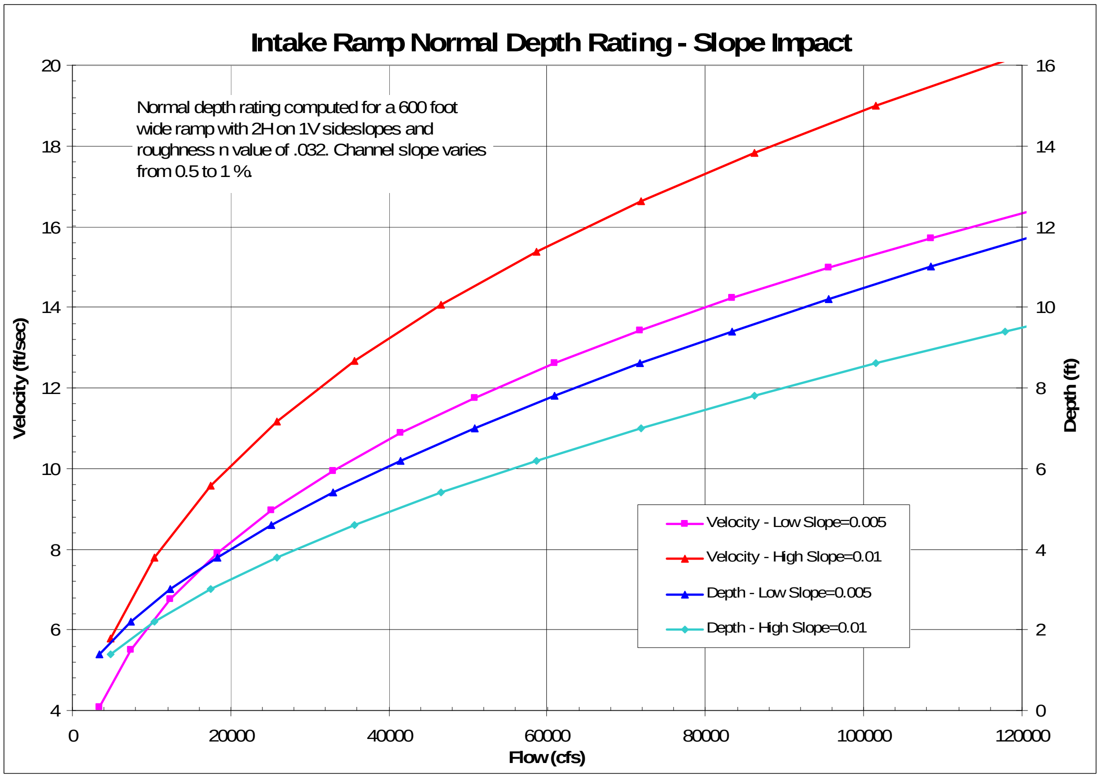

Figure A.2.32 - Constant Slope Ramp Normal Depth Rating-Roughness Impact

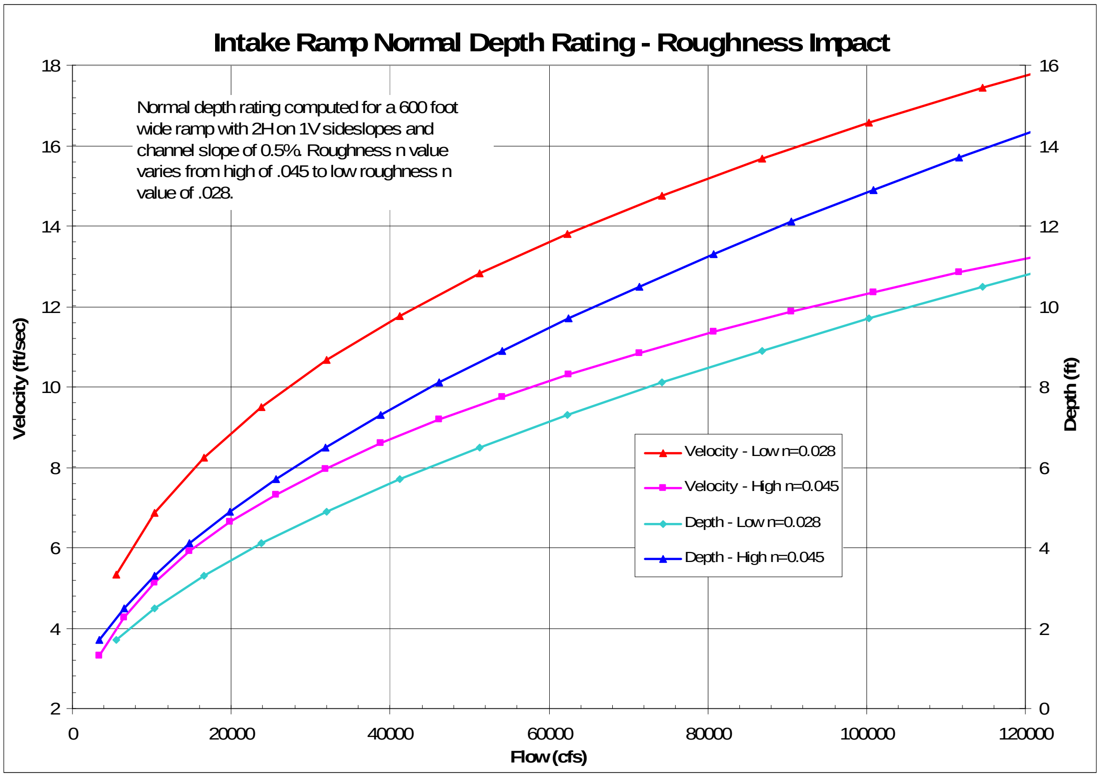

Figure A.2.33 - Constant Slope Ramp Normal Depth Rating-Slope Impact.

Model Data Limitations The hydraulic model available at the time of this analysis included only two surveyed sections within 2,000 ft downstream of the dam. These sections were inadequate to define Yellowstone River topography within the proposed ramp limits. The HEC-RAS model was constructed from LiDAR surveys collected in September 2004. Below water information was not included in the survey. Additional flow area was added to the model, and the model was calibrated to the previous modeling efforts.

The model relies extensively on interpolated cross-sections to define the velocity profile on the ramp. Model results are adequate for evaluating general trends but should be used with caution. Velocity variation of 20% from computed values is probable.

Model Roughness Portions of the rock ramp are expected to have higher roughness values compared to the existing channel due to the rock size and turbulence within the ramp flow. However, overestimating roughness will cause the model to underestimate flow velocity. Consequently, ramp stability would be overestimated. Guidance available relates rock size to roughness using the Strickler method (Corps 1994, eq. 5-2). Computations determined a roughness value of 0.032 for 12 inch D_{100}, 0.036 for 24 inch D_{100}, and 0.042 for 48 inch D_{100} size rock. Since lower roughness values will result in the maximum velocity, a conservatively low roughness value of 0.032 was used for the entire ramp. The selected roughness value is smaller than the 0.035 value used for the boulder drops of the stepped ramp to reflect the slightly smaller rock size used for the flat ramp alternatives and lower turbulence. A normal depth evaluation was also performed to assess roughness sensitivity as previously presented.

Model Geometry Grading plans were not available for the proposed ramp configuration. Therefore, the channel sediment option was used within HEC-RAS to generate fill within the ramp cross-sections. The ramp was modeled by extending the new invert elevation horizontally until intersecting the existing bank elevation. An example section is shown in figure A.2.34.

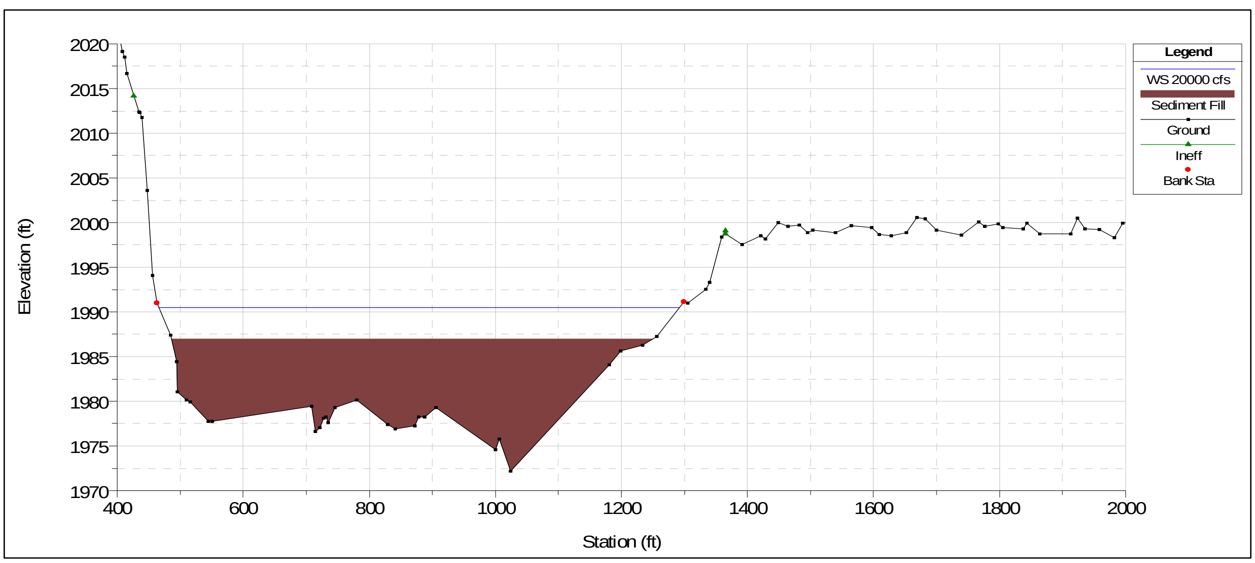

Figure A.2.34 - Example Cross Section with Flat Ramp Fill within Yellowstone River.

HEC-RAS Model Results Computation results from the HEC-RAS model were evaluated to review computed flow parameters and determine the maximum rock size required for stability and are shown in figures A.2.35 - A.2.39. Interpretation of computed results is summarized as follows:

1) HEC-RAS model analysis is based on limited Yellowstone River topography. Future detailed design analysis with accurate survey information will significantly improve model accuracy.

2) Results showed only a small change between the two alternatives when comparing velocity at similar ramp elevation location, generally in the range of 0.5 to 1 ft/sec.

3) Computations determined that critical depth occurs at the ramp crest for all flows above 8,000 cfs and below 120,000 cfs. Turbulent and rapid flow in the crest vicinity should be expected.

4) Computations determined that the velocity rate of change is greatest for lower flows in the range of 0 to 40,000 cfs. Above 40,000 cfs the flow velocity is still increasing but at a smaller rate.

5) Computations above 60,000 cfs show somewhat fluctuating results due to the impact of floodplain flows. Detailed design analysis will further define the channel vs. floodplain flow relationship.

6) Computed water surface elevations increase compared to the base condition over a portion of the ramp by 0 to 3 ft for the flow range evaluated. Since the ramp involves placing substantial fill within the Yellowstone River, the floodplain flow frequency would increase in the ramp vicinity. This increase continues upstream due to the backwater effect of the ramp.

7) Backwater effects on the ramp are present for all flows. For all flows above 12,000 cfs, backwater impacts computed flow depth and velocity for over half the total ramp length. At flows greater than 30,000 cfs, backwater impacts the entire ramp length.

Stable Rock Size for Rock Ramp Stable rock size was evaluated using ramp flow velocities computed with the HEC-RAS model. A comparison of results from different flow events and locations on the ramp is shown in the below tables. The critical threshold for the initiation of motion is often expressed as critical shear stress, which relates the initiation of material movement to material size, flow depth, and slope. Additional empirical methods for evaluating material movement are also available.

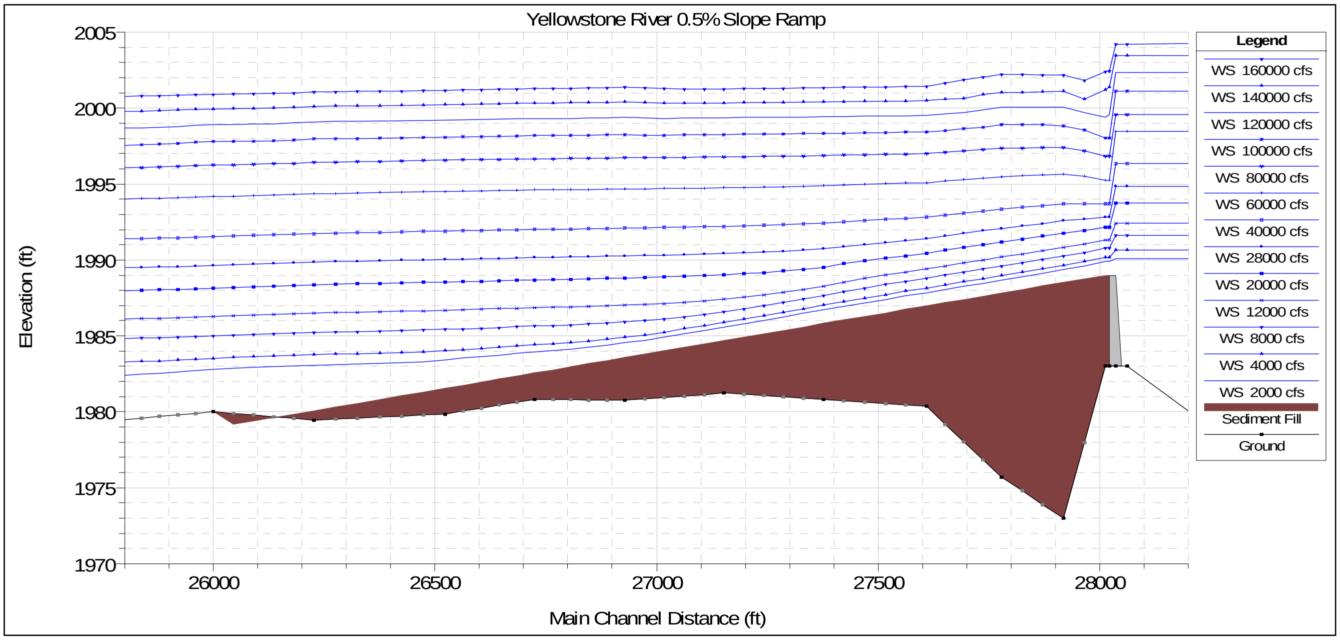

Figure A.2.35 - Computed Water Surface Elevations – 0.5% Constant Slope Ramp.

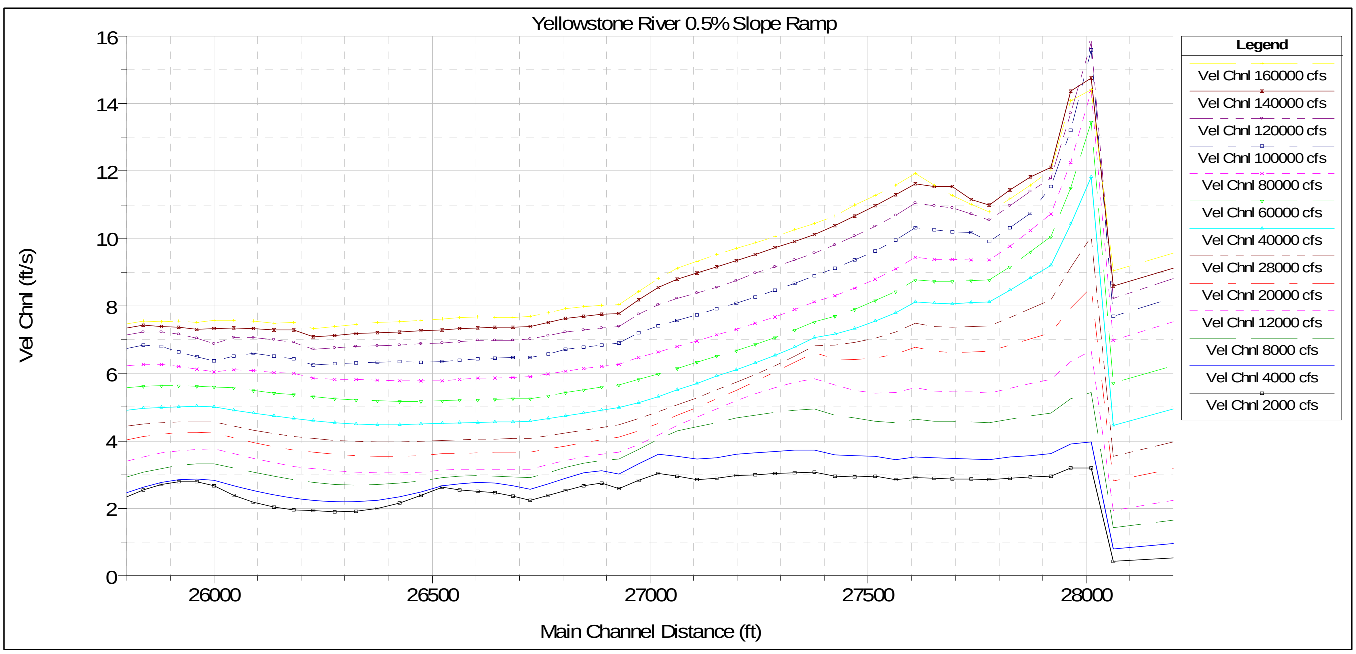

Figure A.2.36 - Computed Flow Velocity – 0.5% Constant Slope Ramp.

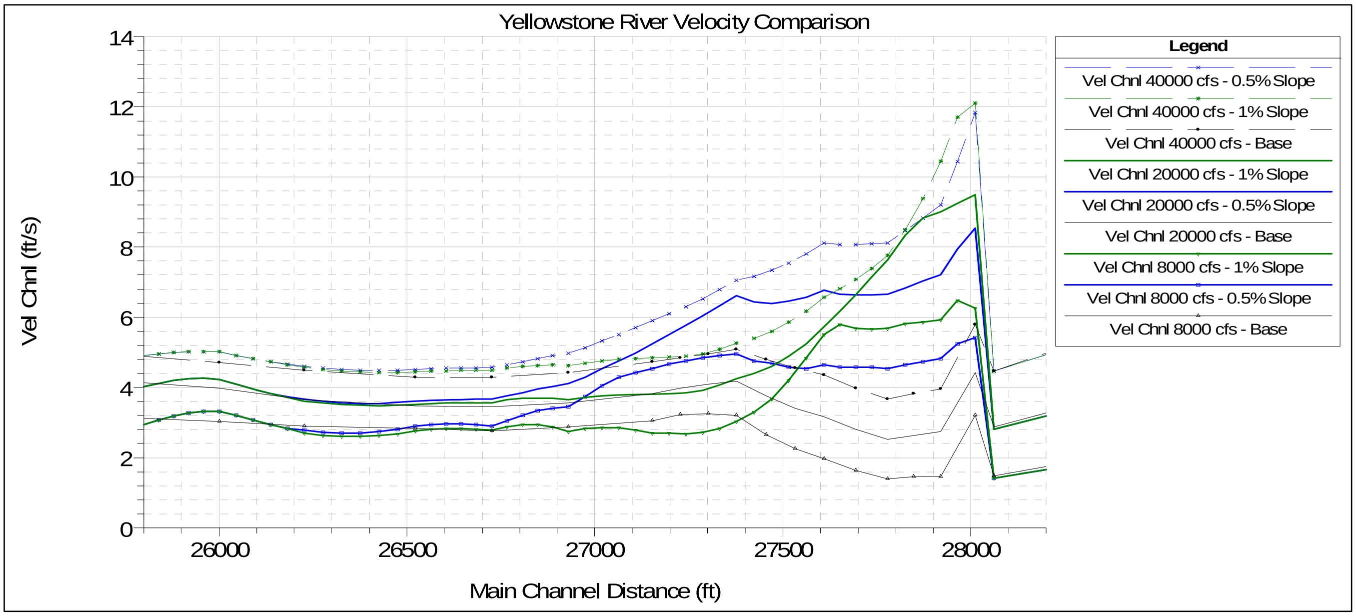

Figure A.2.37 - Comparing Alternative Computed Flow Velocity at Various Flow Rates.
(Note-all computed velocities are average velocities. Actual velocity would vary considerably both horizontally across the ramp and vertically within the water column.)

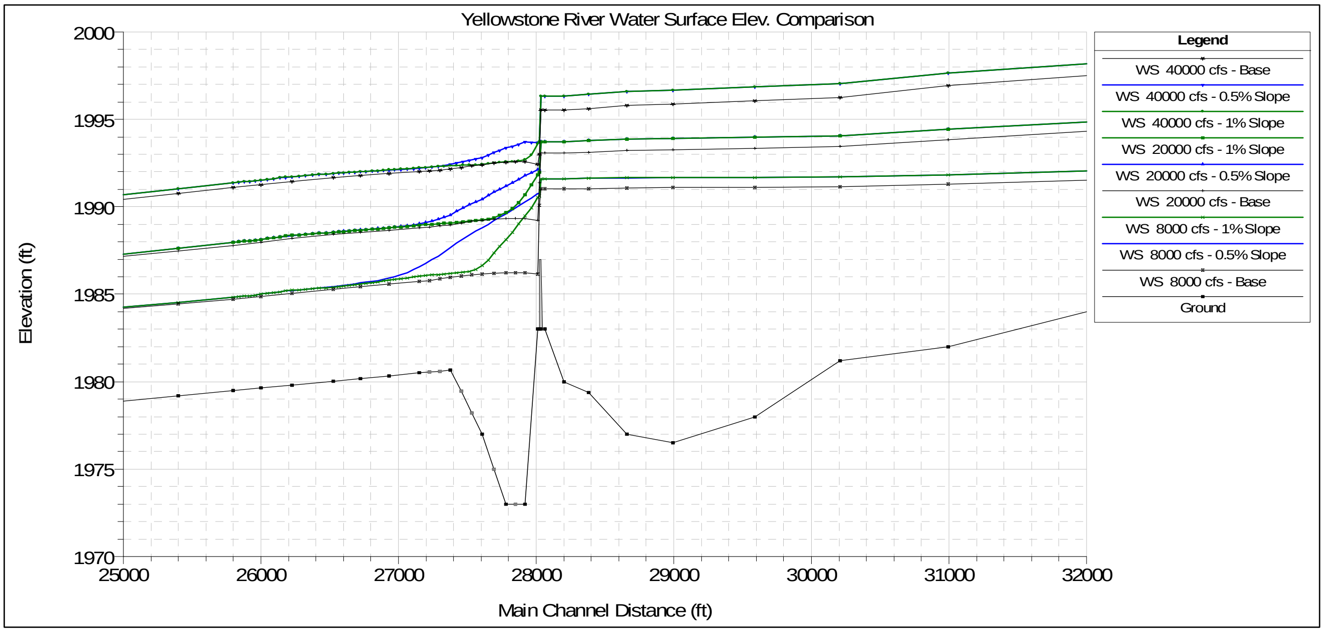

Figure A.2.38 - Comparison of Ramp Flow Elevation.
(Note-while multiple alternatives are compared, the ground invert is shown for existing conditions only.)

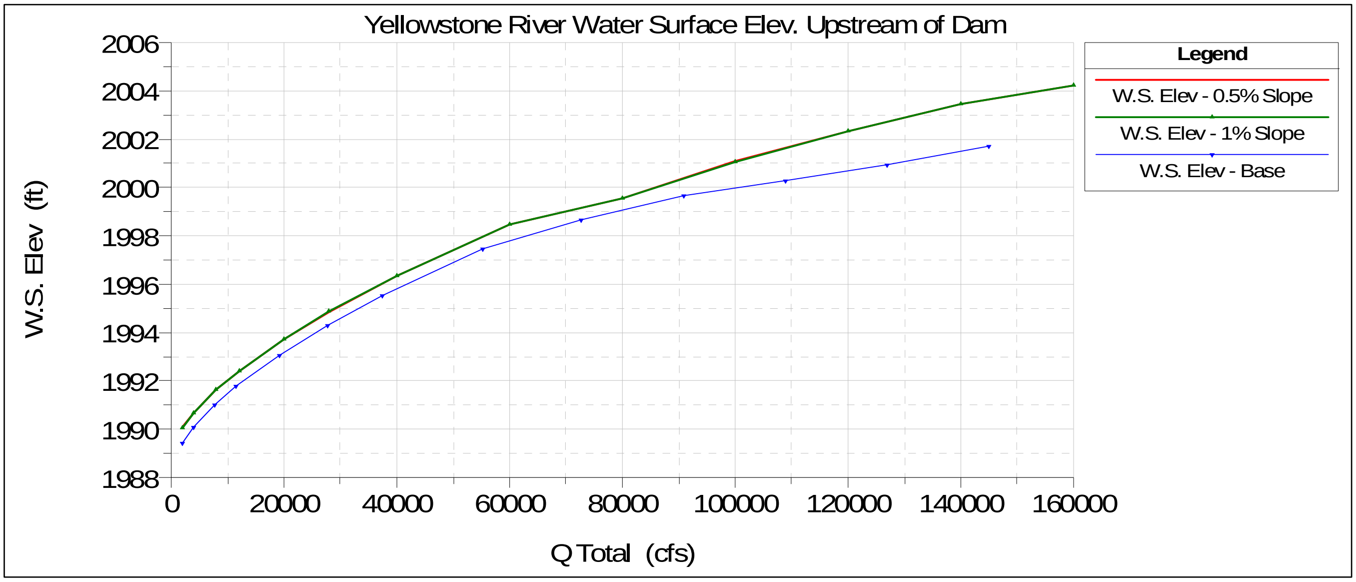

Figure A.2.39 - Comparison of Flow Elevation Upstream of Dam for Both Alternatives.

For the conceptual analysis, stable rock size was computed using the flow velocity and the turbulent method developed by Ishbash presented on HDC Sheet 712-1 (WES 1988). Additional computations were performed using the steep slope riprap equation in EM 1110-2-1601 (Corps 1994, eq. 3-5). Stable rock size computations demonstrate that very large rock is required for ramp stability. In addition, it is doubtful that all rock on the ramp would be stable for extreme events. Results from the Ishbash computation method using HEC-RAS results for a range of flows and both ramp slopes are shown in table A.2.9.

Table A.2.9 - HEC-RAS Rock Ramp Stability Computations.

Yellowstone River Computed Flow Velocity and Stable Rock Size

		60,000 cfs Total Flow		**100,000 cfs Total Flow**		**160,000 cfs Total Flow**	
Ramp Position	Parameter	Flat Ramp at 0.5% Slope	Flat Ramp at 1% Slope	Flat Ramp at 0.5% Slope	Flat Ramp at 1% Slope	Flat Ramp at 0.5% Slope	Flat Ramp at 1% Slope
Top	Comp. Veloc. (ft/sec)	13.5	13.9	15.6	16.5	14.4	14.4
	Stable Rock Size D_{50} (ft)	*2.31*	*2.45*	*3.11*	*3.48*	*2.65*	*2.65*
Ramp Invert Elev 1988	Comp. Veloc. (ft/sec)	9.2	10.4	10.3	11.6	11.2	13.0
	Stable Rock Size D_{50} (ft)	*1.07*	*1.39*	*1.36*	*1.72*	*1.60*	*2.15*
Ramp Invert Elev 1987	Comp. Veloc. (ft/sec)	8.8	8.8	10.3	10.1	11.9	11.5
	Stable Rock Size D_{50} (ft)	*0.98*	*0.98*	*1.36*	*1.31*	*1.82*	*1.68*
Ramp Invert Elev 1985	Comp. Veloc. (ft/sec)	6.7	7.3	8.1	9.0	9.7	10.9
	Stable Rock Size D_{50} (ft)	*0.57*	*0.68*	*0.83*	*1.03*	*1.20*	*1.51*
Ramp Invert Elev 1983	Comp. Veloc. (ft/sec)	5.4	6.2	6.7	7.7	7.9	9.5
	Stable Rock Size D_{50} (ft)	*0.38*	*0.49*	*0.57*	*0.76*	*0.80*	*1.14*
Ramp Invert Elev 1981	Comp. Veloc. (ft/sec)	5.2	5.6	6.3	7.1	7.5	8.8
	Stable Rock Size D_{50} (ft)	*0.34*	*0.40*	*0.51*	*0.65*	*0.72*	*0.99*

A second method was also used to evaluate stable rock size for the conceptual analysis. This method uses the steep slope equation presented within EM 1110-2-1601 (Corps 1994, eq. 3-5). This method computes stable rock size based on unit discharge and slope. Results from those computations are shown in table A.2.10.

Table A.2.10 - Steep Slope Rock Ramp Stability Computations.

Design Flow (cfs)	Bottom width(ft)	Unit q (cfs/ft)	Flow Factor q * 1.25	Design Slope (ft/ft)	COE D_{30} (ft)	Estimated D_{50} (ft)
60,000	550	109	136	0.005	0.86	1.03
100,000	550	182	227	0.005	1.21	1.45
160,000	550	291	364	0.005	1.65	1.98
60,000	550	109	136	0.010	1.26	1.51
100,000	550	182	227	0.010	1.77	2.13
160,000	550	291	364	0.010	2.42	2.91
60,000	700	86	107	0.005	0.73	0.88
100,000	700	143	179	0.005	1.03	1.23
160,000	700	229	286	0.005	1.40	1.69
60,000	700	86	107	0.010	1.07	1.29
100,000	700	143	179	0.010	1.51	1.81
160,000	700	229	286	0.010	2.06	2.48

Results are tabulated for both the 0.5% and 1% slope as well as a bottom width of 550 and 700 ft. Rock size computed with the steep slope equation determined a rock size in the same range as the size computed with the Ishbash method using the HEC-RAS velocity with some variation depending upon ramp location. It should be noted that the steep slope method is stated to be applicable for slopes greater than 2% in the design guidance (Corps 1994:3-8).

Recommended Rock Size for Rock Ramp Based on the computation results, the required rock size near the crest is a maximum for flows of about 100,000 cfs. Further down the ramp, the higher flow rate of 160,000 cfs generates higher flow velocities. A.2.9 also illustrates the reduction in the rock size required for stability as velocities decrease down the ramp. Computed rock size is based on average HEC-RAS model average flow velocity. Referring to the flow frequency analysis from the Hydrology report (Corps 2006), 100,000 cfs is approximately a 50-year event and 148,000 cfs is approximately a 100-year event. Considering all parameters, the recommended rock size is shown in table A.2.11. Gradation for the range of recommended rock sizes is shown on plate A.2.6. The large number of rock sizes is recommended to reduce rock size and limit construction cost for the large rock volume required for the ramp.

Table A.2.11 - Recommended Rock Size.

Ramp Position	1% Slope Ramp	0.5% Slope Ramp
Crest	Concrete required, rock size too large	
Crest to 50 ft downstream	4 Ft D_{100}	4 Ft D_{100}
From 50' D/S to Elev. 1988	4 Ft D_{100}	3 Ft D_{100}
From Elev. 1988 to 1987	3 Ft D_{100}	2.5 Ft D_{100}
From Elev. 1987 to 1985	2.5 Ft D_{100}	2.5 Ft D_{100}
From Elev. 1985 to 1983	2.25 Ft D_{100}	2.0 Ft D_{100}
From Elev. 1983 to 1981	1.75 Ft D_{100}	1.5 Ft D_{100}
Remainder plus 100 ft D/S	1.5 Ft D_{100}	1.0 Ft D_{100}

EM 1110-2-1601 Gradations (Table 3-1, pg. 3-3)

	W_{100}(lbs)		D_{100} (feet)		W_{50}(lbs)		D_{50} (feet)		W_{15}(lbs)		D_{15} (feet)		Minimum (feet)	
D_{100}	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	D_{30}	D_{90}
9	36	15	0.75	0.56	11	7	0.50	0.43	5	2	0.39	0.29	0.37	0.53
12	86	35	1.00	0.74	26	17	0.67	0.58	13	5	0.53	0.39	0.48	0.7
15	169	67	1.25	0.92	50	34	0.83	0.73	25	11	0.66	0.50	0.61	0.88
18	292	117	1.50	1.11	86	58	1.00	0.88	43	18	0.79	0.59	0.73	1.06
21	463	185	1.75	1.29	137	93	1.17	1.02	69	29	0.93	0.69	0.85	1.23
24	691	276	2.00	1.47	205	138	1.33	1.17	102	43	1.06	0.79	0.97	1.4
27	984	394	2.25	1.66	292	197	1.50	1.32	146	62	1.19	0.90	1.1	1.59
30	1350	540	2.50	1.84	400	270	1.67	1.46	200	84	1.32	0.99	1.22	1.77
33	1797	719	2.75	2.03	532	359	1.83	1.61	266	112	1.45	1.09	1.34	1.96
36	2331	933	3.00	2.21	691	467	2.00	1.76	346	146	1.59	1.19	1.46	2.11
42	3704	1482	3.50	2.58	1098	741	2.33	2.05	549	232	1.85	1.39	1.7	2.47
48	5529	2212	4.00	2.95	1638	1106	2.67	2.34	819	346	2.12	1.59	1.95	2.82
54	7873	3149	4.50	3.32	2335	1575	3.00	2.63	1168	492	2.38	1.79	2.19	3.17

Plate A.2.6 – Recommended Rock Size Gradation.

Rock Ramp Ice Stability Additional ice analysis was not performed for this evaluation. Refer to Appendix D (Corps 2006) for a discussion of ice jams and forces. Based on the data presented in Appendix D and Yellowstone River history within the project vicinity, it is likely that ice scouring and gouging of ramp rock lining would occur for any ramp lining size less than 3 or 4 ft diameter rock. Ice scouring depth may pierce the rock layer thickness and cause stability problems. Periodic maintenance of the ramp rock lining is expected.

Rock Ramp Velocity Evaluation Results from the HEC-RAS model were reviewed to evaluate computed velocities for the two ramp slopes. Velocity information may be used to determine a preference between alternatives. However, it should be noted that the accuracy limitations for the conceptual analysis limits the effectiveness of alternative screening. Figures A.2.40 and A.2.41 illustrate the computed velocities downstream of the dam.

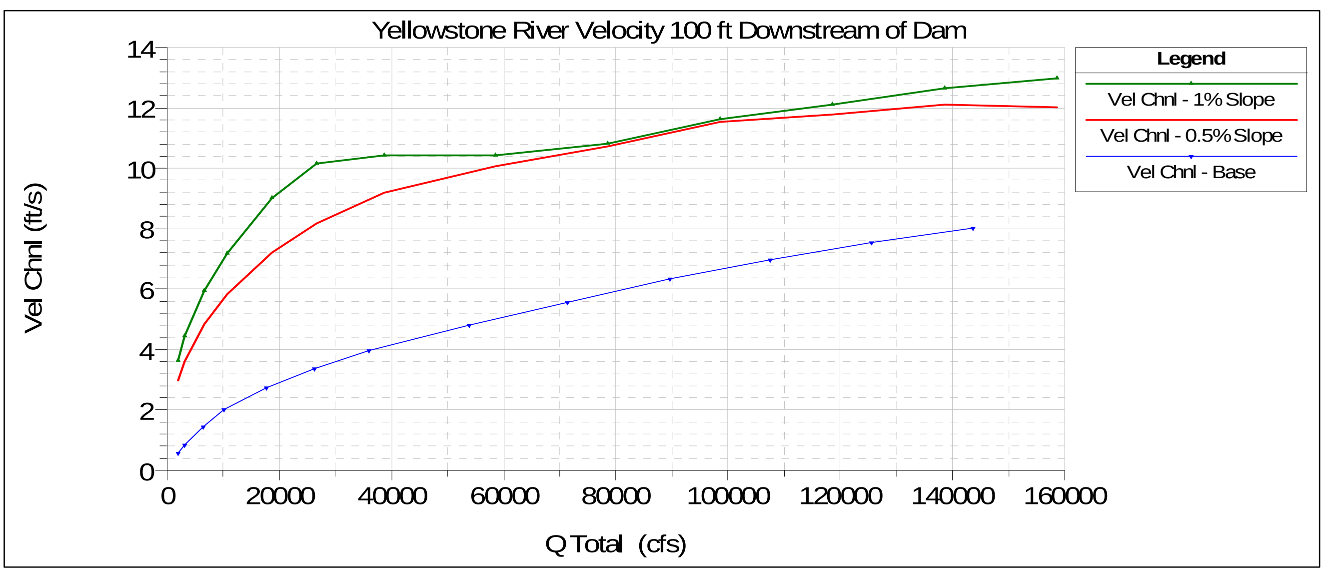

Figure A.2.40 - Comparison of Ramp Flow Velocity 100 ft Downstream of Dam.

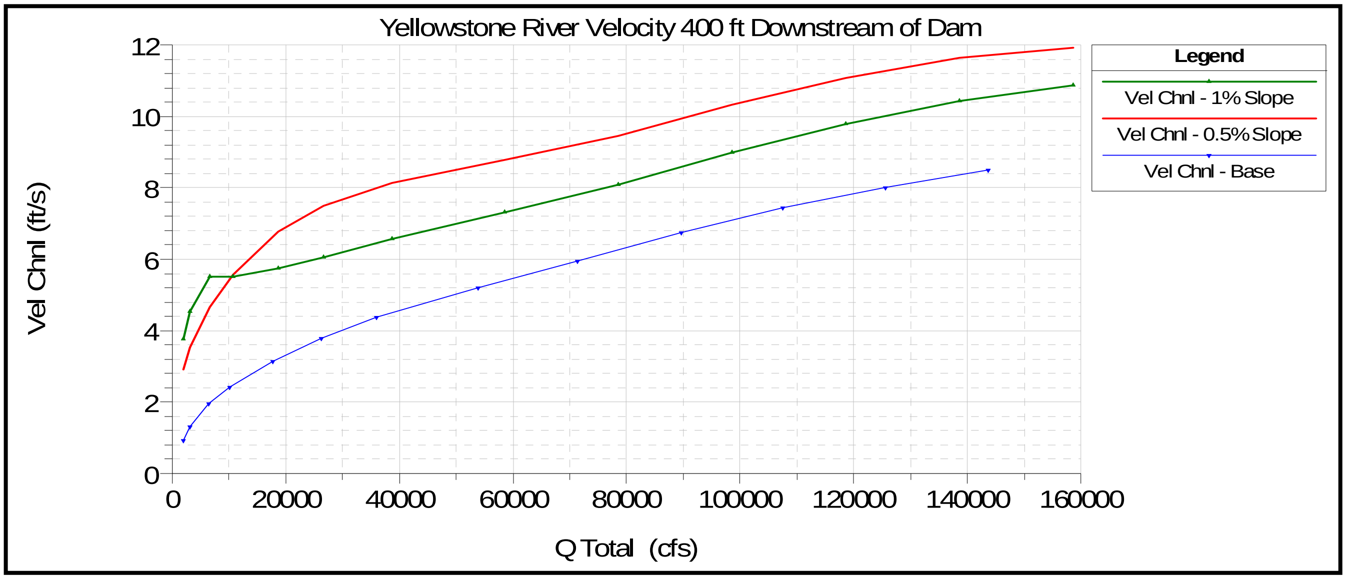

Figure A.2.41 - Comparison of Ramp Flow Velocity 400 ft Downstream of Dam.

Results show that in the range of 100 ft downstream of the dam, the 1% slope ramp has a higher velocity. In the range 400 ft downstream of the dam, the 0.5% slope ramp has the higher velocity for the higher flows. This is due to the elevation difference and the backwater effect of the Yellowstone River. If flow velocities at similar elevations are compared, then the 0.5% slope ramp is usually slightly lower. A further comparison of ramp flow velocity profiles for a few selected flow rates was previously shown in figure A.2.37. This figure illustrates that while the 0.5% slope ramp has lower velocity at an equal elevation, high flow velocities cover a longer distance due to the longer ramp length. Using the computed velocity at each cross-section, the total ramp length that exceeded 6 and 8 ft/sec was determined for a range of flows from 8,000 to 80,000 cfs. These velocity values were selected to provide an indication of fish passage capability. The ramp length exceeding 6 ft/sec is shown in figure A.2.42 and the length exceeding 8 ft/sec is shown in figure A.2.43.

Results were also compared to the previous alternative for a 2% slope ramp with 1 ft steps. These results illustrate that while the velocities are in a similar range, the step configuration generates velocity spikes that are expected to be accompanied by flow turbulence. However, velocity through the boulder gaps would be significantly lower. Figure A.2.44 compares the velocities for the 0.5% constant slope ramp and the 2% slope ramp with 1-ft steps.

Velocity Distribution in a Channel Section Due to the presence of the free water surface and friction along the channel bottom and banks, the velocities in a channel cross-section are not uniformly distributed. The velocity maximum usually occurs a distance below the free water surface of about 5 to 20% of the depth. Velocity depends on factors such as location in reference to the banks, shape of the section, material roughness, presence of bends, and other factors that result in unequal velocity distribution. Changes in channel shape and bends, material roughness, and cross-sectional shape would cause secondary currents or a circular flow motion that is parallel to the primary current flow direction. While velocity is low in the near vicinity of the channel bottom, available guidance suggests that flow velocity exceeds 80% of the average velocity when above the bottom 10% of the water column. Future design efforts will also refine estimates of velocity distribution within the channel section.

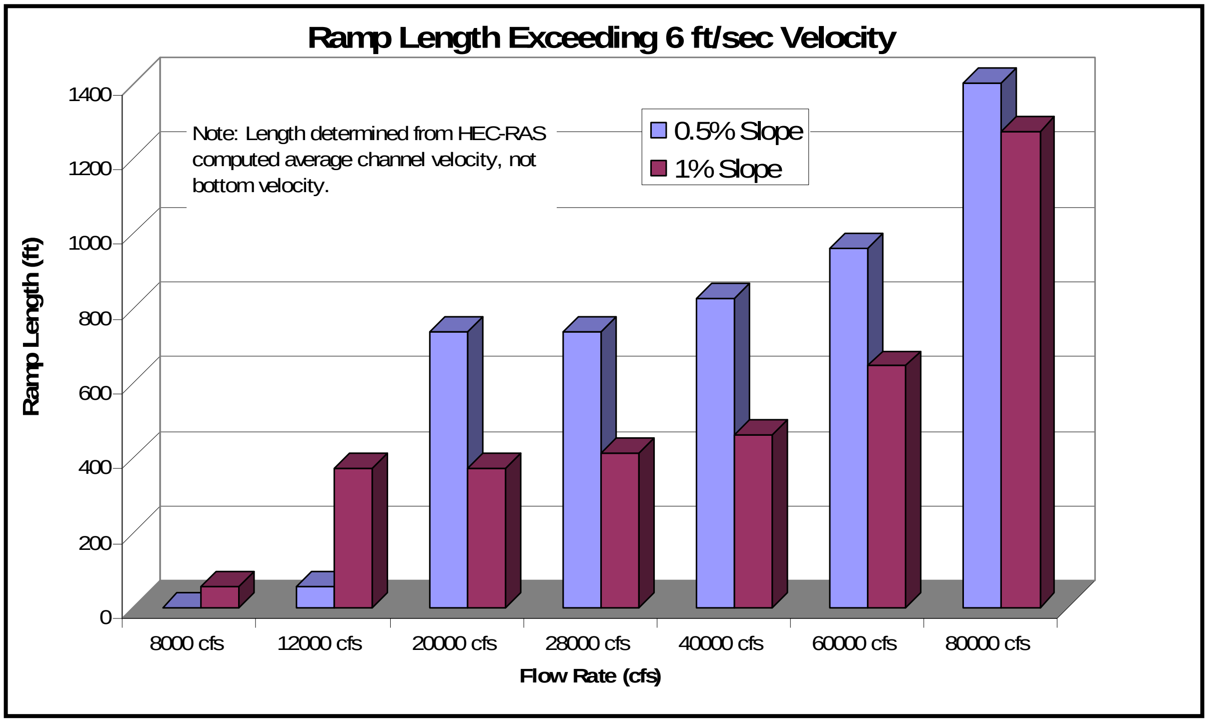

Figure A.2.42 - Ramp Length Exceeding 6 ft/sec for Both Alternatives.

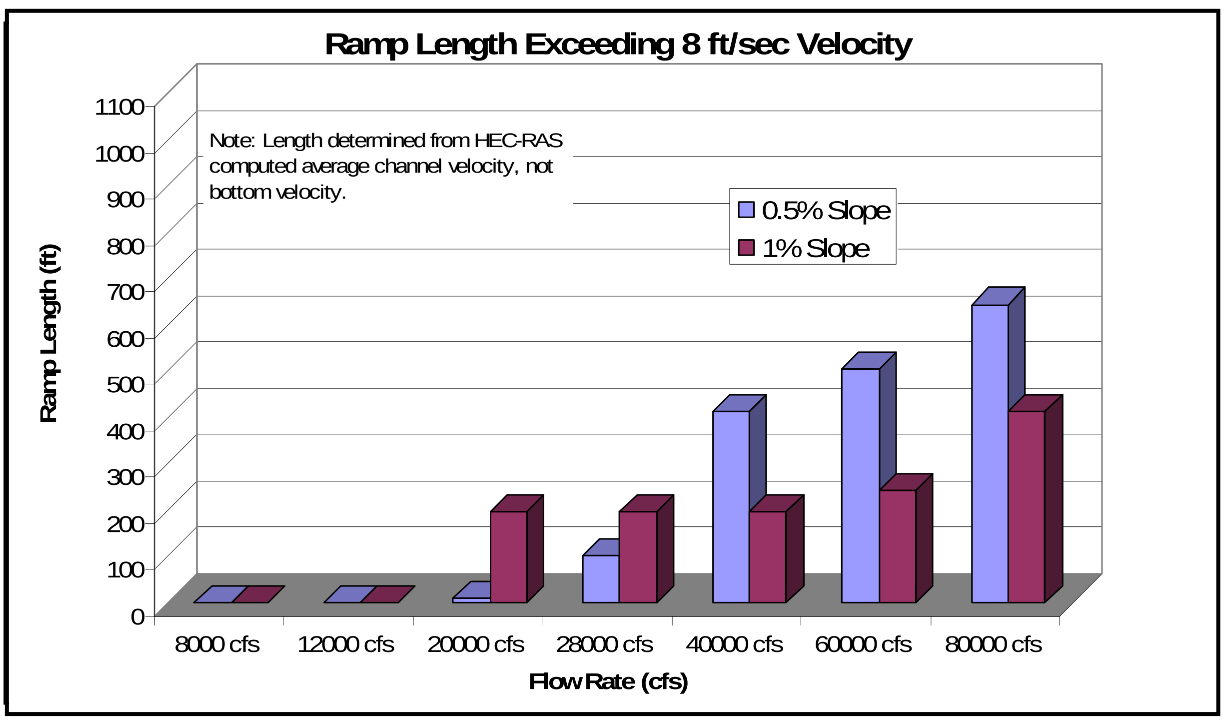

Figure A.2.43 - Ramp Length Exceeding 8 ft/sec for Both Alternatives.

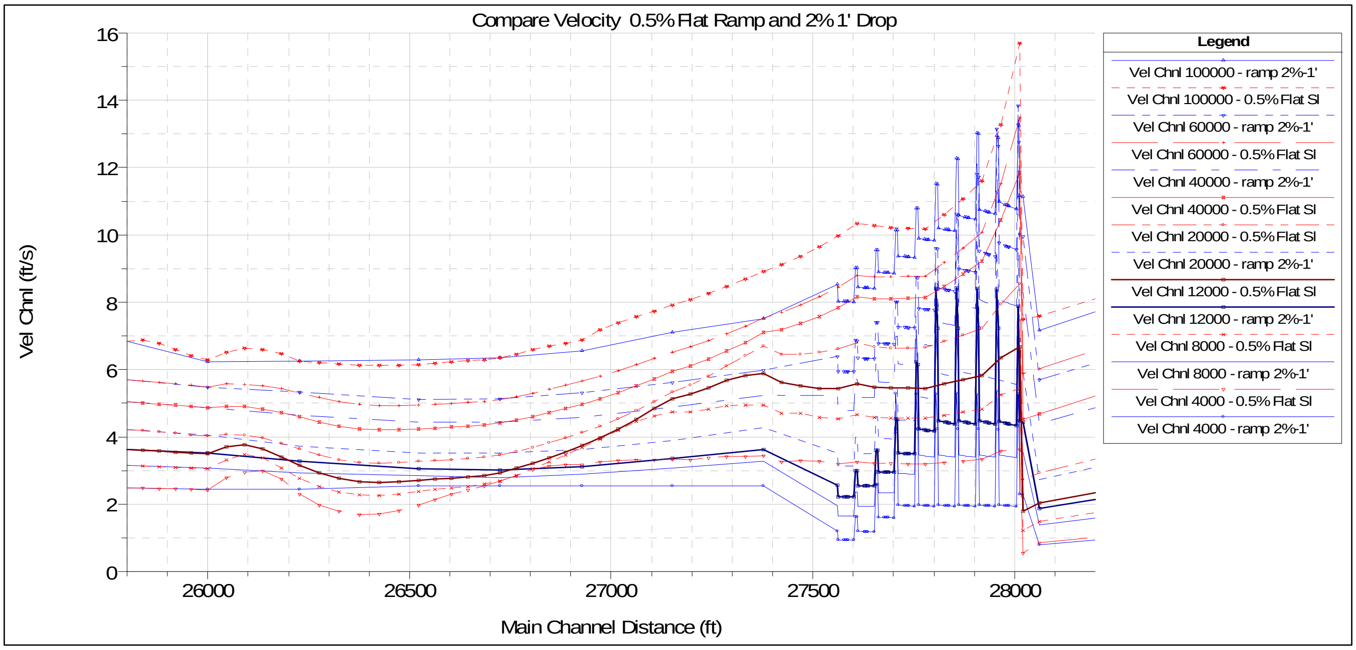

Figure A.2.44 - Computed Velocity for 0.5% Constant Slope Ramp and 2% Slope 1-ft Step Ramp.

Fish Passage Related to Relevant Pallid Sturgeon Swim Guidance Relevant pallid sturgeon fish passage criteria from previous studies (Corps 2002: Appendixes A and B) was reviewed in the previous Ramp Fish Passage Related to Relevant Pallid Sturgeon Swim Guidance section. Available guidance does not include maximum velocity criteria. However, the computed average velocities determined with the HEC-RAS model are high enough to be concerning for flows in excess of 40,000 cfs for the upper portion of the ramp. Interpretation of results should consider that the ramp geometry is variable, and these results are not reflected in the HEC-RAS computations. Flow duration data (Corps 2006) indicates that the percent of time that a flow of 40,000 cfs is equaled or exceeded in June is about 30%. Figure A.2.42 illustrates that over 700 ft of the 0.5% slope ramp exceeds 6 ft/sec velocity at a flow of 20,000 cfs. A flow of 20,000 cfs is equaled or exceeded for nearly 2 months 50% of the time using the flow duration data.

While velocity and turbulence on the ramp may be excessive for high flows, the sloping ramp and bank edges should provide a portion of the ramp that is more amenable to fish passage. In addition, computed velocities are average. Actual velocity would vary both horizontally across the ramp and vertically within the water column. Future design will determine velocity variation within the ramp. Given the computed high velocities for the upper portion of the ramp, it seems probable that fish passage success for high flow events may be less than desirable.

Future Design Efforts Future design efforts are required to further evaluate ramp components and define computation parameters. Normal depth analysis illustrates the significant impact that ramp slope and roughness have on flow velocity and depth. Ramp stability and the corresponding material size would impact ramp roughness. Recommended design components include a two-dimensional computational model and a physical model. Depending upon ramp configuration, the requirement for a physical model may be further evaluated. The two-dimensional model would be constructed of the entire ramp area and include a segment upstream and downstream of the ramp. A two-dimensional model would be constructed of both existing and refined conditions. The two-dimensional model would illustrate depth averaged velocity magnitude and direction throughout the area. The physical and numerical modeling results can be used to refine ramp design features and evaluate ramp performance for a range of flows.

Summary of Design Results and Items to Consider During Future Efforts The analysis performed to date is a conceptual design to evaluate feasibility of the rock ramp. The analysis compared basic ramp geometry and identified several design restrictions that need to be further evaluated. Results are summarized as follows:

- An analysis of other rock ramp alternatives and geometry is summarized in the stepped rock section (above).
- Available data at the time of this analysis was inadequate to define Yellowstone River topography within the ramp limits. The model relies extensively on interpolated cross-sections to define the velocity profile on the ramp. Model results are adequate for evaluating general trends but should be used with caution. Velocity variation of 20% from computed values is probable.
- Normal depth analysis illustrates the significant impact that ramp slope and roughness have on flow velocity and depth. Future analysis will refine roughness estimates.
- All computed velocities are average velocities. Actual velocity would vary considerably both horizontally across the ramp and vertically within the water column. Velocity distribution estimates will be refined in future design to develop estimates of near bottom velocity.
- Results determined high velocities at the ramp crest. A concrete cap provides stability for the upper portion of the ramp and protects against ice damage. To facilitate fish passage and maintain flow distribution, an uneven crest with possibly natural rock set in the crest concrete is probably required. These details would be determined in final design.
- The 0.5% slope ramp generates lower velocity at similar elevation compared to the 1% slope ramp. However, due to the ramp length, the higher velocity portion of the ramp is longer and may not be preferable. Evaluation of ramp preference in future design will consider flow duration, flow velocity, and acceptable length for successful fish passage.
- The performed analysis used HEC-RAS to evaluate ramp flow parameters. A two-dimensional model and possibly a physical model are recommended for future design efforts to determine ramp geometry.
- Large rock is required to provide stability from scour. Previous studies indicate that substrate size may impact fish passage success. The required rock size varies with position and slope.
- Similar to natural river scouring and gouging during ice jams and spring breakup floods, it is likely that ice scouring of ramp rock lining would occur for any ramp lining size less than 3 or 4 ft diameter rock. Periodic maintenance of the ramp rock lining should be expected.
- Computed water surface elevations increase compared to the base condition over a portion of the ramp by 0 to 3 ft for the flow range evaluated. Since the ramp involves placing substantial fill within the Yellowstone River, the floodplain flow frequency would increase in the ramp vicinity. This increase continues upstream due to the backwater effect of the ramp.

- The right bank floodplain currently conveys a limited amount of flow. An excavated bypass on the right bank could be used to reduce the ramp unit discharge for extreme events and reduce the maximum ramp flow to enhance ramp stability.

The ramp cross-section was modeled as trapezoidal. Future design will refine the cross-sectional shape to promote depth diversity for a range of flows. The flat ramp alternative does not include boulders as an integral design component. Boulders could be inserted if required to add depth diversity and fish friendly habitat.

Relocate Main Channel

This section describes the hydraulic analysis conducted to develop preliminary hydraulic design information for the alternative consisting of relocating the main channel of the Yellowstone River to allow unimpeded fish passage. Highlights of this alternative include excavation of a new channel, construction of a new headworks structure with fish screens at the upstream end of the relocated channel, placement of fill in the existing channel, construction of an irrigation canal extension to carry flow to the existing intake structure, and tieback levees to prevent unrestricted flow into the canal extension.

Concept Features and Layout

The Relocate Main Channel Alternative is comprised primarily of the following elements:

- Excavated channel
- In-channel grade control structures
- Concrete control structure at upstream end of relocated channel
- Extension of irrigation canal connecting existing canal and relocated channel
- New headworks with fish screens
- Tieback levees

The Relocate Main Channel Alternative would move the main channel of the Yellowstone River from its current location to bypass the existing Intake Diversion Dam. The channel move would result in relatively unimpeded fish passage. The existing main channel of the river would serve two purposes. First, a portion of the existing channel would be reconfigured to serve as an extension of the diversion canal. Second, the remainder of the existing channel would be used to spoil material excavated from the relocated channel.

In addition to the relocated channel and extended diversion canal, this alternative would require an upstream concrete control structure, riprap grade control structures, new headworks with fish screens, and tieback levees. The concrete control structure would be located at the upstream end of the relocated channel and would ensure the upstream end of the relocated channel would maintain its location and elevation. The headworks would include fish screens and gates to control flow into the diversion canal and prevent fish entrainment. The tieback levees would prevent unrestricted water and sediment from entering the irrigation canal extension during high flow events.

The features described above can be seen on plate A.2.7.

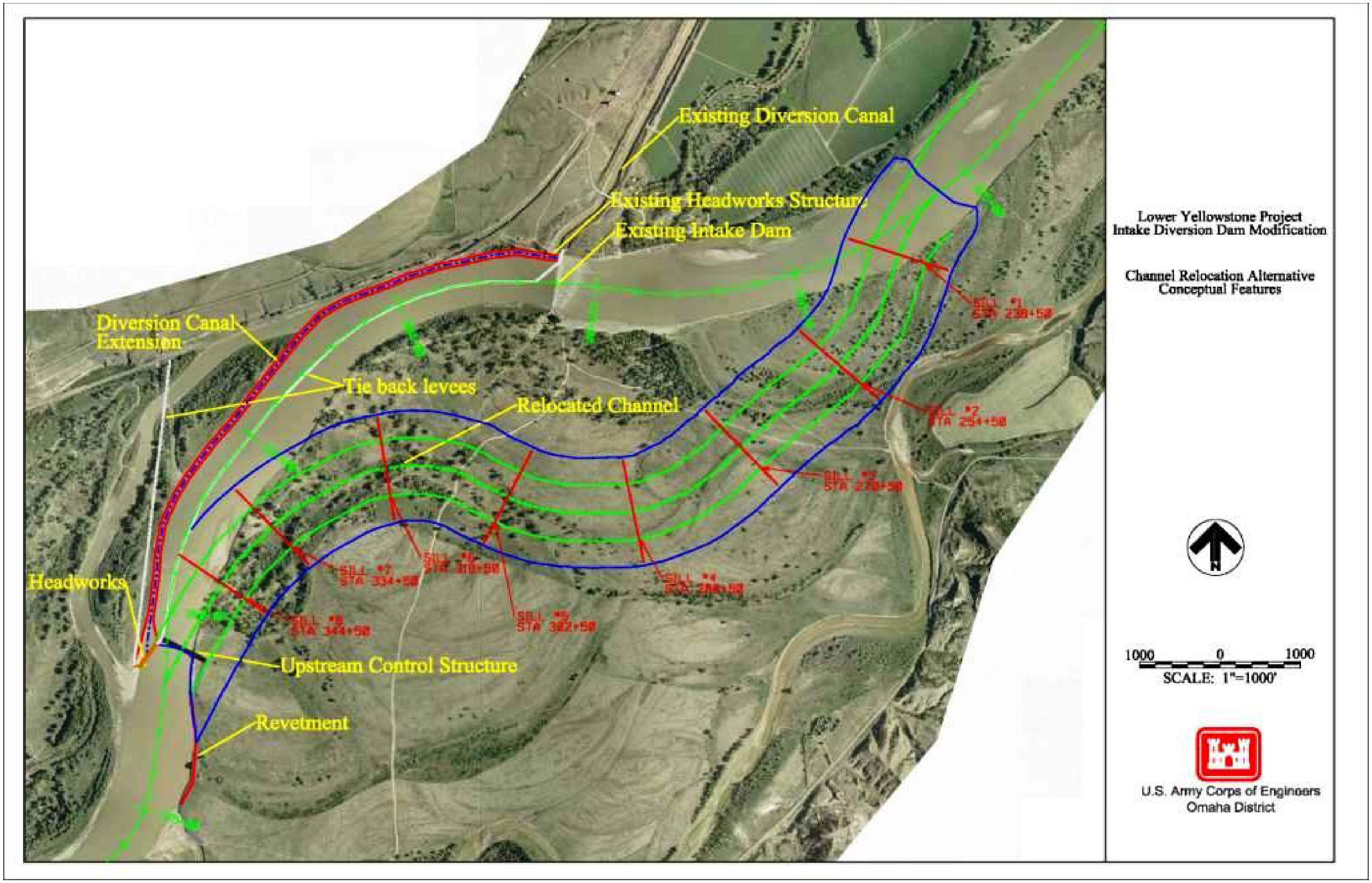

Plate A.2.7 – Relocate Main Channel Alternative Overview

Relocated Channel The primary component of the Relocate Main Channel Alternative is the excavation of a new channel. The new channel would be approximately 12,500 ft long, connecting to the Yellowstone River about 5,000 ft downstream and 8,000 ft upstream from the existing dam. The longitudinal slope of the new channel would be approximately 0.00085 ft/ft.

Initially, the alignment of the existing right bank high flow chute was used as the centerline of the relocated channel alignment. However, this alignment was discarded due to upstream floodplain impacts as the water surface elevation was increased in excess of 4 ft since nearly the entire floodplain was blocked (tieback levees on left and high banks on right).

The compound channel configuration would consist of a low flow channel 50 ft wide by 2 ft deep, a normal flow channel 6 ft deep with a 600 ft bottom width, and a 1250 ft wide high flow channel tying into existing ground. All side slopes are 4H:1V (4 units horizontal to 1 unit vertical). Figure A.2.45 shows the proposed channel configuration.

Numerous channel alignments and configurations were evaluated. Variables considered include channel alignment (length and location), longitudinal slope, bottom width, and high flow bench configuration.

The primary criteria used to determine the selected channel configuration include:

- Head at upstream end of relocated channel must be sufficient to divert the irrigation district's allocated water right (≈ 1400 cfs), of concern especially at low flows.
- Relocated channel length should be similar to that of the existing channel between tie-in locations
- Relocated channel slope should be similar to that of a reference reach of the existing channel
- Relocated channel width should be similar to the existing channel
- Water surfaces for high flows (100-year event in particular) should not increase above existing conditions
- Channel sinuosity should be similar to that of the existing channel

While it is desirable to design a channel which would meet all the above criteria, several are conflicting and thus some compromises had to be made. In order to divert the irrigation district's full water right at low flows, the slope of the relocated channel was adjusted to provide the necessary head at the upstream end. The proposed slope (0.00085 ft/ft) is steeper than the average slope of the existing channel. While the existing channel slope varies considerably in the reach of interest due to the effects of the dam over the last 100 years, the average channel slope upstream and downstream of the dam is on the order of 0.0005 ft/ft.

To prevent the 100-year water surface elevation from increasing, the high flow bench was added.

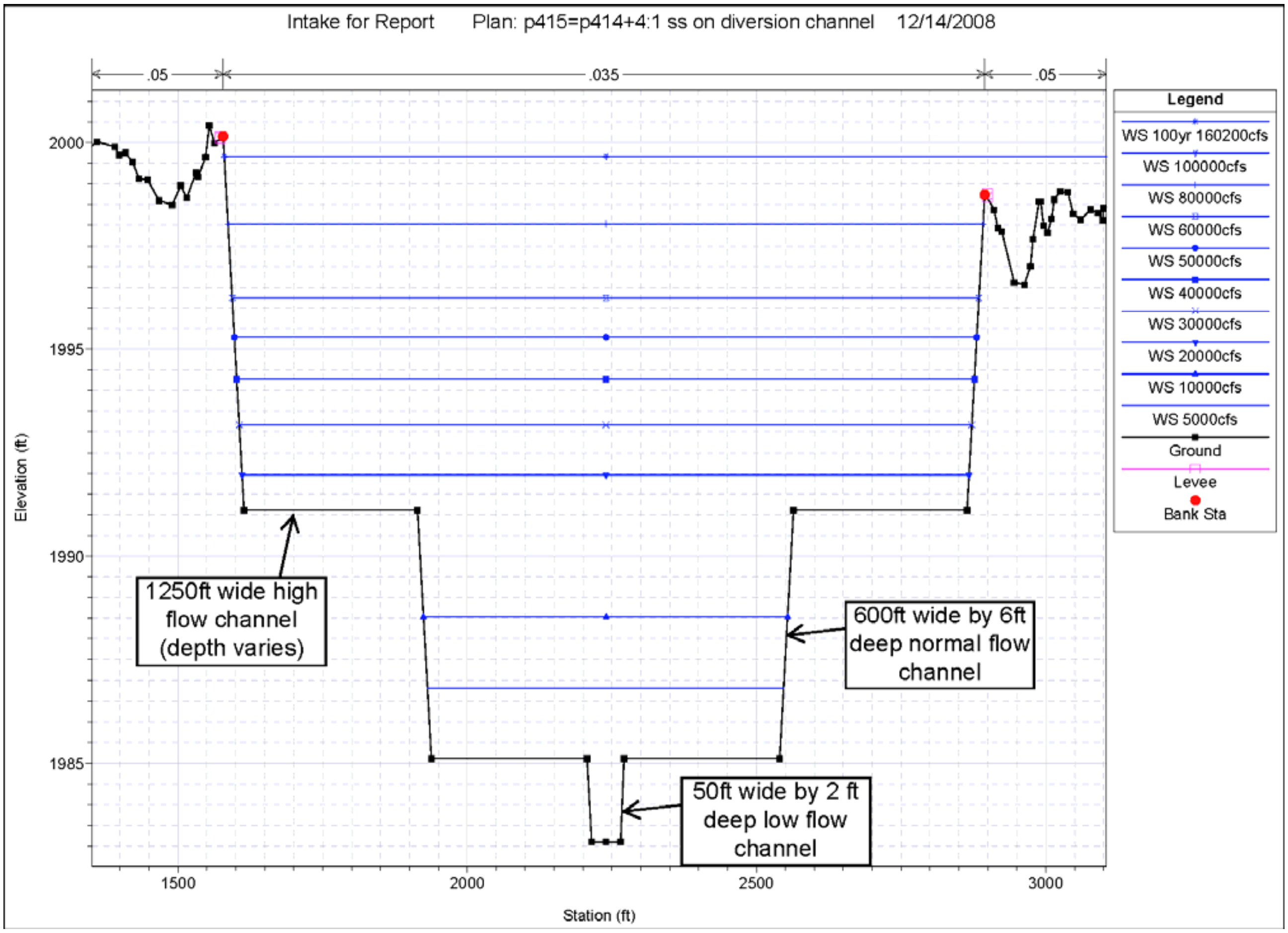

Figure A.2.45 - Proposed Relocated Channel Configuration.

Excavation of the channel would remove approximately 6 million cubic yards of material. Some of the removed material (approximately 3.5 million cubic yards) would be used to fill the existing channel and construct the tieback levees. The remaining balance would need to be spoiled.

In-Channel Grade Control Structures This section details structures that would be put in place in order to ensure that the designed geometry remains stable and is not subject to geomorphic changes caused by differing slopes and geometries than what are currently in place.

It is proposed that a series of keyed sills be placed in the relocated channel in order to deter any potential headcutting and widening from the resulting change in energy from the relocation. Maintaining the design configuration of the relocated channel is critical to ensuring fish passage and function of the relocated diversion inlet.

The proposed relocation alignment is approximately 12,500 ft in length with a slope of 0.00085 ft/ft. The slope of the river directly upstream of the relocation is approximately 0.000645 ft/ft. Spacing of the proposed sills was determined using the following equations:

$$H = (S_o - S_f)\,L_p$$
$$N = H/h$$
$$X = L_p/N$$

Where H is the Total vertical drop in bed elevation for structures, Lp is the length of the project, h is the drop at each structure, N is the number of structures, and X is the spacing of the structures. Using this equation set as a basis, the project will include 8 riprap sills with a drop of 1ft per structure at a spacing of approximately 1,600ft. Table A.2.12 summarizes the sill stations and elevations. Plate A.2.7 shows the approximate sill locations.

Table A.2.12 - Sill Stations and Elevations.

SILL	STATION	RIPRAP INVERT ELEVATION (ft)	CHANNEL INVERT ELEVATION (ft)
1	238+50	1974.57	1978.57
2	254+50	1975.93	1979.93
3	270+50	1977.29	1981.29
4	286+50	1978.65	1982.65
5	302+50	1980.01	1984.01
6	318+50	1981.37	1985.37
7	334+50	1982.73	1986.73
8	344+50	1983.49	1987.49

The spacing of the sills is more frequent than necessary for geomorphic stability, but in order to preserve fish passage and maintain the rating curve at the relocated intake diversion inlet, the above spacing is proposed.

The structures would consist of a keyed trench 10 ft wide by 4 ft deep that would be tied into the high banks filled with riprap.

An 1,800 ft revetment would also be placed from the control structure at the inlet of the relocated channel upstream to the inlet of the natural high flow channel in the project area to deter flanking.

Twenty-four inch riprap material (D50) would be used for all the structures.

Each sill has an approximate volume of 1,550 cubic yards, for a total volume of approximately 12400 cubic yards for the project. A rough conversion of 2.09 tons/cu yd for stone fill equates to 26,000 tons of riprap required for construction of the sills.

For the revetment, using an estimated value of 5.1 tons/ft, a total of 9,200 tons of rock would be required for construction.

Upstream Control Structure The upstream control structure was included to prevent degradation of the relocated channel invert. The channel invert must remain stable in order to provide sufficient head to divert the full water right to the irrigation canal.

The concrete control structure would be constructed to laterally conform to the channel bed (i.e., low flow channel included). The structure would not protrude from the channel bed (looking upstream) so that fish passage is not hindered.

Headworks and Fish Screens The fish screening technique for this alternative could use either the cylindrical screens or the v-shaped screen. Because analysis had previously been completed to design the cylindrical screens for a headworks structure similar to that proposed for this alternative, the cylindrical screens are proposed here. Further discussion and comparison of the various screen alternatives is presented on pages A.2-97 through A.2-100.

The only analysis completed for this alternative relative to the headworks and fish screen was to determine the top of the headworks structure. The proposed top of headworks is at elevation 2011ft NAVD88 based on the 100-year ice profile plus 5 ft. The 100-year ice profile was determined in a separate analysis conducted by the Corps Omaha District for FEMA.

Seventeen fish screens are proposed for this alternative (compared to fourteen proposed in the rock ramp alternative). The additional three screens are proposed due to uncertainties in the delivery of water. First, without the dam in place, there would be less available head for diversion during periods of low flow. Second, specifics concerning the diversion water rights and losses are unclear. While these losses would not likely amount to an additional 300 cfs, no analysis has been completed to determine the appropriate number of additional screens.

Irrigation Canal Extension The new diversion channel would essentially be an extension of the existing diversion canal to carry water from the new headworks to the existing headworks. The proposed diversion canal would have a longitudinal slope of 0.001 ft/ft, 50 ft bottom width, and 4H:1V side slopes. The upstream and downstream invert elevations are 1985.54 ft NAVD88 and 1978 ft NAVD88, respectively. The length of the diversion channel is approximately 7,400 ft.

Tieback Levees Tieback levees are included in this alternative to prevent unrestricted flow of sediment-laden floodwaters into the new diversion canal. Because minimal maintenance is required on the existing irrigation canal, minimal maintenance on the new diversion channel is desired. The upstream tieback levee ties into the top of the headworks, runs parallel to the channel for approximately 1900 ft, then goes straight to high ground near the railroad tracks. The downstream tieback levee ties into the top of the headworks, follows the existing main channel of the Yellowstone River (to be filled in), and ties into high ground on the downstream side of the existing headworks structure near the existing dam.

Due to uncertainty in the ice conditions following relocation of the channel, the top of levee elevations were set at the 100-year ice profile plus 5 ft.

HEC-RAS Channel Relocation Model Hydraulic modeling was completed to determine the proposed channel configuration as well as to determine necessary channel stability measures. The base model is described in Section 2.5. The hydraulic modeling was completed using HEC-RAS version 4.0.

Hydraulic modeling for the Relocate Main Channel Alternative consisted of extracting new cross-sections along the proposed alignment, replacing the existing main channel with the proposed relocated channel, and varying the slope and channel configuration of the proposed channel to maintain the required head at the upstream end of the channel relocation. Additionally, cross-sections from the existing main channel between the new headworks and the existing headworks were utilized in determining the size of the proposed diversion channel. The Channel Design/Modification editor was used to cut the channels, allowing for evaluation of a large number of various alternatives.

The proposed channel alignment and configuration are described above and shown in figure A.2.45, and plate A.2.7.

Figure A.2.46 compares rating curves for existing conditions and proposed project conditions at the upstream end of the relocated channel.

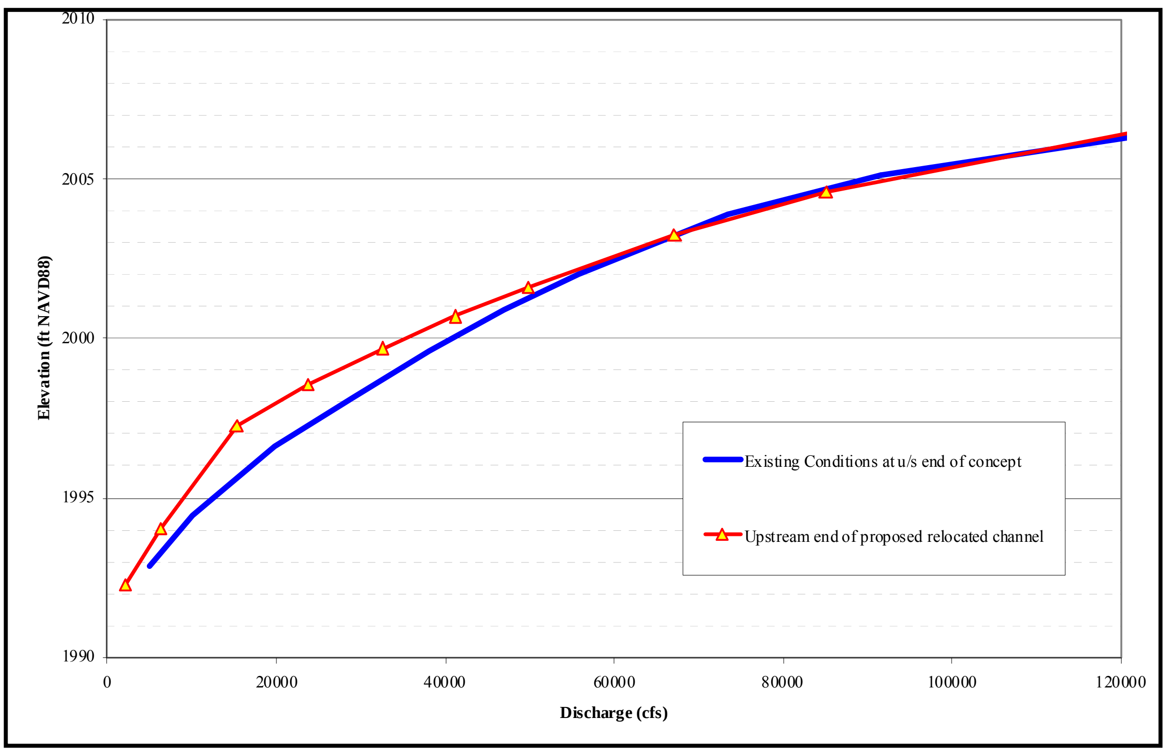

Figure A.2.46 – Rating Curves at Upstream End of Concept Alignment.

Plate A.2.8 compares existing conditions water surface profiles with the relocated channel water surface profiles.

Relocated Channel Stability Analysis Modifications to the proposed conditions Yellowstone Intake HEC-RAS model were performed to indicate anticipated changes in the bed due to the sills. Changes to the model included an assumed 1 ft drop at the location of all the proposed sills. Channel widening is often a result of bed degradation. The model was also revised to include 100 ft of bank erosion in the relocated channel due to changes in grade.

Figure A.2.47 represents the HEC-RAS results for the water surface profiles through the relocated Yellowstone River. By adding the 1 ft drops beneath the sills, the water surface changes only slightly through the reach. When the expected widening was modeled there were drops of up to 1 ft in the water surface through the relocated channel.

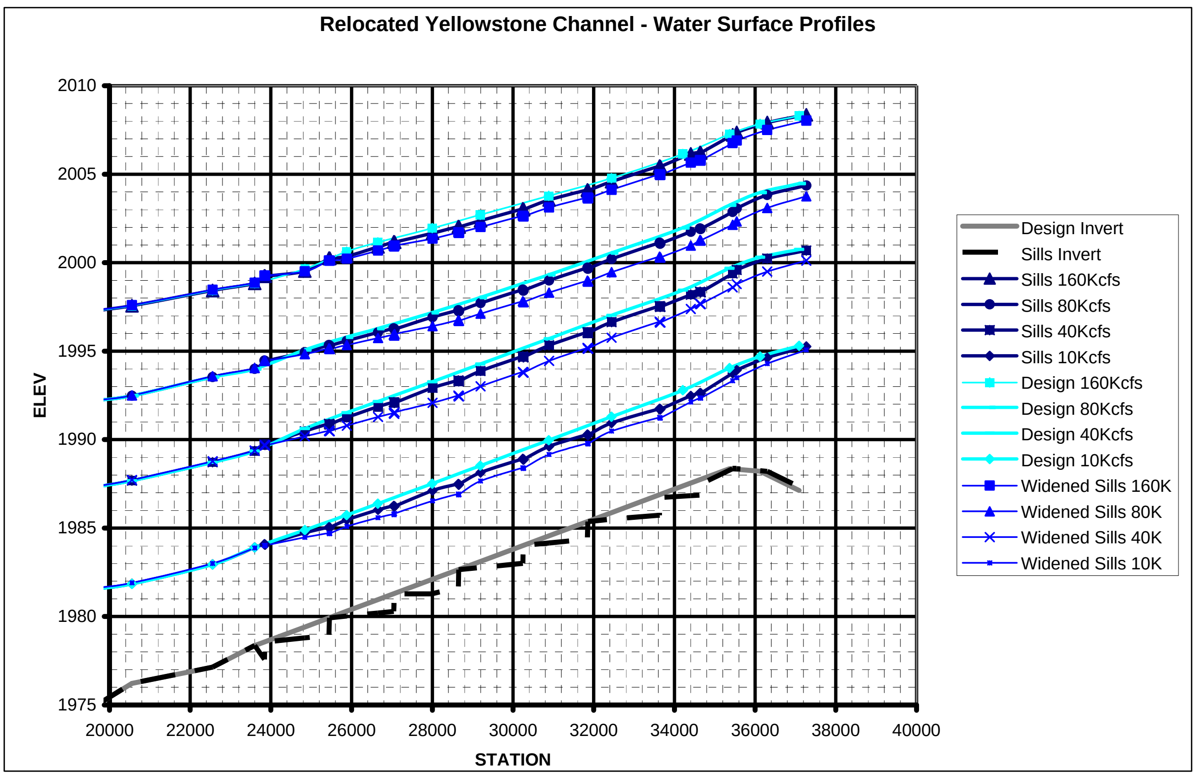

Figure A.2.47 – Relocated Yellowstone Chanel Water Surface Profiles.

Figure A.2.48 represents the rating curve directly upstream of the relocated diversion structure and lateral weir to the relocated channel. HEC-RAS model results indicate little change as a result of the 1 ft drops at the sills in the relocated channel. However, when projected widening is accounted for in the model, the rating curve shifts by as much as a foot.

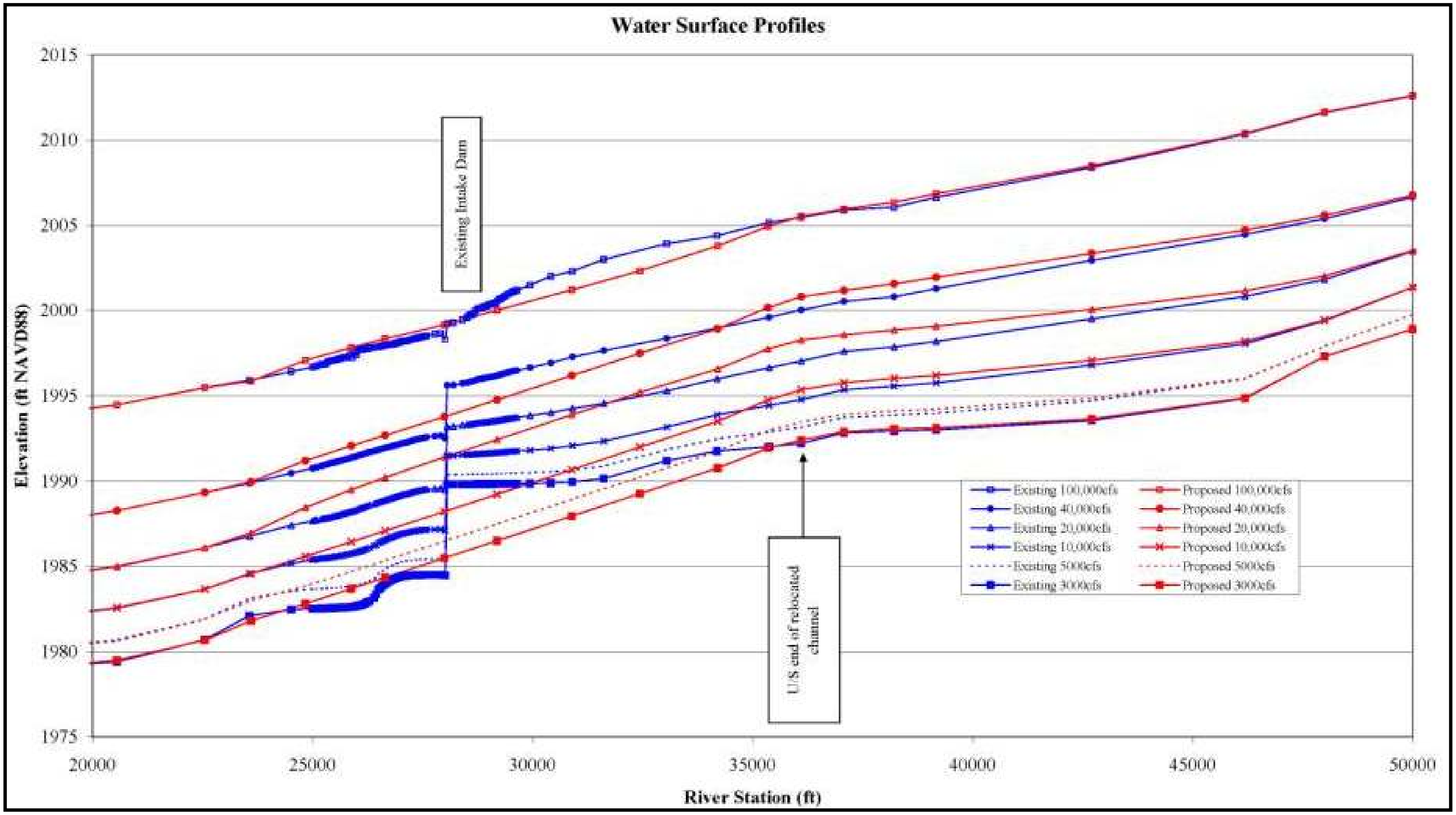

Plate A.2.8 – Channel Relocation Water Surface Profiles.

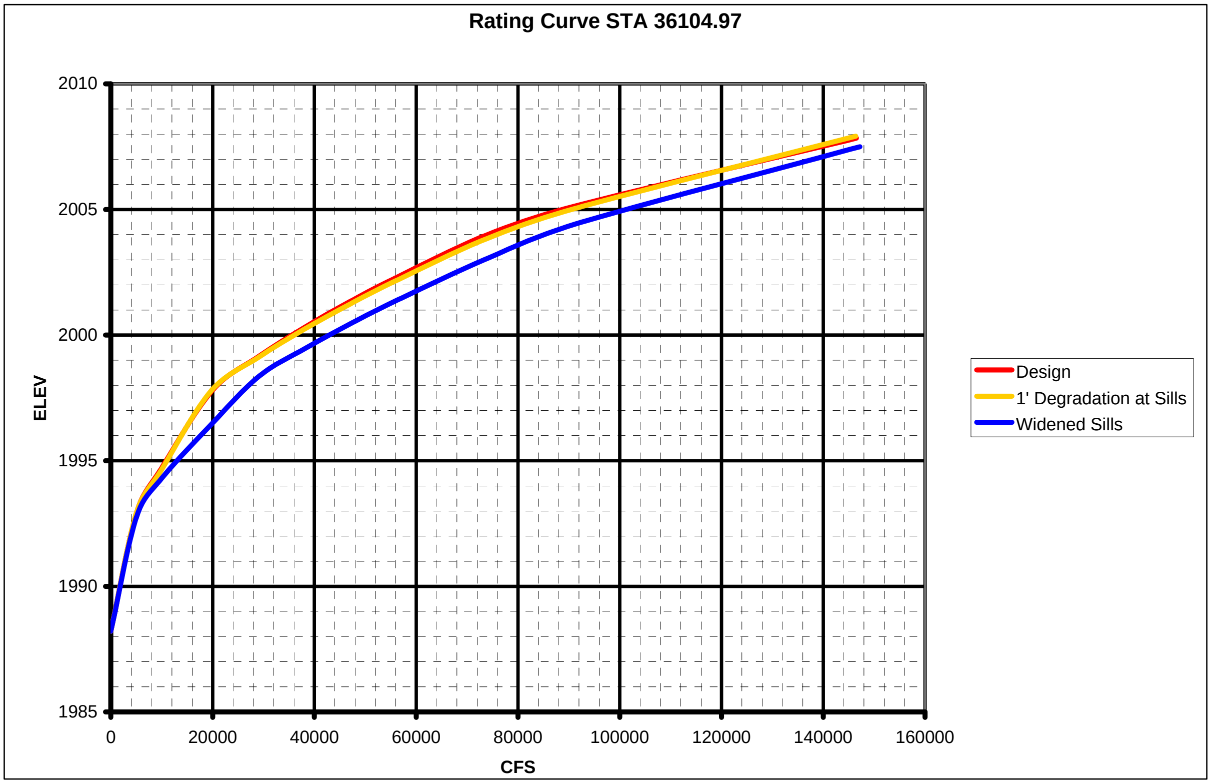

Figure A.2.48 – Rating Curve at Yellowstone River Station 36104.97.

Figure A.2.49 represents the functionality of the gated diversion structure proposed in the relocation. Neither the projected 1ft drop at the sills nor the resultant channel widening would affect the ability of the structure to divert the design flow.

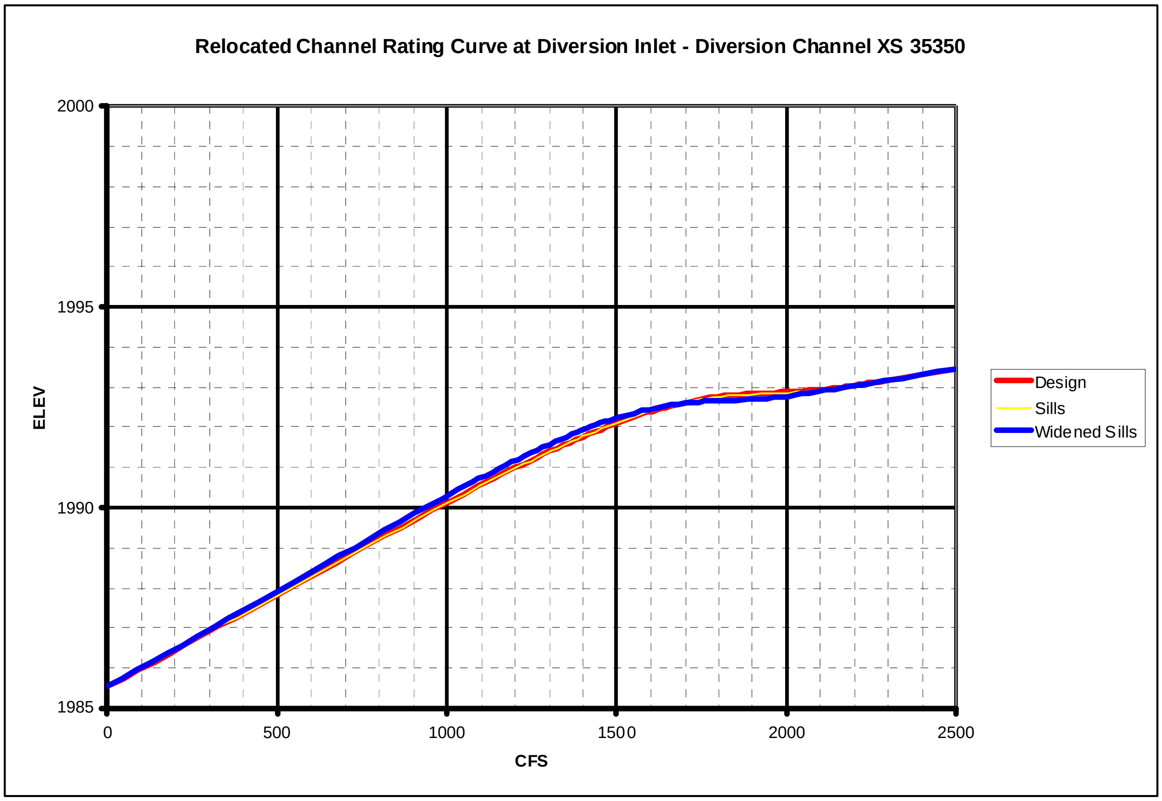

Figure A.2.49 - Relocated Channel Rating Curve at Diversion Inlet, Cross Section 35350.

Table A.2.13 summarizes HEC-RAS computed water surface elevations and velocities for the relocated channel. Note that all computed velocities are average velocities. Actual velocity would vary considerably both horizontally and vertically within the water column.

The results of the HEC-RAS models show that the proposed sills for the Yellowstone Relocation would be sufficient to resist geomorphic changes to the channel that would inhibit fish passage and affect the functionality of the relocated diversion structure.

Table A.2.13 - Water Surface Elevations and Velocities of Yellowstone Relocation.

Yellowstone Channel Relocation Design				
Flow Description	Inlet W.S. Elevation (ft) Invert 1988.36	Inlet W.S. Elevation (ft) Invert 1974.86	Inlet Velocity (fps)	Outlet Velocity (fps)
10KCFS	1994.04	1981.54	2.7	1.9
40KCFS	1999.69	1987.3	4.2	3.8
80KCFS	2003.25	1992.19	5.6	4.7
100KCFS	2004.61	1993.75	5.4	5.1
160KCFS	2007.26	1997.27	6.0	5.6
Yellowstone Channel Relocation with Sills				
Flow Description	Inlet W.S. Elevation (ft) Invert 1988.36	Inlet W.S. Elevation (ft) Invert 1974.86	Inlet Velocity (fps)	Outlet Velocity (fps)
10KCFS	1993.93	1981.54	2.7	1.9
40KCFS	1999.59	1987.3	4.3	3.8
80KCFS	2003.07	1992.19	5.7	4.7
100KCFS	2004.49	1993.75	5.5	5.1
160KCFS	2007.37	1997.26	5.9	5.6
Yellowstone Channel Relocation with Sills and Widening				
Flow Description	Inlet W.S. Elevation (ft) Invert 1988.36	Inlet W.S. Elevation (ft) Invert 1974.86	Inlet Velocity (fps)	Outlet Velocity (fps)
10KCFS	1993.5	1981.6	2.4	1.9
40KCFS	1998.79	1987.32	4.2	3.8
80KCFS	2002.33	1992.2	5.6	4.7
100KCFS	2003.88	1993.76	5.6	5.1
160KCFS	2006.91	1997.29	6.1	5.7

Existing Conditions				
	Average Channel Velocity		Average Total Velocity	
Flow Description	Upstream *	Downstream **	Upstream *	Downstream **
10KCFS	2.5	2.4	2.5	2.3
40KCFS	4.4	3.9	4.4	3.8
80KCFS	5.4	4.9	4.4	4.1
100KCFS	5.9	5.1	4.2	4.0
160KCFS	7.0	5.2	4.5	3.3

* Upstream reach is a 3.4 mile reach upstream from the right bank chute (RS 38200-56000). Intake Dam is located at RS 28000.

** Downstream reach is a 3.3 mile reach downstream from the right bank chute (RS 2000-19200). Intake Dam is located at RS 28000.

Future Design Efforts Further analysis will be required to finalize the design of the Relocate Main Channel Alternative. Further analysis should include (but is not limited to) the following:

- Evaluation of relocated channel alignment, especially at the upstream end. Due to constructability issues, it may be desirable to construct the upstream control structure in the existing right overbank. The current drawings show the control structure in the existing channel, but passage of water during construction may be an issue. Additionally, the current alignment cuts off some of the high flow bench on the left bank near the headworks.

- Determination of final selected flows. The flow frequency data is being updated and will probably show a reduction in the 100-year discharge from what is given in table A.2.1. The discharges given in table A.2.1 were computed based on the entire period of record. However, an analysis using only the post-Yellowtail Dam period broken into the ice-affected and open water seasons will likely reduce the discharges.
- Evaluation of the channel configuration. Depending on the final selected flows, the size of the channel may be reduced.
- Channel stability and geomorphology should be investigated further. Channel dimensions and elevations affect both fish passage and the ability to divert water, so a reasonable guarantee that both functions can be sustained is necessary.
- Determination of spoil of the excess excavated material. If possible, the excess material could be used to make the levee sections more robust. Because the material is all being excavated from within the floodplain, a net balance should be achievable. However, the floodplain impacts need to be investigated further.
- The need for additional channel stabilization measures in both the relocated channel and the diversion channel should be evaluated.
- The required number of fish screens should be evaluated further.

Channel Relocation Summary Analysis was completed for a 10% design of the Relocate Main Channel Alternative. Highlights of the alternative are summarized below:

- Excavation of a 12,500 ft long channel with the following configuration:
  - 50 ft wide by 2 ft deep low flow channel
  - 600 ft wide by 6 ft deep normal flow channel
  - 1,250 ft wide high flow channel (benches on both sides, side slopes extending to natural ground)
  - Longitudinal slope of 0.00085 ft/ft
  - Side slopes at 4H:1V
- Construction of 8 grade control structures (sills), each with a drop of 1 ft at a spacing of approximately 1,600 ft. The sills are necessary to prevent downcutting and widening, which would be expected to occur since the proposed channel slope is steeper than existing conditions.
- A concrete control structure to prevent degradation which would lead to the inability to divert the full water right to the irrigation canal.
- A new headworks with 17 gates and fish screens at the upstream end of the relocated channel to divert water.
- A diversion channel that would carry water from the new headworks to the existing headworks.
- Tieback levees to prevent unrestricted flow of sediment-laden flood flows into the proposed diversion channel.
- Material from the excavated channel would be used to fill in the old channel, as well as to construct the tieback levees. Because a net balance cannot be obtained, some excavated material would need to be spoiled.

Pumping Plant(s)

The use of pumps rather than gravity to divert water into the irrigation canal has been considered as an alternative that would potentially include removal of the existing Intake Diversion Dam.

Both a large single pumping plant and multiple smaller pumping plants have been considered. Reclamation's Technical Service Center (TSC) completed a preliminary 10% design of the single, large pumping plant. The concept of multiple smaller pumping plants (stations) distributed along the Lower Yellowstone Project later was developed, but was considered but eliminated from further study (see appendix A.1).

The initial Corps role in design of the single large pumping plant was to provide available bathymetry and water surface elevations to the TSC for their design. Once the concept was developed by the TSC, it became apparent that some form of structure would be required in the river to provide the head necessary for the pumps to operate at extreme low flows. This section describes the analysis performed in support of the TSC's design efforts.

Concept Layout

Layout of the proposed pumping facility is shown in plate A.2.9 (taken from TSC drawings). The concept pumping facility uses thirty 48-inch diameter removable cylindrical screens on the upstream end of thirty 48-inch diameter fish screen pipes. The fish screen pipes manifold into fifteen 60-inch diameter suction pipes which bring water to the 15 separate pump bays in the sump. The fifteen 200-hp pump motors would each pump 98 cfs. The fifteen 48-inch diameter discharge lines manifold into three 10-ft diameter discharge lines, which convey water from the pumping plant to the discharge structure. The discharge structure ties into the canal with a reinforced concrete stilling basin to dissipate excess energy. Additional details on the pumping plant design can be seen in the TSC's pumping plant appendix.

Rock Ramp Head Control Structure

The goal of the pumping plant alternative was to completely remove the dam to allow unimpeded fish passage. However, the water surface elevations computed based on the estimated removed dam conditions made it apparent that the pumping plant would not function during low flows without some type of head control structure in the river.

Discharges From the TSC's analysis, the minimum water surface elevation that would provide enough head to maintain acceptable approach velocity at the fish screen (0.4 ft/s) is 1987.0 ft NAVD88. The pumps could still operate (at a lower capacity) down to an elevation of 1985.0 ft NAVD88. However, between elevation 1987 and 1985, the fish screen approach velocity criteria would be violated.

Therefore, a rock ramp head control structure is proposed to provide the necessary head to allow the pumping plant to operate at low flows. The proposed structure would be very similar to the constant slope ramp described in Section 3.1.2. The structure would be lower in elevation than the constant slope rock ramp, but would still be a large structure.

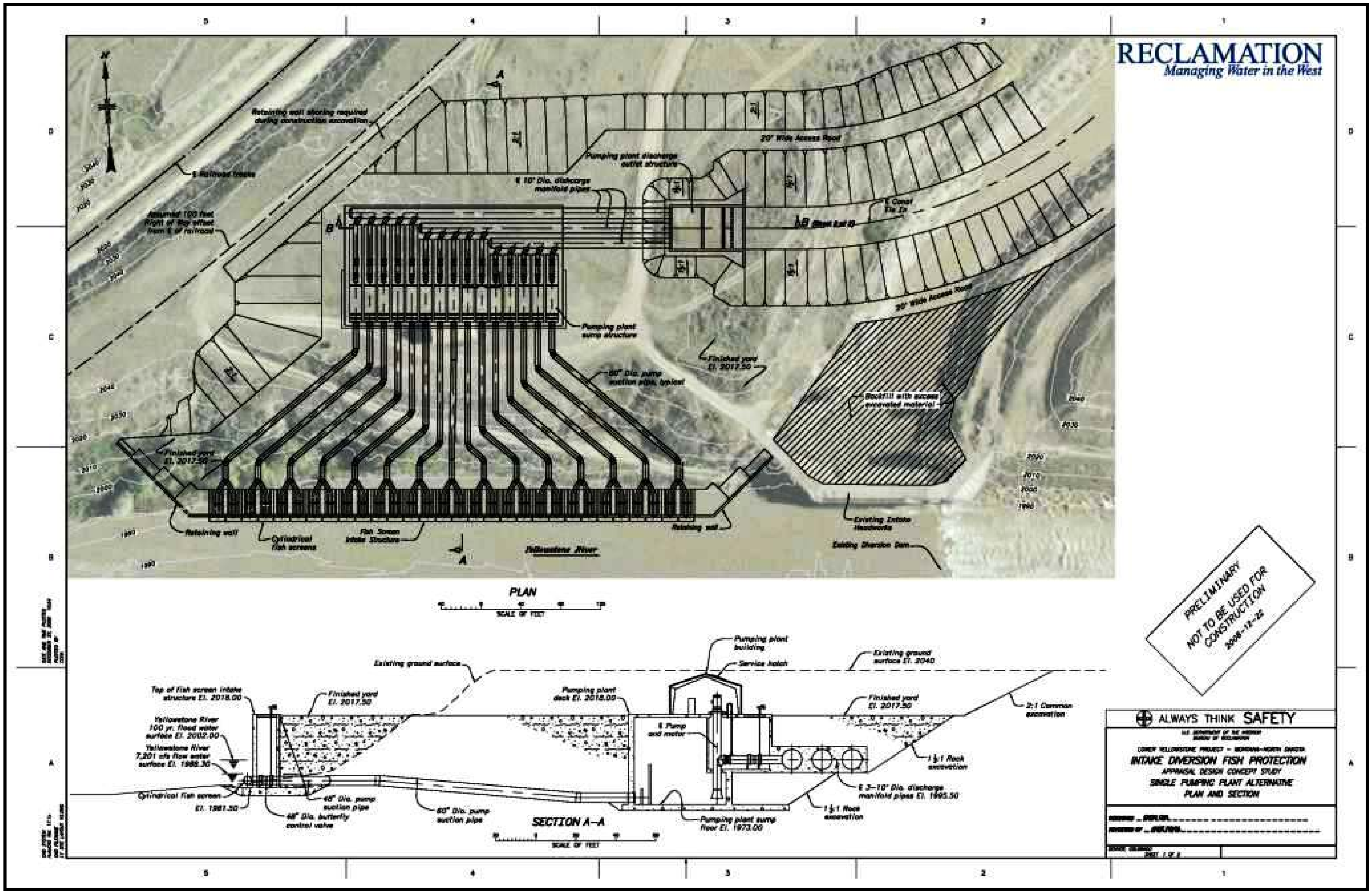

Plate A.2.9 – Single Pumping Plant Alternative Overview.

The head control structure was evaluated based on the concept of pumping plant reliability. The flow-duration curves developed by the Hydrology Section of the Corps Omaha District (see Corps 2006) were used to estimate a range of discharges at Intake Diversion Dam during the month of lowest flow, August. The flow-duration curves were developed based on the gage at Sidney, MT. Due to the uncertainty in hydrology, diverted flow, and return flows between Intake Diversion Dam and the Sidney gage, an estimate upper and lower bound of discharges was used to bracket the flow at Intake. The lower bound assumes only 300 cfs is diverted and consumed (i.e., diverted flow above 300 cfs is returned to the river) while the upper bound assumes the entire water right (≈ 1360 cfs) is diverted and consumed.

The range of flows are given in the table on plate A.2.10.

Hydraulic Modeling The existing conditions HEC-RAS model was modified to reflect estimated post-dam removal conditions. The post-dam removal conditions are described further in the Dam Removal Response Section. Based on the results of the hydraulic modeling, the pumping plant would only be able to operate with approximately 50-60% reliability with the dam completely removed.

Two structure heights were evaluated with the HEC-RAS model to determine the structure elevation necessary to provide 90% reliability of diversion (i.e., diversion capability at the discharge that is equaled or exceeded 90% of the time during August, the month of lowest flow). Structure elevations of 1983 and 1985 ft NAVD88 were evaluated. For comparison, the existing dam crest is estimated to range from elevation 1987-1989 ft NAVD88. The structures were modeled with a weir coefficient of 2.6 and a downstream slope of 200H:1V (0.5%).

For this conceptual analysis, the structure was assumed to be similar to the constant slope rock ramp with a slope of 0.5%. The structure was modeled in HEC-RAS as an inline structure. Downstream from the structure, the sediment fill option was used to approximate the rock structure.

Results of the analysis indicate that with a structure elevation of 1985 ft NAVD88, the pumping plant could operate at full capacity and without violating the fish screen approach velocity criteria for the upper bound discharge of the 90% exceeded flow (4070 cfs). Using the lower bound discharge (3010 cfs), the pumping plant could still operate, but the fish screen approach velocity criteria would be exceeded and lower pumping capacity would be realized.

Using a structure elevation of 1983 ft NAVD88, the pumping plant intakes would violate the fish screen approach velocity criteria nearly 50% of the time during August.

The reliability of the pumping plant is summarized in the table on plate A.2.10. Plate A.2.10 tabulates the Sidney gage flow-duration curves, range of flows evaluated at Intake, reliability of the dam for existing conditions, and reliability of the pumping plant for three conditions (complete dam removal, structure at elevation 1985 ft NAVD88, and structure elevation at 1983 ft NAVD88).

Flow Duration Curve at Sidney, MT for **August** (month of lowest flow)		Potential range of flows at Intake Dam*		Existing Conditions		Complete Dam Removal		Dam Removal with Rock Ramp Control Structure at Elevation **1985****		Dam Removal with Rock Ramp Control Structure at Elevation **1983****	
				Top of dam varies, approximate elevation range = 1987 to 1989 ft NAVD88		Lower Bound Discharges	Upper Bound Discharges	Lower Bound Discharges	Upper Bound Discharges	Lower Bound Discharges	Upper Bound Discharges
Percent Time Flow Equaled or Exceeded	Discharge (cfs)	Lower Bound (cfs)	Upper Bound (cfs)	Water Surface Elevation for lower bound discharges (ft NAVD88)	Diversion Reliability Notes	Water Surface Elevation (ft NAVD88)	Water Surface Elevation (ft NAVD88)	Water Surface Elevation (ft NAVD88)	Water Surface Elevation (ft NAVD88)	Water Surface Elevation (ft NAVD88)	Water Surface Elevation (ft NAVD88)
50	7080	7380	8440	1991.0	Diversion reliability for existing conditions is reportedly 100% during all flows exceeding the allocated water right because of the ability to impound water behind the dam.	1985.3	1985.7	1988.4	1988.7	1986.7	1987.0
60	6010	6310	7370	1990.7		1984.8	1985.3	1988.0	1988.3	1986.3	1986.7
70	4810	5110	6170	1990.4		1984.2	1984.7	1987.5	1987.9	1985.8	1986.2
80	3980	4280	5340	1990.2		1983.8	1984.3	1987.2	1987.6	1985.4	1985.9
85	3490	3790	4850	1990.1		1983.3	1984.1	1986.9	1987.4	1985.1	1985.6
90	**2710**	**3010**	**4070**	**1989.8**		**1982.8**	**1983.6**	**1986.5**	**1987.1**	**1984.7**	**1985.3**
95	1770	2070	3130	1989.5		1981.6	1982.9	1985.9	1986.6	1984.0	1984.7
98	1470	1770	2830	1989.4		1981.0	1982.6	1985.6	1986.4	1983.7	1984.4
99	1390	1690	2750	1989.4		1980.8	1982.5	1985.5	1986.4	1983.6	1984.3

*Due to the uncertainty in hydrology, diverted flow, and return flows between Intake Dam and the Sidney, MT gage, an estimated upper and lower bound of discharges is used to bracket the flow at Intake. The lower bound assumes only 300cfs is diverted and consumed (i.e. diverted flow above 300cfs is returned to the river) while the upper bound assumes the entire water right (≈1360cfs) is diverted and consumed.
** For reference purposes, the existing dam crest elevation is estimated to range between 1987 and 1989 ft NAVD88. Actual dam crest elevation is not known due to hazardous conditions preventing survey data collection.

(green)	Green highlighted cell indicates the ability to divert full allocated water right and meet fish screen approach velocity criteria.
(orange)	Orange highlighted cell indicates the ability to divert water. However, fish screen approach velocity criteria is not met and diversion of fully allocated water right is not realized.
(red)	Red highlighted cell indicates no ability to divert water via pumping plant.

Plate A.2.10 – Pumping Plant Diversion Reliability.

From plate A.2.10, it is apparent that the reliability of the pumping plant would be limited during the month of August, especially with no head control structure in the river.

Channel inverts for existing conditions, complete dam removal, and the structure at elevation 1985 ft NAVD are compared in figure A.2.50.

Rock stability analysis and sizing were assumed to be the same as that described in the constant slope rock ramp section.

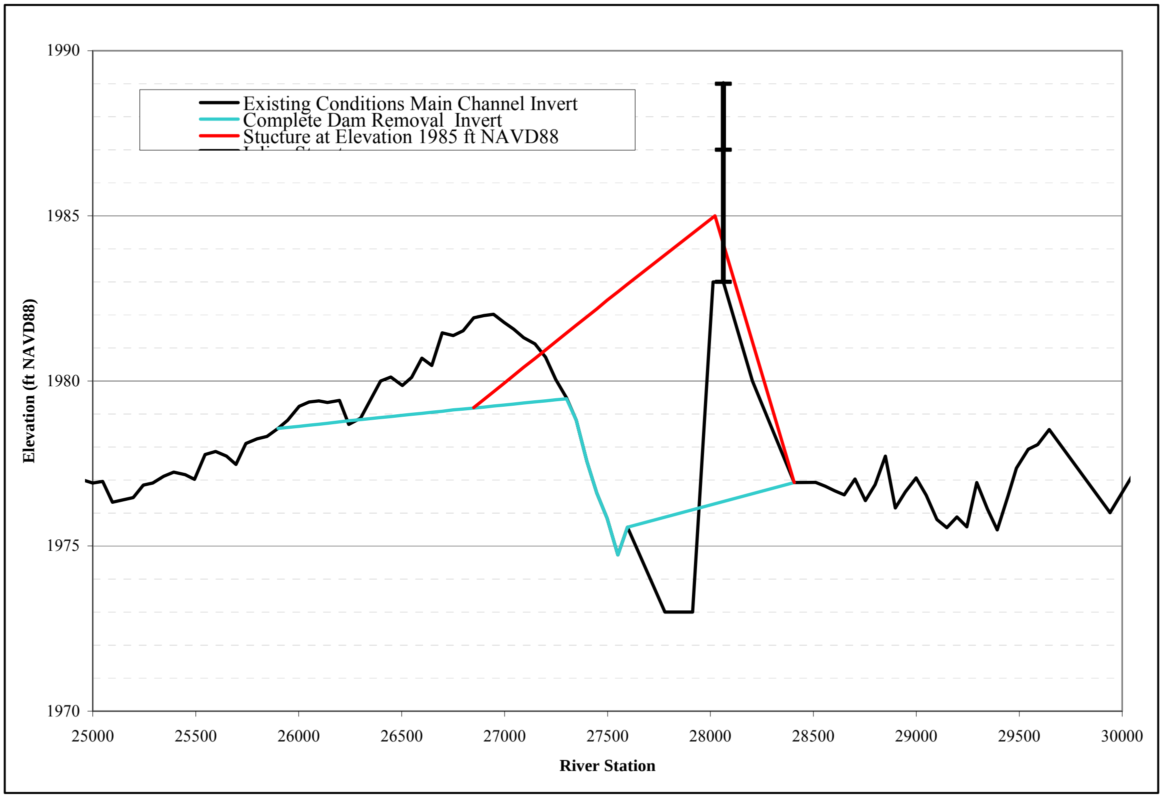

Figure A.2.50 - Channel Invert Profile Comparison.

Relocate Diversion Upstream

Analysis was performed to evaluate the feasibility of moving the intake upstream from the present location. The existing diversion dam would be removed to a suitable level. Highlights of the proposed project are as follows:

- Remove existing dam to a suitable level and decommission existing intake.
- Install channel stability and stabilization structures within the Yellowstone River.
- Dam removal impacts and potential effect on the Relocate Diversion Upstream option have not been evaluated.
- The alignment includes two crossings beneath the railroad and a tributary crossing. The tributary crossing and the upstream railroad crossing would be combined into a single crossing to save funds. The pipe length for the single crossing is longer but an entrance and exit is eliminated.

- Canal alignment was selected to minimize impact to the railroad right-of-way. A second alignment that was placed on the river side of the existing railroad was evaluated but abandoned.
- Canal configuration: bottom width of 50 ft with 2H on 1V side slopes. The VE study assumed 1.5H on 1V. However, due to the cut depth and slope length the side slope was flattened for stability. Also, a midslope bench was added to reduce slope length for erosion and a maintenance access road on one side.
- Canal has a longitudinal slope of 0.00013 ft/ft. Maximum flow depth is about 10 ft. With 2 ft of freeboard, this gives a minimum canal depth of about 12 ft.
- Canal has a length of over 13,000 ft.
- Construct a straight drop structure downstream of the inlet to reduce the canal tailwater depth and accommodate the required diversion of 1,400 cfs at minimum Yellowstone flow rates. Canal invert elevation at the gate was selected as 1986.7 to be low enough to allow 1,400 cfs flow diversion combined with a canal flow depth of 10 ft.
- Construct an 8' high drop structure at the new canal entrance to the old canal. A baffled chute may be preferable for this location and should be evaluated in future design.
- Construct Yellowstone River floodplain protection berms to protect against canal flooding. Significant floodplain fill would impact Yellowstone River flood elevations that may require mitigation.
- Remove and replace farm access roads at several locations to accommodate the new structures and canal.
- Initial evaluation of the Relocate Diversion Upstream alternative estimated the invert of the Yellowstone River at about 1992 ft NAVD88. Collection of bathymetric data in the vicinity revised this estimate downward to approximately 1988-1989 ft NAVD88.
- Initial design of the Relocate Diversion Upstream Alternative assumed low flow in the Yellowstone River of about 5000 cfs. However, to be consistent with other alternatives, a low flow of approximately 3000 cfs has been selected.
- The combination of the lower channel invert and lower design flow has resulted in the need for a rock ramp head control structure in order to provide the head necessary to divert the full water right.

Plan views of project features and the new canal alignment are illustrated in plate A.2.11.

Profile Tabulation

Elev.	Station	
1992.0	133+80	New Intake at Yellowstone River with 17 5'x5' sluice gates.
1992.0	133+70	D/S end of new Intake, upstream crest of straight drop structure.
1986.73	133+70	U/S toe of straight drop structure.
1986.72	133+55	D/S end of straight drop structure, transition to trapezoidal earth channel.
1986.72	132+05	End of transition to trapezoidal channel, 50' bottom width, 2H on 1V sideslopes. Canal slope of 0.00013 ft/ft. Compound channel with side maintenance berm and midslope erosion berm.
1985.0	0+50	U/S end of drop structure, 35 ft bottom width rectangular, vertical drop of eight ft. Roughly follows SAF basin outlet design.
1977.0	0+22	D/S end of drop structure with end sill. Transition to existing canal.
1977.0	0+00	Centerline of existing canal.

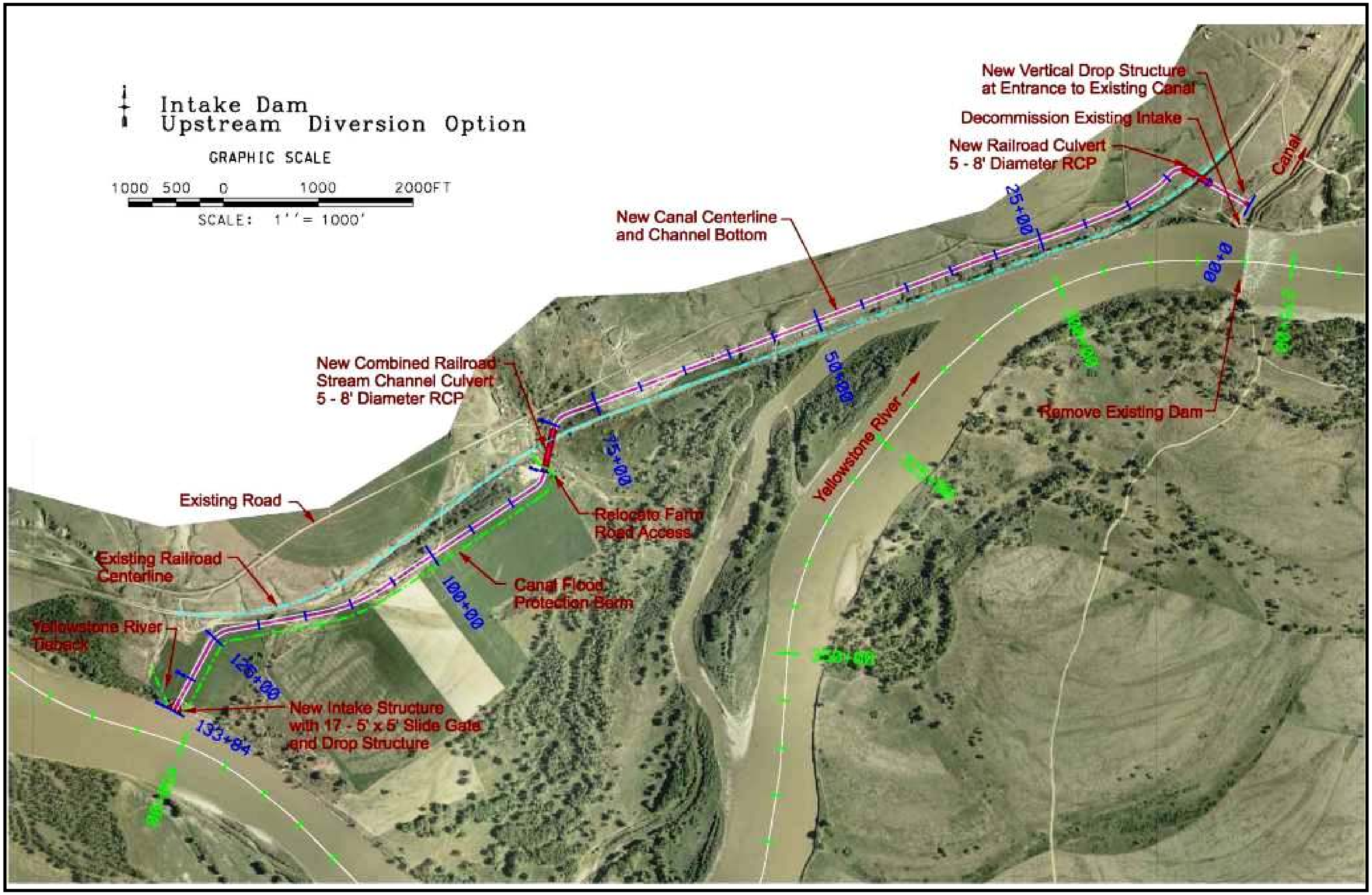

Plate A.2.11 – Relocate Diversion Upstream Alternative Overview.

HEC-RAS Model An HEC-RAS model was constructed to determine the geometry of the upstream diversion channel and structures. The existing condition model was modified to include a reach for the new canal. Features within HEC-RAS were used to size the new intake number of gates and the culvert structure geometry for the new railroad crossings.

Original design of project features was based on attaining the canal diversion flow of 1,400 cfs at the minimum Yellowstone River flow of 5,000 cfs. As discussed in the *Existing Conditions HEC-RAS Model* section, the available survey data at the time of the analysis did not include Yellowstone River bed topography. Therefore, the accuracy of the computed Yellowstone River stage-flow relationship at the proposed diversion site was limited.

Additional analysis was completed in January 2009 to evaluate the ability to divert 1,400 cfs at a minimum Yellowstone River flow of 3,000 cfs. The hydrographic survey data were incorporated in the model. Using the updated model and the minimum flow of 3,000 cfs, it was determined that a rock ramp head control structure would be necessary to divert the irrigation flows.

Model Roughness The HEC-RAS model uses a Manning roughness value of 0.030 for the channel region of the new canal. The roughness parameters established for the model were similar to the previous modeling effort. Since the canal flow level is relatively constant, vegetation growth should be minimal and a roughness value lower than the Yellowstone River is expected.

Structure Modeling All proposed structures were modeled with HEC-RAS for the conceptual analysis. The intake gate structure was modeled to consist of similar dimension gates (5’x5’) as the existing condition intake. Notable parameters used in the model for all structures are included in table A.2.14.

Table A.2.14 - Relocate Diversion Upstream Option HEC-RAS Data.

New Intake Structure	Modeled as sluice gates, discharge coefficient of 0.6 Orifice coefficient of 0.8, Head exponent of 0.5.
Culverts	Circular concrete pipe, square edge with headwall, entrance loss coefficient 0.5, exit loss coefficient 1.0, pipe roughness of 0.012.

Intake Diversion Dam The new model assumed that the existing dam would be removed entirely. Complete removal may not be preferable due to concerns with erosion, bank stabilization, and impact to the Yellowstone River. However, complete removal results in a lower upstream water surface elevation for evaluating diversion capability.

NOTE: Dam removal would almost certainly result in some bed and bank erosion upstream of the existing structure. Such erosion was NOT included in this analysis. Detailed analysis would be required to evaluate erosion potential due to dam removal and also optimize dam removal.

Rock Ramp Head Control Structure The HEC-RAS model was used to evaluate the rock ramp head control structure. An inline structure was modeled within HEC-RAS. Additional details on the rock ramp head control structure can be found on page A.2.72.

HEC-RAS Model Results The new model was used to evaluate diversion capability, canal capacity, and structure design. All Relocate Diversion Upstream components were sized to provide the required diversion capacity of 1,400 cfs when the Yellowstone River total flow is a low as 5,000 cfs. Different combinations of canal bottom width, drop structure height, and intake structure gates are also possible. For the design flow rate of 1,400 cfs, the computed normal canal flow depth is estimated as less than 10 ft. Proposed structures affect the flow depth with a minimum depth of less than 8 ft in the reach upstream of the canal exit drop structure. The Yellowstone River rating curve from the 2006 evaluation is compared with the existing conditions, with-project conditions, and canal flow depth in A.2.51.

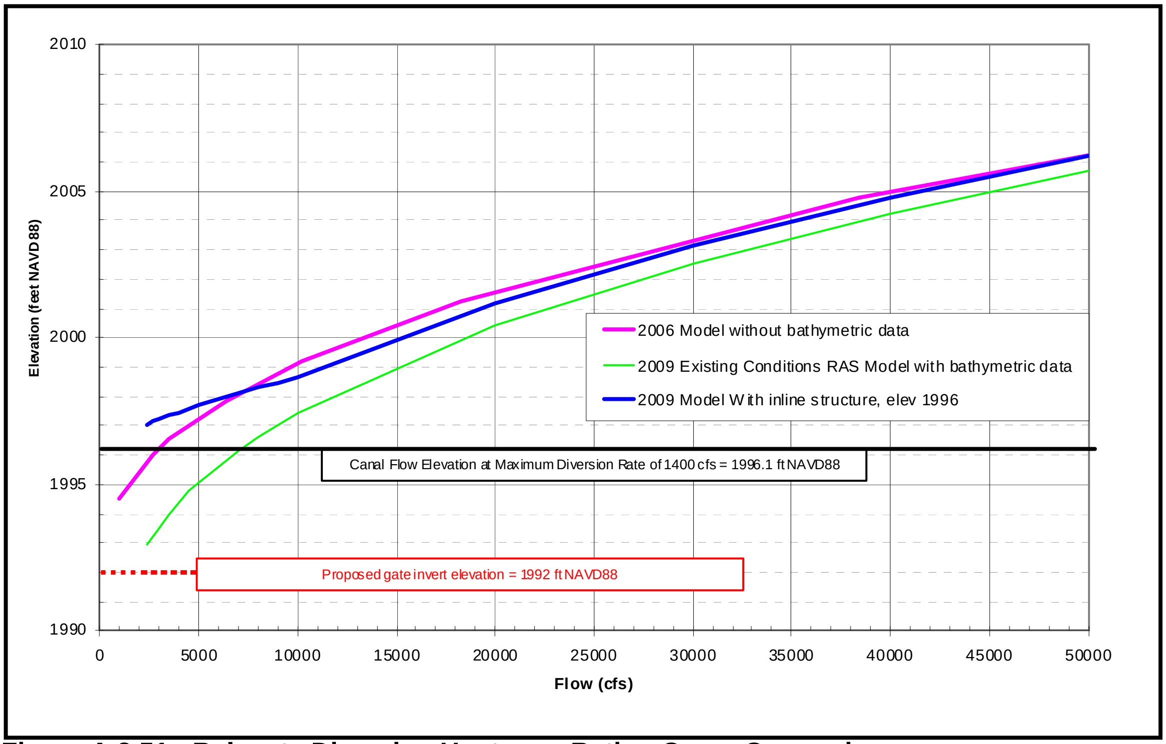

Figure A.2.51 - Relocate Diversion Upstream Rating Curve Comparison.

New Canal Alignment and Geometry The canal alignment was selected based on site constraints. The existing railroad grade is very near the Yellowstone River for the first several thousand ft upstream of the existing dam. An alignment was considered that was on the river side of the existing track. However, this alignment required about 250 – 300 ft of encroachment into the river for about 5,000 ft. This encroachment would require a berm armored with large riprap to protect the canal from flooding and ice damage. The selected alignment requires two railroad crossings but eliminates the substantial river fill.

The new canal would have a 50 ft bottom width and 2H on 1V sideslopes at a slope of 0.00013 ft/ft. The canal includes a 16 ft wide maintenance access road located 12 ft vertically above the canal invert. On the opposite bank, the cut depth is over 60 ft with a large sideslope length for about 6,000 ft of canal length. The canal would include a midslope channel and berm to intercept sideslope flow and prevent slope erosion. Canal invert elevation was designed to allow diversion from the Yellowstone River at 3,000 cfs. Excavation quantities estimated along the proposed alignment are as follows:

New Canal Excavation – 3,720,000 cubic yards of cut.
New Canal Length – 13,400 ft including all structures.

The new canal profile is illustrated in plate A.2.12. Typical sections are illustrated in plates A.2.13 and A.2.14.

Rock Ramp Head Control Structure Evaluation of the rock ramp head control structure was completed in January 2009 while the preceding evaluation was completed in July 2006. As discussed previously, during the 2006 evaluation, hydrographic survey data were not available. Trapezoidal cross-sections were estimated and used to size the diversion canal and headworks. Figure A.2.52 compares channel cross-sections estimated for the 2006 evaluation with the surveyed cross-sections used in the current model upstream and downstream from the proposed diversion location.

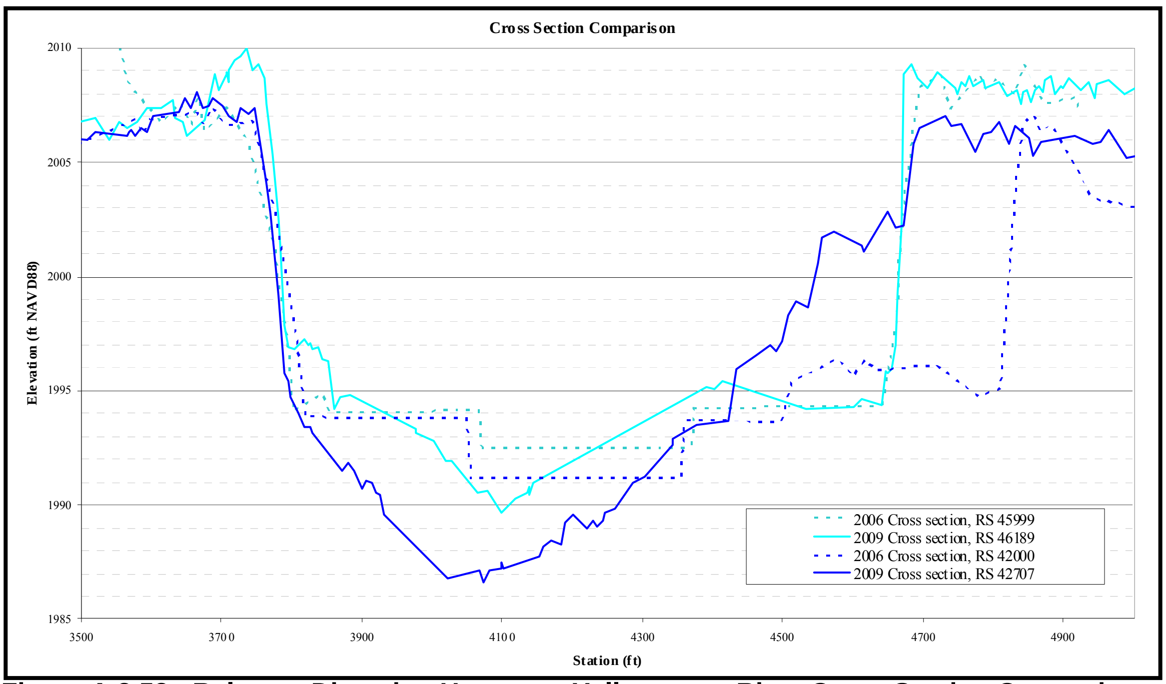

Figure A.2.52 - Relocate Diversion Upstream-Yellowstone River Cross Section Comparison.

The 2006 evaluation determined a water surface elevation of 1996.1 ft NAVD88 in the diversion canal at the upstream end. Sizing of the rock ramp head control structure assumed approximately one foot of headloss through the headworks. It was assumed that a design water surface elevation of 1997.1 ft NAVD88 was needed in the Yellowstone River at a discharge of 3,000 cfs.

It should be noted that evaluation of the rock ramp head control structure only used the Yellowstone River reach (i.e., the diversion canal was not included). This was done because the 2006 evaluation already included the diversion canal and all associated structures. To expedite the analysis, the structure was modeled and adjusted until the water surface for a discharge of 3,000 cfs equaled or exceeded 1997.1 ft NAVD88 at the proposed point of diversion.

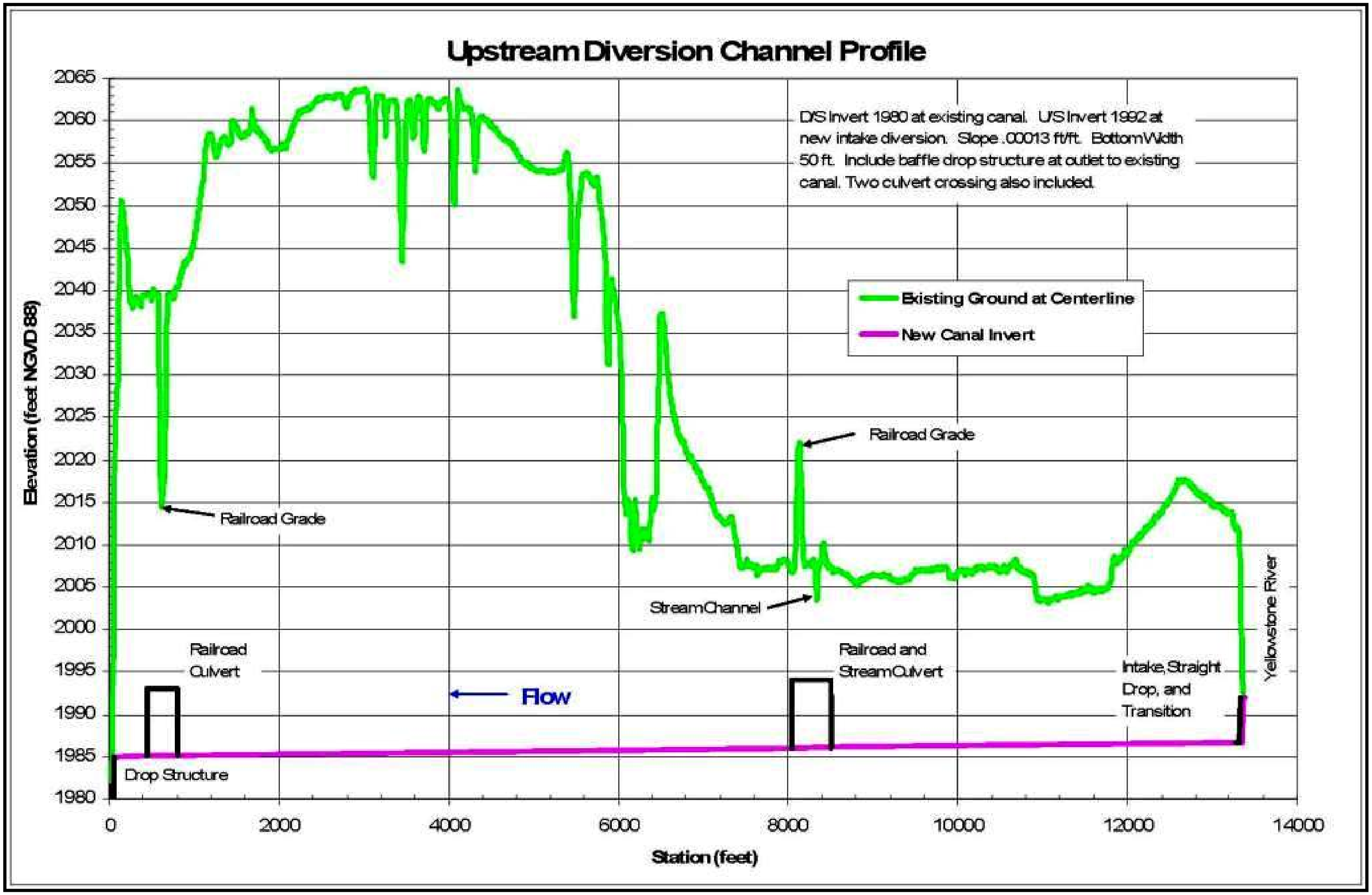

Plate A.2.12 – Relocate Diversion Upstream Canal Profile.

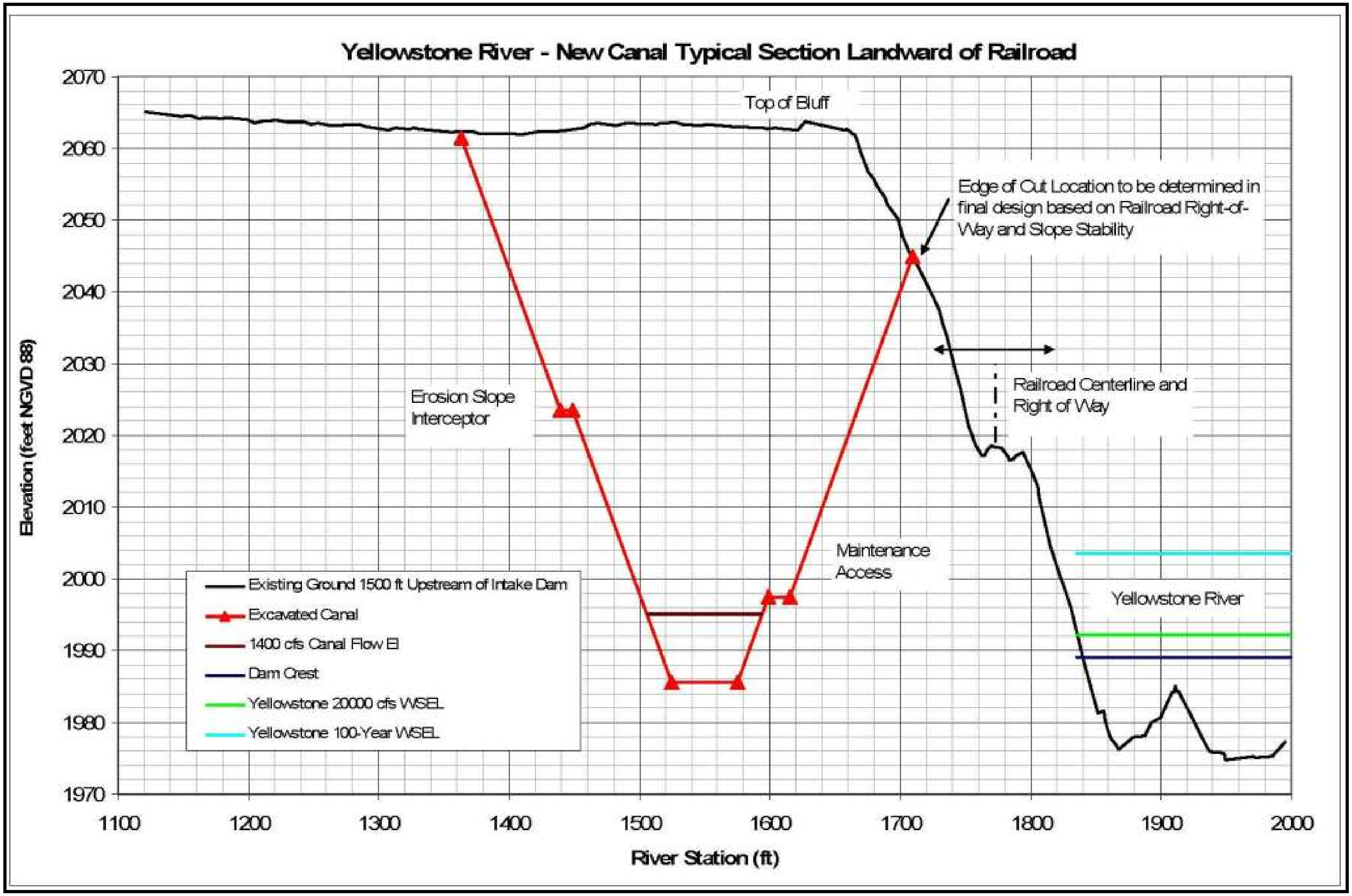

Plate A.2.13 – Relocate Diversion Upstream Canal – Typical Section.

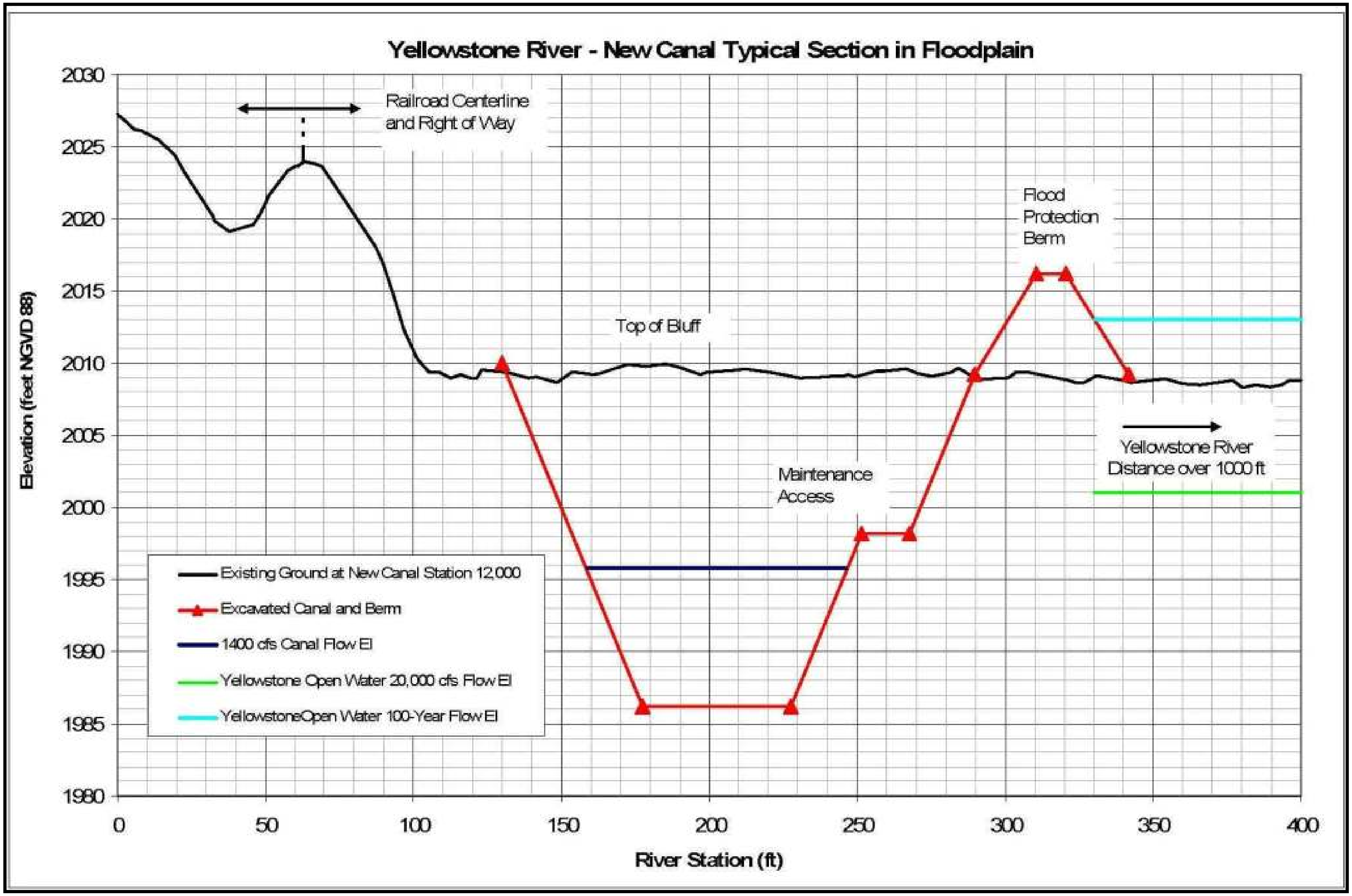

Plate A.2.14 – Relocate Diversion Upstream – Typical Section 2.

An inline structure was modeled within HEC-RAS to evaluate the structure's elevation required to provide the necessary head for diversion of 1,400 cfs at a Yellowstone flow of 3,000 cfs. The evaluation indicated a structure crest elevation of 1996 ft NAVD88 was needed. The structure was modeled with a weir coefficient of 2.6 and a downstream slope of 200H:1V.

Existing and proposed conditions channel invert profiles are compared in figure A.2.53. Figure A.2.54 shows a cross-section at the site of the proposed rock ramp crest.

Rock stability analysis and sizing were assumed to be the same as that described in the constant slope rock ramp section.

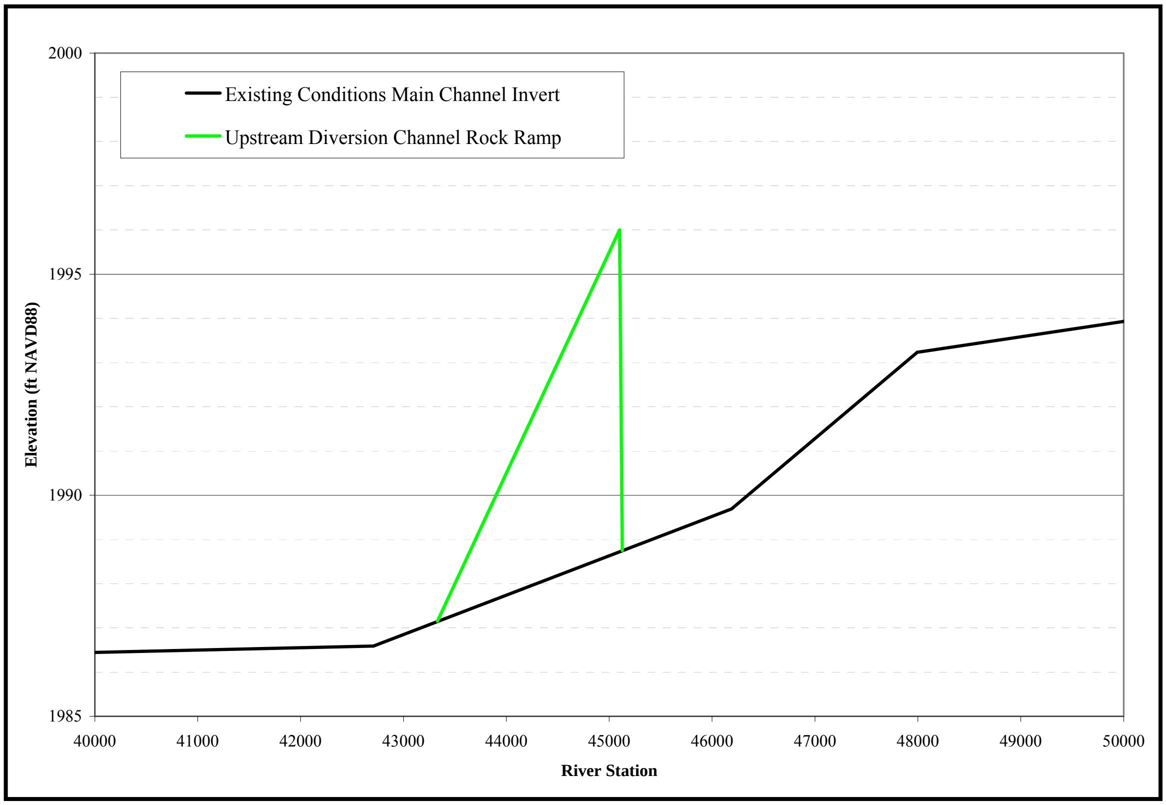

Figure A.2.53 - Relocate Diversion Upstream Invert Profile Comparison.

New Headworks and Fish Screen A new intake is required on the Yellowstone River. The new structure is rectangular with 17 gates. Assuming 4 ft between each gate, the total length perpendicular to the river is about 159 ft including 5 ft each side of the outside gate structure. Top of structure is elevation 2016 that is about 4 - 6 ft above existing ground elevation and 3 ft above the estimate 100-year Yellowstone River flow elevation. The new intake structure would include a straight drop structure on the downstream side of about 3.3 ft vertical drop. Gate invert elevation is assumed as elevation 1992 based on approximate channel bottom elevation. No channel survey data were available; elevations are approximate based on available information. A schematic of the structure is included in plate A.2.15.

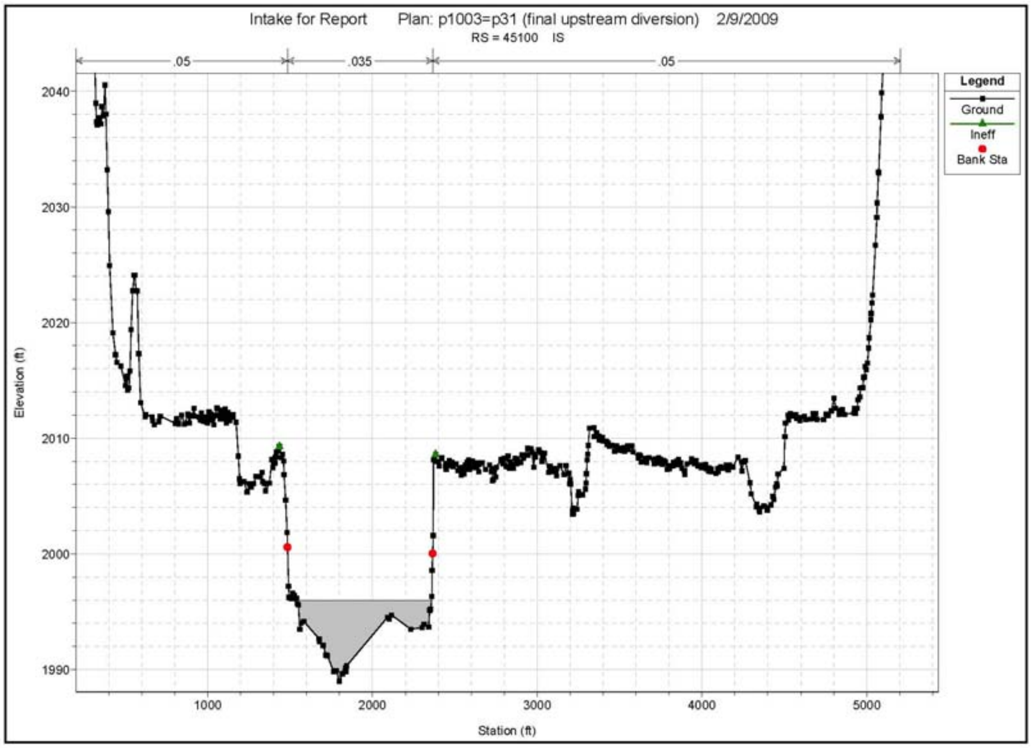

Figure A.2.54 - Relocate Diversion Upstream Rock Ramp Control Structure Cross Section.

The fish screening technique proposed for this alternative is the v-shaped screen. However, the headworks design could be modified to use the removable cylindrical screens instead. Further discussion of the screening method is presented on pages A.2-97 through A.2-100.

Note: Locating the new intake elevation near the river bottom provides additional head at low flow and reduces the number of gates. However, sediment load at higher Yellowstone River flow levels would be an issue. Future design will consider the incorporation of several bi-fold or top lowering gates to alleviate sediment during periods of higher Yellowstone River flow diversion.

Railroad and Tributary Crossings Two crossings of the railroad are required with the new canal alignment. For the conceptual design, the maximize culvert size beneath the railroad was assumed to be an 8 ft diameter. This assumption is based on boring/jacking limits as stated in the structural appendix.

Elev. Station (Centerline)
1986.06 82+70 Bore/jack culvert beneath railroad. Continue culverts beneath stream and farm road. Five culverts each 8' diameter RCP, length of about 460 ft, with concrete headwall. Culvert installed from station 80+40 to 85+00. Total culvert length of 460 ft, match canal slope of .00013 ft/ft. Rock riprap is included 10 ft upstream and downstream of the structure. A schematic of the structure is included in plate A.2.16 and the profile is illustrated in plate A.2.17.

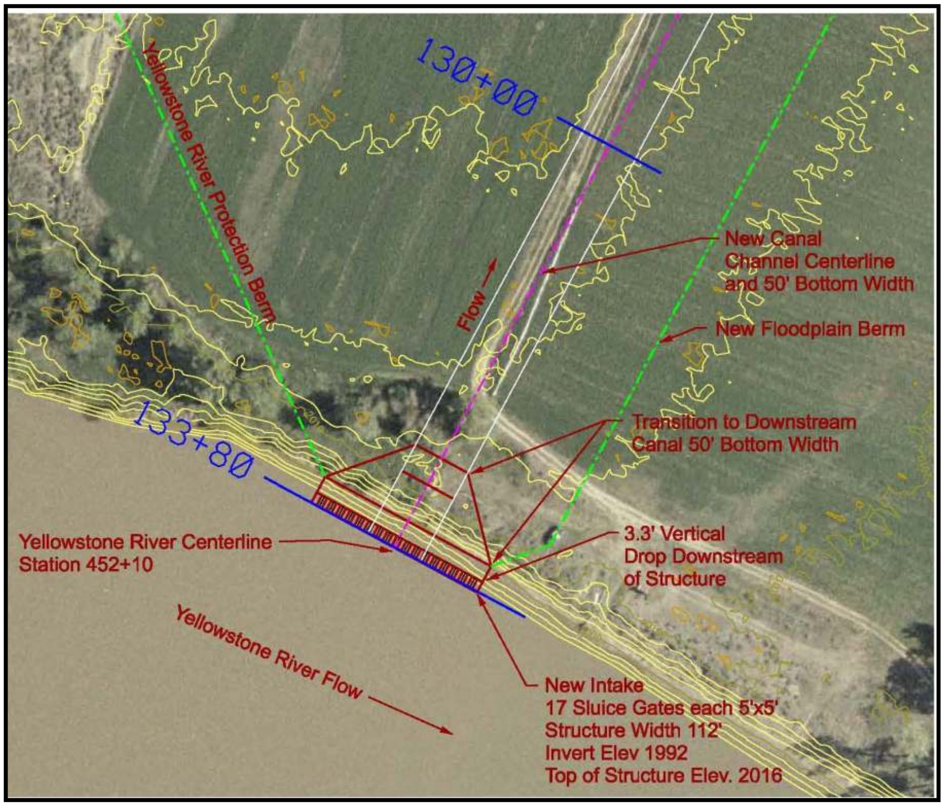

Plate A.2.15 – Relocate Diversion Upstream Alternative Headworks Structure.

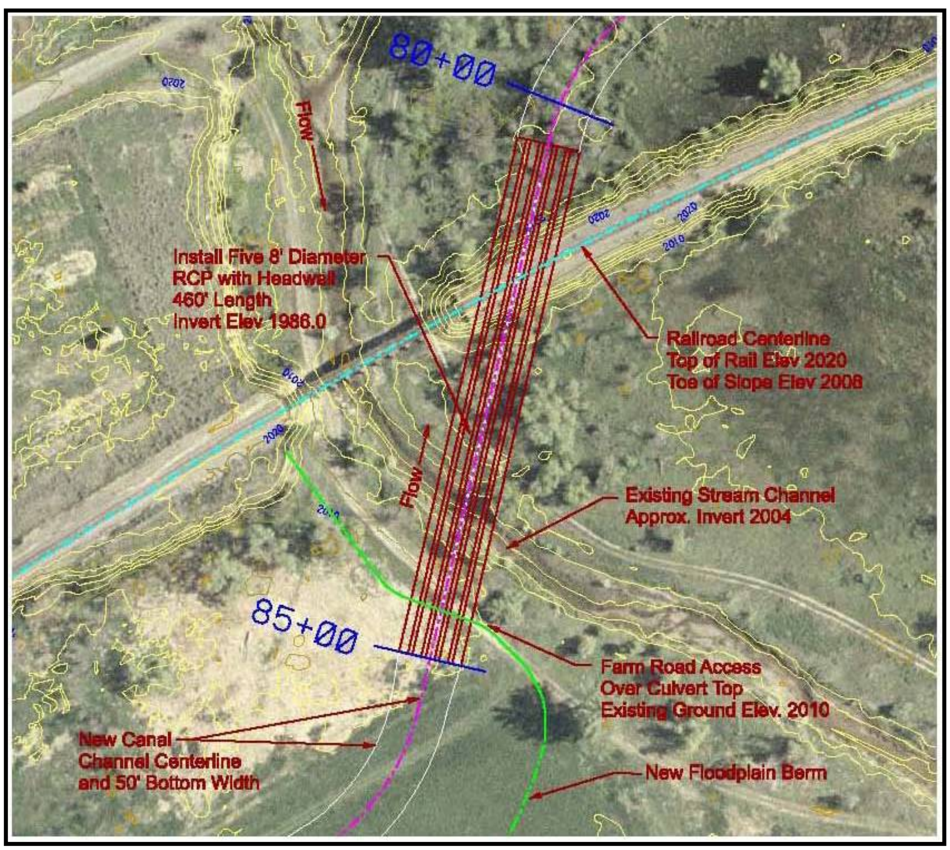

Plate A.2.16 – Relocate Diversion Upstream Alternative – Station 82+70 Structure Schematic.

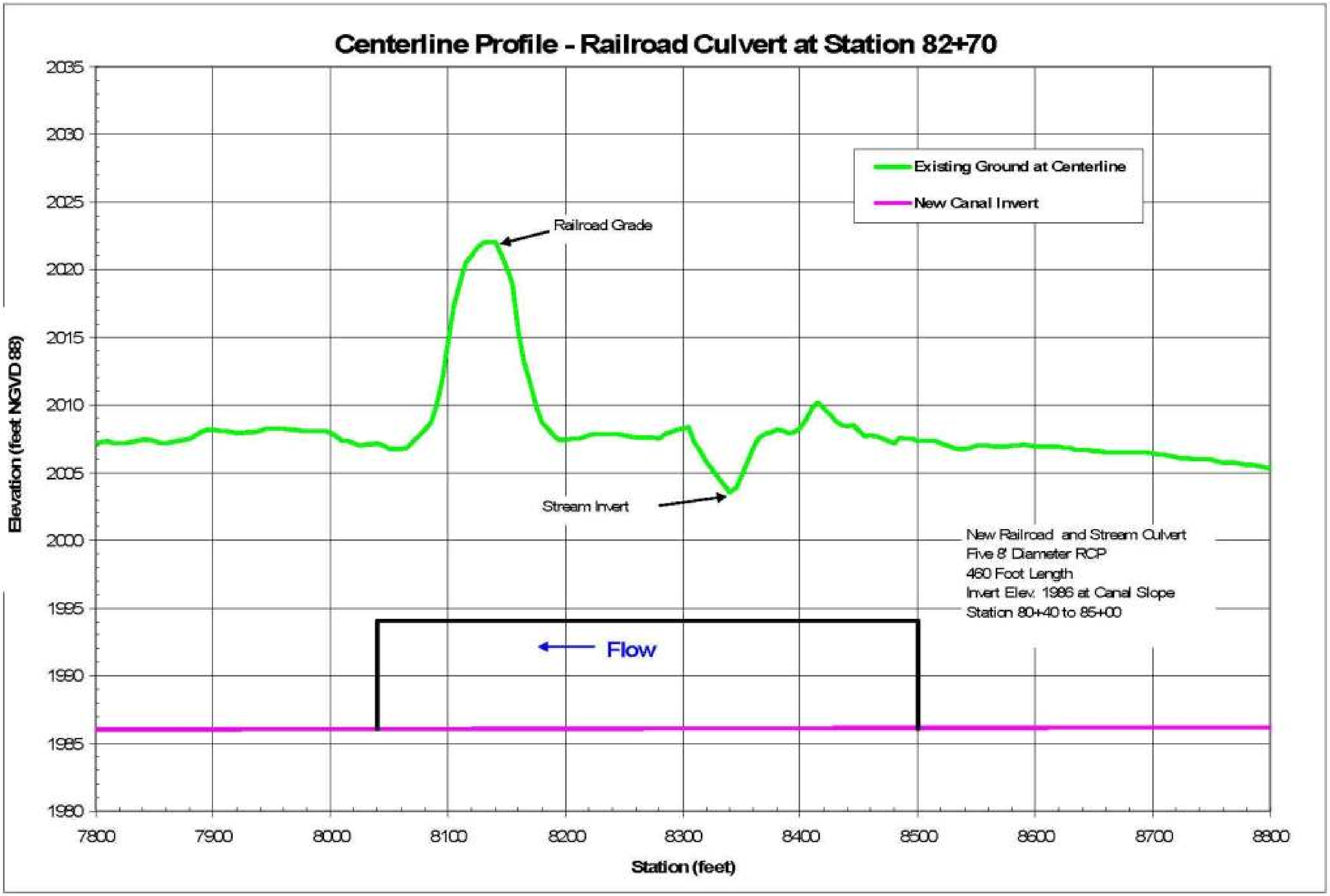

Plate A.2.17 – Relocate Diversion Upstream – Station 82+70 Profile.

Elev. Station (Centerline)
1985.08 6+30 Bore/jack culvert beneath railroad. Five culverts each 8' diameter RCP, center line length of about 360 ft with concrete headwall. Culvert installed from station 4+50 to 8+10. Top of rail about 2016, existing ground slopes upward to about 2038 at edge of culvert. Rock riprap is included 10 ft upstream and downstream of the structure. A schematic of the structure is included in plate A.2.18 and the profile is illustrated in plate A.2.19.

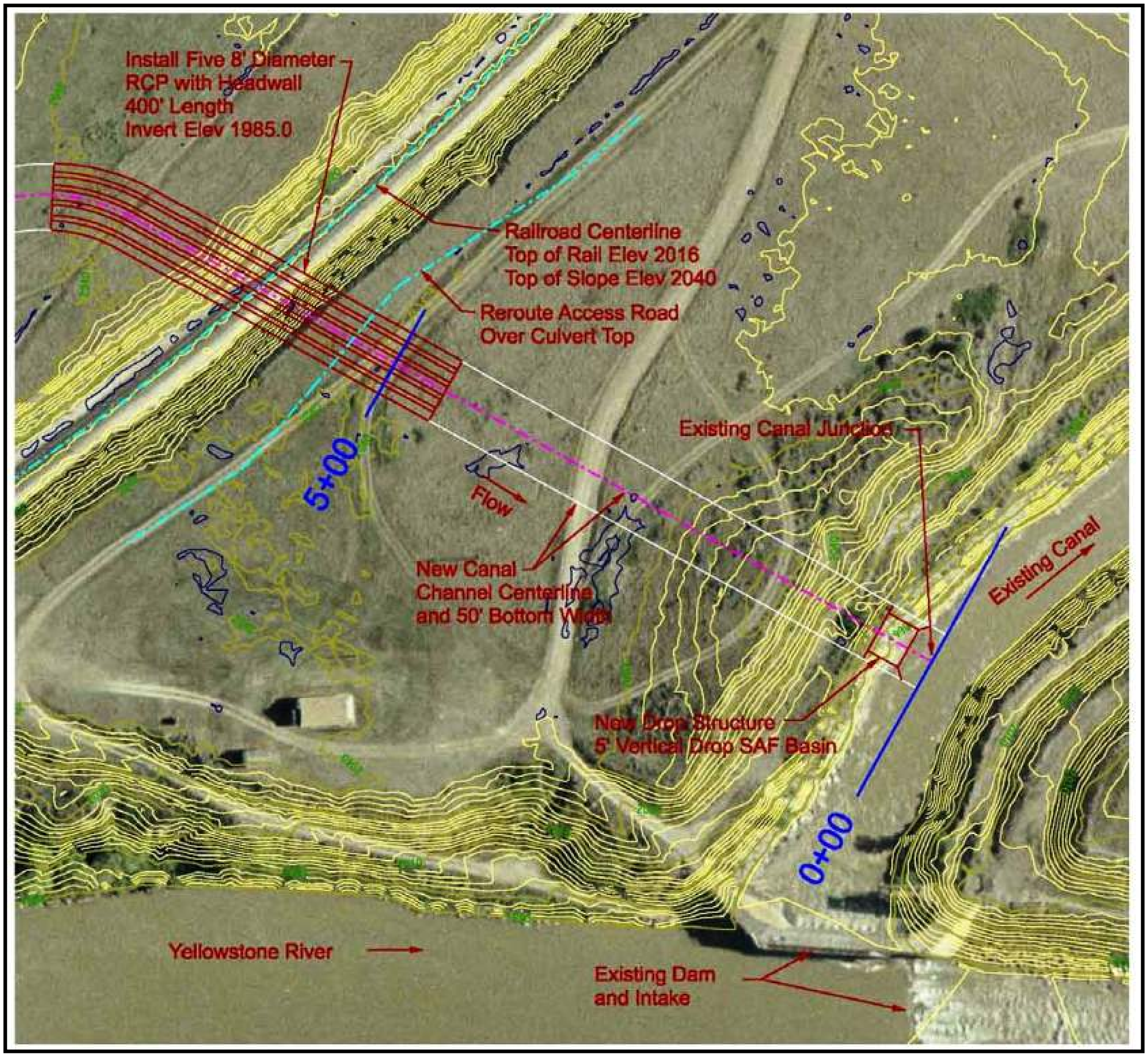

Plate A.2.18 – Relocate Diversion Upstream Alternative – Station 6+30 Structure Schematic.

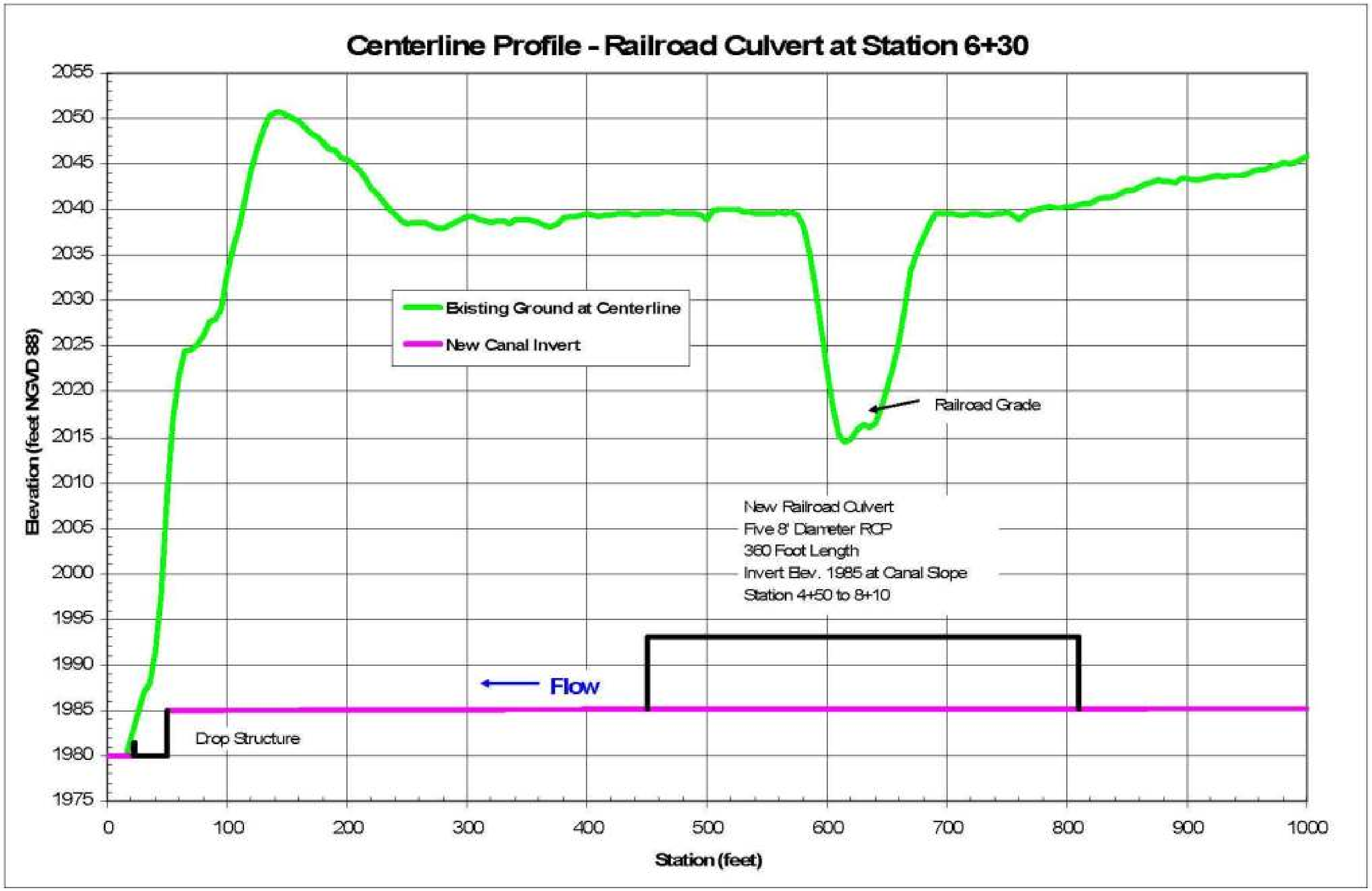

Plate A.2.19 – Relocate Diversion Upstream Alternative – Station 6+30 Profile.

Drop Structures Station 133+50. The drop structure downstream of the new intake structure is a SAF straight drop structure following criteria illustrated in HDC Sheet 623 - 624-1 (WES 1988). The structure width matches the intake width with vertical sidewalls. Downstream of the structure, a transition is required from the drop to the new canal. The structure would include grading to avoid using wingwalls through the transition. Rock riprap is included 10 ft downstream of the end sill. The drop structure is required to transition from the gate invert to the downstream canal invert.

Station 0+50. The drop structure from the new canal to the existing canal is a SAF straight drop structure following criteria illustrated in HDC 624. A baffled chute structure may be preferable for this location, may be less cost, and should be evaluated in future design. The structure is rectangular with a 35' bottom width. Structure width is reduced from canal bottom width to lower upstream flow velocities and canal erosion potential. Structure width will be revised in future design. Rock riprap is included upstream of the structure for 25 ft and downstream of the structure for 20 ft. The drop height is 8 ft.

The structure length of both basins was estimated based on roughly following the criteria developed for SAF basins in HDC Sheet 623 - 624-1 (WES 1988). Estimated tailwater elevation at both locations is not within the optimum range and energy dissipation is expected to be less than desirable. Basin design will be refined in future analysis.

Floodplain Protection Berms Two berms are required to prevent Yellowstone River flooding from damaging the canal. One berm is parallel to the canal and the second berm ties off to high ground upstream of the intake. The location of both berms is illustrated in plate A.2.11 and a cross-section of the floodplain berm is shown in plate A.2.14.

Conceptual design berm height was estimated based on the 100-year open water elevation of 2013 in the vicinity of the new diversion. Ice affected stages were not evaluated. If an additional 3 ft is included for freeboard, the top of berm elevation is roughly 5 – 7 ft above existing grade. The berm is parallel to the canal and is installed from the new intake structure at the Yellowstone River downstream to the railroad culvert crossing at station 82+70. Downstream of this location, the canal is protected by the railroad embankment. The berm would be earth only, not designed to resist ice forces as it is remote from the river. Construction of the berm would place significant fill within the floodplain and would probably impact Yellowstone River flood elevations and floodway. Mitigation for the berm would probably be required.

The typical cross-section for the berm is 5 ft above the existing grade with 3H on 1V sideslopes and a ten ft top width. A second berm is required upstream of the intake structure to protect the canal from direct flooding and ice jam attack. In order to accommodate rock riprap protection for this berm, a top width of 15 ft is required. The berm proceeds from the structure northwest toward an existing high knoll over a distance of about 470 ft. Quantities are estimated as follows:

Canal Floodplain Protection Berm Length – 5,220 ft.
Canal Floodplain Protection Berm Fill – 24,200 cubic yards (average 125 sq ft per ft berm)
Yellowstone Upstream Berm Length – 470 ft

Yellowstone Upstream Berm Fill – 1600 cubic yards (average 92 sq ft per ft berm)

Rock Riprap Rock riprap is included at several locations where localized turbulence may occur. Rock riprap is also required to protect the canal from ice jam flooding on the Yellowstone River along the Yellowstone River upstream berm.

In the vicinity of structures for erosion protection due to turbulence, all rock riprap is a 12” layer thickness. Rock riprap is also included on the Yellowstone River flood protection berm located upstream of the intake structure. This berm serves to protect the canal from open water and ice jam flooding. The downstream side of the canal is assumed to be protected from ice jam action as it is located away from the Yellowstone River and in the flow shadow of the upstream flood protection berm and intake structure. Rock for this location is a 4 ft layer thickness to resist the ice forces.

Rock riprap is proposed in the following locations:

- Downstream of Intake drop structure for a distance of 10 ft, Station 133+15 to 133+05
- Upstream and Downstream of Culvert Crossings for a distance of 10 ft (station 85+10 to 85+00, station 80+40 to 80+30, station 7+50 to station 7+40, and station 5+20 to 5+10).
- Upstream of drop structure for a distance of 25 ft, station 50 to station 75.
- Downstream of drop structure for a distance of 20 ft, station 22 to station 02, wrap around the existing canal banks for a distance of 10 ft each direction.

Rock riprap placement is summarized in table A.2.15.

Table A.2.15 Rock Riprap for Relocate Diversion Upstream-Summary.

Location	Station	Layer Thickness
Downstream of Intake Drop for 10 ft	Station 133+15 to 133+05	12”
Upstream and Downstream of Culvert for 10 ft	Station 85+10 to 85+00 Station 80+40 to 80+30 Station 7+50 to 7+40 Station 5+20 to 5+10	12”
Upstream and downstream of drop structure for 25 and 20 ft	Station 75 to 50 Station 22 to 2 (wrap on existing canal banks as needed)	12”
Yellowstone protection berm	NA – 470 ft length	48”

Future Design Effort Future design effort for the Relocate Diversion Upstream is required to define Yellowstone River stage-flow rating at the proposed diversion site. Different combinations of canal bottom width, drop structure height, and intake structure gates should be evaluated to optimize the minimum cost design.

Relocate Diversion Upstream Summary A conceptual analysis was conducted to evaluate the feasibility of moving the intake upstream from the present location. The existing diversion dam would be removed to a suitable level. An HEC-RAS model was constructed of the new Relocate

Diversion Upstream to verify that the required diversion rate of 1,400 cfs could be achieved with the designed components. Results are summarized as follows:

- Major components of the Relocate Diversion Upstream includes a rock ramp head control structure, an excavated canal, a downstream drop structure, a railroad crossing, a combined railroad and stream crossing, flood protection berms, a new intake structure with drop, removal of the existing dam and decommissioning the intake structure, and Yellowstone River stabilization structures.
- Design of project features was performed with an HEC-RAS model. Design is suitable for a conceptual level only.
- Locating the new intake elevation near the river bottom provides additional head at low flow and reduces the number of gates. However, sediment load at higher Yellowstone River flow levels would be an issue. Future design will consider incorporation of several bi-fold or top lowering gates to alleviate sediment during periods of higher Yellowstone River flow diversion.
- Canal flow depth is less than 10 ft with a normal velocity of less than 2.5 ft/sec.
- The drop structure at the new canal junction with the existing canal is required to meet grades. The structure has a width narrower than the upstream canal to reduce flow velocity. Future design will further evaluate canal erosion potential and structure size.
- Different combinations of canal width and structure size are possible to meet the required diversion rate. These combinations were not investigated due to the conceptual nature of the design.
- A single siphon could be used in place of the five 8' diameter culverts. Due to concerns with construction beneath the railroad, this option was not pursued for the conceptual design.
- Floodplain berm construction would probably impact Yellowstone River flood elevations and floodway. Design and cost for any mitigation was not included in the conceptual analysis and should be addressed in future design.

Options Within Alternatives

This section addresses features used in multiple alternatives that have more than one viable option: dam removal, fish screening, and sediment sluicing. A qualitative discussion of anticipated impacts to the Yellowstone River from removal of the Intake Diversion Dam is included.

Dam Removal Response

The scope of this section includes:

- Discussion of degree of dam removal (i.e., remove top several ft of dam or remove all traces of dam and affiliated downstream rock field)
- Discussion of anticipated geomorphologic response to dam removal
- Discussion of techniques that could be used to mitigate potential negative impacts of dam removal
- Discussion of alternatives that include dam removal

Dam removal would be included in the Relocate Diversion Upstream and the Pumping Plant(s) Alternatives.

Dam removal has become a more common occurrence on small water impoundments in the United States. Over the past 20 years, increasingly larger dams have been removed. Many dams the size of Intake Diversion Dam have been removed in arid regions of this country. Many reasons underlie this management decision, including:

- High dam densities and the aging of dam infrastructure. Of large dams, 85% will have exceeded their design lifespans by 2020 or soon thereafter (Federal Emergency Management Agency (FEMA) 2001). Though inventories are poor, dams exist at much higher densities than many realize.
- Threats or occurrences of dam failures. In 2000 and 2001, 520 dam incidents and 61 dam failures occurred; the American Society of Civil Engineers (ASCE) gave dam management and safety a grade of "D" in the last two editions of its "Report Card for America's Infrastructure" (ASCE 2006). Although inventories are incomplete (with 11 states having no inventory at all), 2,100 dams are categorized as unsafe and almost 10,000 as high hazard potential, and both categories show significant growth in recent years (ASCE 2002).
- Failure of traditional restoration. The mixed success or outright failure of expensive efforts to protect and recover various threatened and endangered species as well as critical prey populations, e.g. the herrings, has received much attention in recent years. The effect of dams on both upstream and downstream migration success is usually cited as a central factor (Conyngham et al. 2006).

In the case of Intake Diversion Dam, fish passage and habitat has been cited as the primary goal when considering modifications to the existing dam infrastructure. Many possible solutions exist to improve fish passage. Dam removal encompasses the process of physically removing the entire structure. A preliminary assessment was performed to qualitatively discuss possible channel response to dam removal.

Degree of Dam Removal

Determination of the degree of dam removal would affect the geomorphic response. The question that needs to be answered is whether removing the top portion of the dam would suffice or if the entire dam, to include any wooden substructure and all rock that has been placed on the dam and subsequently moved downstream by the river, needs to be removed.

For purposes of this evaluation, it is assumed that the entire dam would be removed. In order to remove the entire dam, a coffer dam would likely need to be constructed so dam removal could be accomplished in the dry.

The existing dam crest and downstream rock field would be mechanically removed. Ideally, the rock could be used as bank protection or grade control on other features of the various alternatives. However, the quality and gradation of the rock would need to be evaluated to determine its suitability. If the rock is not of sufficient quality or gradation for reuse, it would need to be spoiled at an as-yet undetermined location. The wooden substructure, current state unknown, would then be removed.

Analysis of Existing Data

Specific gage plots for the Yellowstone River at the Sidney, MT, gage (41.9 miles downstream) were prepared to indicate river trends. Results were interpreted to indicate the possibility of substantial channel aggradation or degradation near the irrigation diversion (see figure A.2.55). Measured data for this site was available from the USGS sporadically from 1967 to 1976 and approximately once per month from 1976 to 2006. Three flows of 6000, 10000, and 20000 cfs were plotted. Exact values of these flows were not always present, so gage height values were interpolated or extrapolated based on measured values close to the flow of interest. Some obvious outliers were removed that may have been influenced by ice or bed changes due to recent high flows.

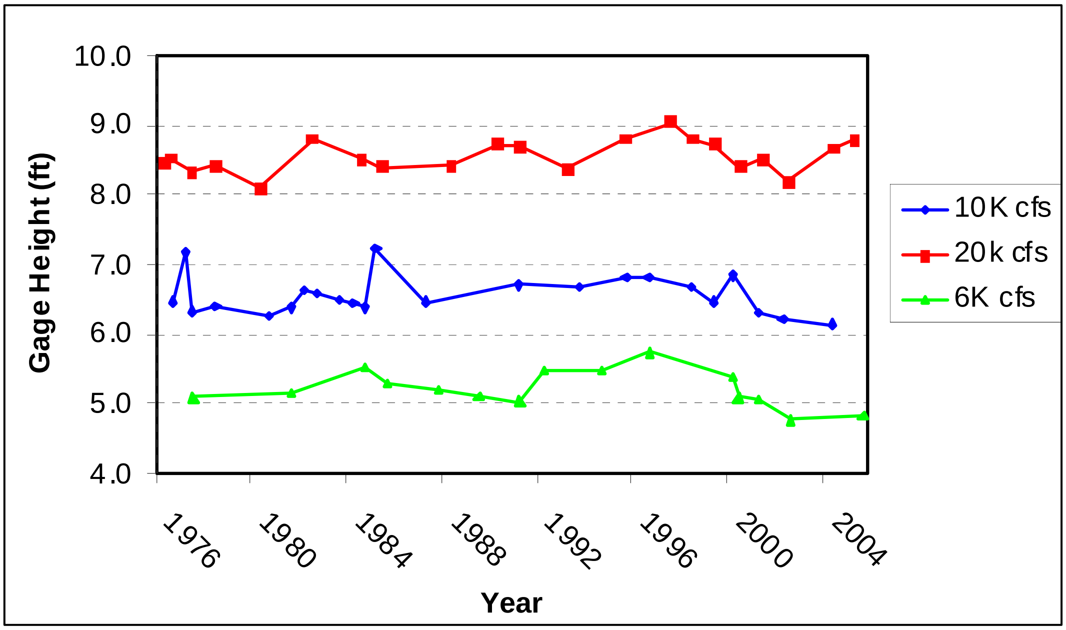

Figure A.2.55 - Yellowstone River at Sidney, MT, Specific Gage.

No trend is apparent from the gage height values at any of the discharges plotted. The river in this reach has likely adjusted to the long term presence of the diversion structure and has now reached a stable geometry. Only very limited data is available at the closest upstream (17 miles) gage at Glendive, MT.

Data collected in the area near the dam in 2008 indicates that there has been a coarsening of the bed directly below the dam, a common result known as armoring. This action also usually causes a lowering of the bed. Unfortunately, there is not sufficient survey or gage data to establish any kind of trend below the dam. After many years of dam operation, it would be expected that the bed is armored and partial or full removal of the dam would not significantly degrade the bed any further.

Removal of the intake diversion would result in an increased sediment transport capacity in this reach. For a constant flow and sediment size, the ratio of the natural river slope to the backwater slope caused by the dam provides an estimate of the increased sediment transport capacity after dam removal. Water surface profiles generated by a previously developed Reclamation HEC-RAS model were used to estimate the increased transport capacity at the intake dam site. At 5,000 cfs, there is a six-fold increase, at 15,000 cfs a three-fold increase, and at 20,000 cfs, the transport capacity doubles. In reality, the sediment deposit behind the dam is not homogeneous, but varies as different sediment sizes were deposited by various flows. Nevertheless, the coarser sediment is likely to be on top of the deposit and would be moved while the slope is the highest in the removed dam. The Yellowstone River would see increased sediment transport of delta sediments until a stable channel is reached. Transport of these delta sediments may cause downstream aggradation in the Yellowstone River reach downstream of the dam. The extent of the deposition and its location would need additional study.

Cross-section data, collected in 1976, from the dam at river mile 71.1 downstream to river mile 69.4 was also available. This was compared to the geometry used for the hydraulic numerical model. Average bed elevations were calculated using both data sets but little conclusions can be gained because the current cross-sections and the 1976 cross-sections are not at the same location.

Some channel widening is expected to occur in the vicinity of the dam. River widths upstream, near the dam, and downstream of the dam were measured on aerial photography. The channel just upstream of the dam is approximately 16% narrower than the upstream reach, and 10% narrower than the downstream reach. After dam removal, the reach near the dam would likely conform to the planform geometry of the upstream and downstream reaches.

Anticipated Response to Dam Removal

Intake Diversion Dam has been in place for approximately 100 years. The previous analysis described in the section on Deltaic Sediment and Geographic Extent describes the evaluation and estimate of deposited sediment volume. It is likely that channel adjustments would occur if the existing structure is removed. If the structure is removed or lowered, the energy slope across the sediment delta would increase. There would then be a much greater capacity for the river to transport the sediment that has accumulated behind the dam. Complete removal of the structure is likely to result in headcutting that migrates upstream until it reaches another hard point or is limited by armoring of the bed material. River response to dam removal may be separated into the following components:

> a) **Timing of Material Removal** It is likely that much of the sediment material would be mobilized fairly quickly following dam removal. However, sediment transport is directly dependent on river flow. If dam removal occurs during a prolonged drought, then sediment transport is reduced and the river adjustment would take longer. Channel expansion and the bank failure action would also require additional time. A reasonable expectation would be for rapid river degradation through deposited sediments to occur within the first few weeks or months. This would be followed by a period of more gradual adjustment with channel widening, continued downcutting, and some bank failure.

b) **Headcutting** Typically, a headcut starts where the deposition consists of primarily fine materials. At the Intake Diversion Dam vicinity, the deposition appears limited to the inside of the bend due to the operation of the irrigation canal. This material would be removed with a headcut traveling upstream. Headcutting would assist in mobilizing deposited sediments, and as any headcut migrates upriver, the energy slope, or head, across the deposits would increase, resulting in increased sediment transport capacity.

c) **Channel Widening** Bank failure and channel widening would also likely occur as increased bank heights along the newly exposed stream are scoured and become unstable. Based only on limited observations and samples, much of the bank material in the reach of interest consists of relatively fine material on the order of fine sand. This material would erode easily resulting in a typical stream width comparable to the upstream and downstream reaches.

d) **Downstream of Dam Response** Transport of the delta and bank materials after dam removal/modification would most likely cause aggradation of the sediments in the river below the dam site. Prediction of the scale and location of these deposits requires a large amount of data to use predictive models, and even these models have significant uncertainty. As recent experience has shown at Marmot Dam and others, the time required to transport deposited from the delta to downstream locations is often significantly shorter than was predicted.

The Yellowstone River location is also known to experience large amounts of ice buildup during the winter months with significant ice flow and jam potential during spring breakup. If the dam captures most of the ice and reduces the amount of ice built up downstream, ice buildup may be more frequent and severe in the downstream reach after the dam is removed. Ice may continue to build up at the former dam location, and degradation that occurs near the dam location could increase due to higher velocities under the ice that is not limited by the presence of the dam.

Alternatives Including Dam Removal
Not all alternatives include complete dam removal. Many of the alternatives rely on the existing dam to maintain the current Yellowstone River stage-flow relationship and operation of the existing canal intake. Alternatives that do not require using the dam to provide the head required for irrigation canal diversion would allow dam removal. Examples of such alternatives include the relocate channel upstream and the multiple Pumping Plant(s) Alternative.

Fish Screen Options
Two fish screen options are presented and compared in this section.

V-Shaped Screen
A fish screen installed within the irrigation canal downstream of the intake could be used to return entrained fish from the canal back to the Yellowstone River. Fish screen design was briefly evaluated to determine any hydraulic items that should be further evaluated in future design. In addition, fish screen head loss was evaluated with respect to screen mesh size. Screen design data were reported in the Concept II report (USBR 2004, App. A pg. 13-16). Reported

significant features includes a V configuration screen with a total length of 440 ft, design flow rate of 1,400 cfs, approach velocity of 0.4 ft/sec, sweeping velocity of 2 to 2.5 ft/sec, 1.75 mm slot opening stainless steel wedge wire with about 40% open area, a 12 inch sill height of the screen above the invert, a bypass return structure that includes 700 ft of 48" diameter pipe and slide gate, a check structure with two radial gates to raise canal head and prevent Yellowstone River backflow through the bypass pipe, and an estimated head loss through the baffles and fish screen of less than 0.5 ft.

- The Concept II report (Reclamation 2004, App. A pf. 14) states that sediment deposition is reportedly negligible in the reach of the canal. However, given the small mesh size and alteration of hydraulics through the screen area, additional sediment evaluation is recommended to estimate removal requirements and potential screen blockage issues.
- The crown of the bypass culvert is about equal to the 5,000 cfs Yellowstone River flow elevation. Therefore, the bypass pipe would nearly always be filled with backwater from the Yellowstone River, even during winter months. Freeze damage to the bypass structure may be an issue if provisions are not included to dewater the pipe. Slide gate closure would prevent backup into the canal.
- The proposed screen size of 1.75 mm slot opening may be smaller than required and feasible for reliable operation. As head loss and flow velocity through the screen decrease with open area, it may be possible to reduce the total screen length by using a larger opening.
- With regard to the fish screen bypass pipe, existing elevations in the proposed screen location prevent the effective use of an open channel due to high cut depths. An alternative alignment is possible that would provide a combination of open channel and about 300 ft of pipe length.

In addition to the fish screen, a trash rack would be included at the point of diversion to prevent larger adult fish from entering the canal. The trashrack is evaluated in detail in a document produced by Reclamation's TSC (Reclamation 2008).

Cylindrical Drum Screens

Fish screen hydraulics were provided by a manufacturer representative, Mr. Darryl Hayes, of Intake Screens, Inc (dhayes@intakescreensinc.com). Illustration concepts are shown in figure A.2.56. A summary of fish screen design parameters that apply to the Intake project are as follows:

- Fourteen separate units with an assumed 100 cfs per unit with flow roughly equal to all units.
- Each unit would include a slide gate behind the screen unit to help regulate flow imbalance and allow closure. Each unit may be operated separately if a unit is clogged or undergoing repair.
- The proposed screen is a 72 in diameter unit with two screen cylinders each 84 in long. That translates to 264 square ft of screen surface area for each complete screen unit.
- The screen consists of a #69 wedgewire (width of 0.069 in) and a slot opening of 0.068 in. This results in a 50% open area. A 50% open area is typical for slots down to about 1.75 mm. If slot size is desired to be less, the open area would decrease because the wire size is generally wider than the slot.

- The assumed screen approach velocity is 0.4 ft/sec over the screen area (i.e. a slot velocity of 0.8 ft/sec). This is the general fisheries criteria used in the western states for most fish. If the water was especially dirty or desired to screen for smaller fish (i.e. larval or weak swimmers), the approach velocity would be lower and more screens would therefore be required. A slot velocity of 0.5 ft/sec is desirable to really minimize headloss, but many installations have velocity up to 0.8 ft/sec with no real issues. Debris would clog the screen faster as the slot velocity is increased. Brush cleaning intervals are increased if the slot velocity is higher.
- It is possible to install water level differential sensors for the screen. If a set value is triggered, for instance 2 in across the screen surface, the sensor would trigger an additional cleaning cycle.
- The screens can be raised when the canal is not operating to prevent damage from large flood debris and ice. In addition, a plate could be placed upstream of the screen raising track to deflect ice flows. The track may also be recessed a depth of about 12 to 15 in for a screen of this size.
- Head loss also occurs through the collection pipes and downstream gate if flow velocities are high. Manufacturer design guidance is to keep the maximum flow velocity in the screen unit less than about 5 ft/sec. At Intake, this would mean keeping the suction pipe inside each screen cylinder sized at 42-in and the pipe connection to intake greater than 5 ft diameter for the design flow of 100 cfs.
- The portal downstream of the screen collection pipe was assumed to be a 6 ft square opening. This opening would have a coarse trashrack for periods when the screen is in the raised position.

Raised Screens **Screen Side View**

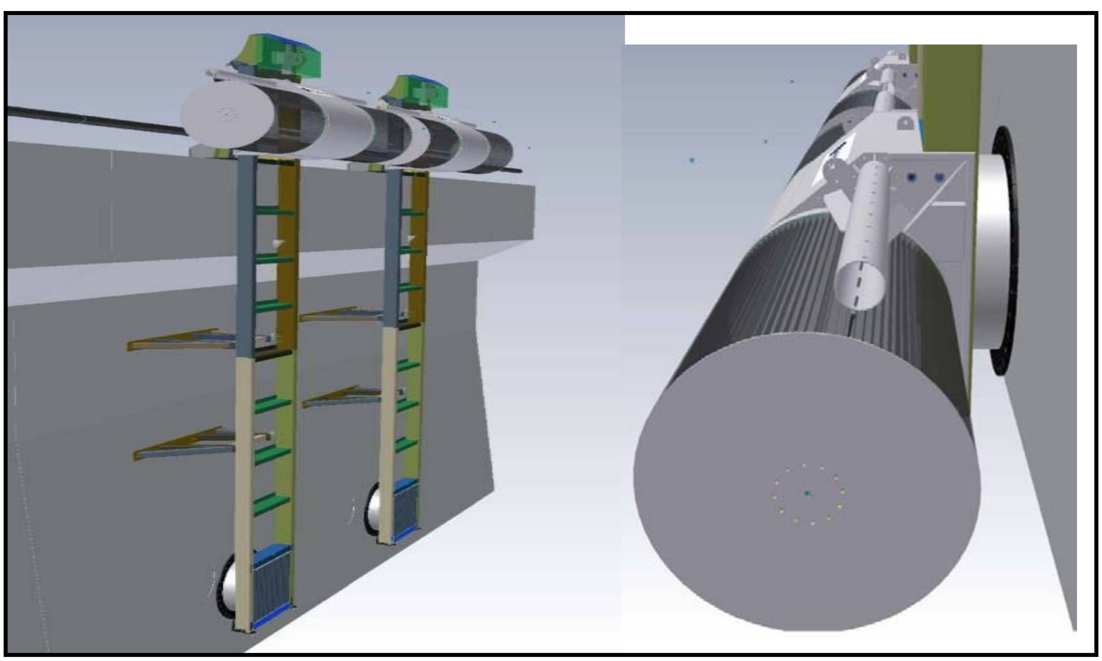

Figure A.2.56 - Cylindrical Fish Screen Concept Illustration.

Comparison of Fish Screen Options

Table A.2.16 compares the two fish screen options.

Table A.2.16 Fish Screen Option Comparison

Issue	V-Shaped Screen	Cylindrical Screens
Partial entrainment	Fish may still enter the upstream portion of the canal. Fish that do not enter the return pipe will be entrained.	Not an issue unless a screen is removed for repair.
Fish entering return pipe	Fish entering the canal would be returned to the river through a pipe or combination pipe and open channel. Stress on the fish could be an issue.	No return pipe necessary for cylindrical fish screens as fish are prevented from entering the canal altogether.
Maintenance	Maintenance of the V-shaped fish screens would need to be performed in the canal. If one portion of the screen needs to be removed, part of the diverted flow would be unscreened. Shutdown of diversion capabilities during maintenance should be investigated. Additionally, the V-shaped screen option also includes the trashrack, resulting in two systems that would require maintenance.	Each screen can be raised and lowered individually. Maintenance for one screen could be performed while the remainder are in operation. Slide gates would allow for all flow to be screened while maintenance is performed on one.
Damage from debris	Because the V-shaped screen is located in the canal and the trashrack would prevent large debris from entering the canal, debris damage should not be an issue.	The cylindrical screens would be vulnerable to debris damage during extreme low flows and when the debris is near the middle or bottom of the water column. Bollards are proposed to minimize large debris coming in contact with the screens.
Damage from ice	Because the V-shaped screen is located in the canal, ice damage should not be an issue.	The cylindrical screens can be removed during the winter, so ice damage should not be an issue.
Sediment accumulation	Sediment transport has not been evaluated in detail for either screen. It is anticipated that sediment accumulation could be an issue for either screening system	

Sediment Sluice

Concerns have been raised by the design team that minimal amounts of sediment would be able to pass through the proposed fish screen structure. Low velocities in the vicinity of the proposed headworks could cause deposition to occur. Numerous irrigation diversions managed by the USBR have sediment sluiceways installed. The goal of each alternative is to pass sediment from upstream of the diversion dam to downstream. In this case, the sediment would return to the river at the base of the rock ramp. Each alternative evaluated must maintain a velocity adjacent to the proposed gates and in the sluiceway fast enough to entrain any sediment that has deposited in the vicinity of the headworks. The design velocity was determined to be 6.0 ft/sec. This is the minimum velocity required to move coarse gravel (Schwab et al. 1993 p. 269). Coarse gravel was considered the target sediment size to transport.

Sluiceway options have only been evaluated for the rock ramp alternative at this time. It is expected that the concepts presented here could be adapted to other alternatives in final design. Three alternatives were evaluated for use as a sluiceway. The first alternative was vertical lift gates positioned perpendicular to the bank line on the downstream end of the proposed headworks, with a sluiceway parallel to the bank. This would require building the sluiceway through the existing dam. The second and third alternatives evaluated using the existing headworks as the sluice gates. One option with the existing headworks is to use concrete culverts to route sediment through the bank and return it to the river. The second option with the existing headworks is to use an open channel as a sluiceway to return the sediment to the river.

For all sluiceway alternatives, a training wall upstream of Intake Diversion Dam is required to maintain flow velocity in the vicinity of the gate and maximize sluice capability. The goal of the sluiceway is to move material from in front of the proposed headworks. The training wall would prevent expansion of the flow area contributing to the gate structure and thus increase velocity in this area when the sluice is operated. Future design is required to evaluate the design length, width, and elevation of the training wall. The current wall top elevation is 1986.00 ft, which is approximately five ft above the bed of the river. The alignment of the wall is approximately 40 ft from the riverward side of the intake screen for the length of the headworks. This distance was selected by visually analyzing the depression maintained adjacent to the existing headworks. Rather than a concrete wall, it may also be possible to use a linear riprap structure.

Sediment Sluice Options

In-Channel Sluiceway The sluiceway gate structure is located just downstream from the new headworks screening structure approximately 250 ft upstream from the existing diversion dam. The in-channel sluice invert was set at 1981.58 ft as controlled by invert elevation of the toe of the rock ramp (approximately 1980.0 ft) and providing sufficient slope to maintain the required velocities. The top of the gate housing would extend to the same elevation as the new headworks structure and would be connected by a walkway to provide access the gate operators. The sluiceway would utilize four 8-ft wide by 6-ft tall flat, vertical lift gates. The sluiceway downstream from the gates would consist of two covered conduits 20.5 ft wide by 10 ft high extending approximately 2,050 ft downstream to the toe of the rock ramp (slope 0.077% or 4.1 ft per mile). Plate A.2.20 illustrates the layout of the proposed in-channel sluiceway.

Selection of Gate Invert Elevation and Location The invert elevation of the proposed intake structure is 1981.58 ft. The gate invert of the sluice must be no greater than this to allow movement of bed material past the intake. A scour hole exists in front of the existing intake gates. The most recent digital terrain model (dtm) was analyzed to determine the depth and extent of this scour. Elevations from the dtm indicate that elevations in front of the existing gates are as low as approximately 1977.0 ft. The invert elevation of the sluice gates is set at 1981.58 ft. Ideally, the invert elevation of the sluice should be set lower than that of the intake structure to prevent sediment from depositing adjacent to the screens. However, this elevation is limited by the downstream ramp elevation of 1980.0 ft. Gate and sluice invert elevations less than this would be flat or slope upstream.

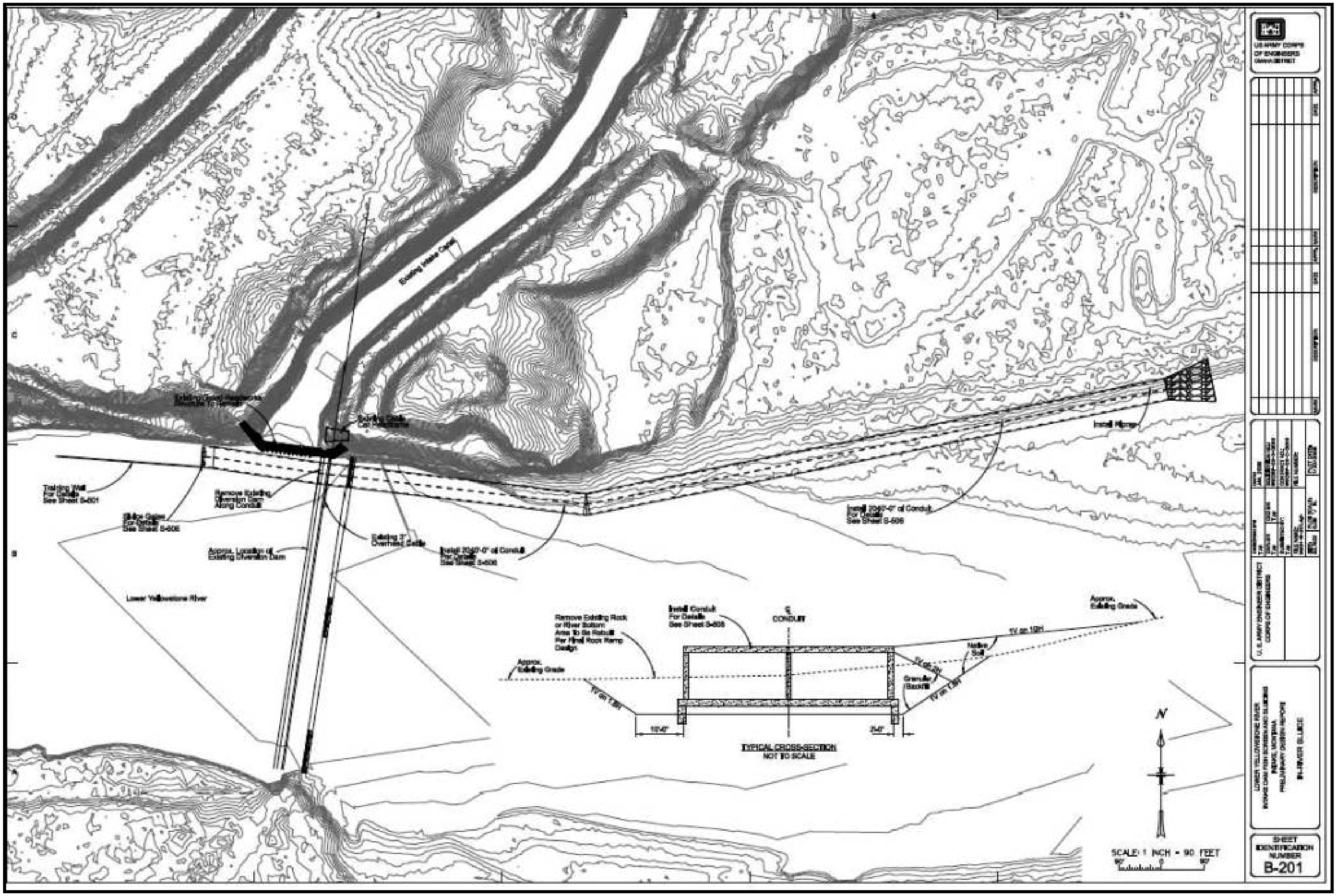

Plate A.2.20 – In-Channel Sluiceway Layout.

The proposed new intake structure would begin approximately 250 ft upstream from the dam crest. The proposed location for the sluice gates would be just downstream of the new intake structure. The gates are placed perpendicular to the bank line. The walkway to access operations could attach to the walkway for the headworks.

Gate Selection Radial, or tainter, gates are commonly used for sediment sluiceways in irrigation diversion dams. Advantages of tainter gates are reduced friction during movement since the hydrostatic forces are focused on the trunnions around which the gate pivots. Tainter gates typically have lower maintenance costs than vertical lift gates. Ice and flood debris impacts to gates at the Intake, MT, site would be severe. To keep the top of the gate above the 100 year elevation, the top elevation would require a gate size of approximately 20x30 ft. The structure above the gate with the lifting mechanisms would be very large.

If it was acceptable for water and debris to flow over the tainter gate, a smaller gate could be selected. In this case, two gates 11x18 ft would be required. The top of the gate would be approximately 2 ft higher than the proposed top of the new rock ramp (1989. ft). Due to repetitive damage concerns, the design assumed that that ice and debris are not allowed to flow over the tops of the gates. Smaller tainter gates are therefore not feasible.

Flat vertical lift gates were also evaluated. The primary goal of the gates is to transport bed material from in front of the intake structure, so a large size is not necessary. The concrete gate housing extends above the 100 year water surface elevation. The top of the structure housing the lifting mechanisms and walkway is at elevation 2006 ft and is integrated into the walkway over the intakes. The top of structure elevation prevents flood damage to the gates and lifting mechanisms.

HEC-RAS Model Sediment sluice feasibility was evaluated with the previously constructed HEC-RAS model during 2008. The model was not updated to include the new survey data. The sediment sluice option was evaluated with the split flow option within HEC-RAS. A rectangular reach with n=0.012 was added to simulate a concrete sluiceway. Three design flows were identified to evaluate the flow and velocity in the sluice with different gate sizes. The flows used within the model were the average monthly flows for May equaled or exceeded 20, 50, and 80% of the time. These flows were 23,300, 14,800, and 9,770 cfs, respectively (see Corps 2006). These flows were selected as representative of discharge when Yellowstone River sluice operations may occur. For purposes of the model, the entrance of the sluiceway started adjacent to the proposed intake structure. The sluice gates were positioned approximately 250 ft upstream of the crest of the rock ramp.

Four gate sizes were evaluated; these were (width x height) 5x4 ft, 5x5 ft, 8x6 ft, and 8x8 ft. Six gates were evaluated using the five ft wide gates and four were evaluated using the eight ft wide gates. The split flow analysis was used to estimate the amount of flow moving through the sluiceway and the velocities. The preliminary results of the split flow modeling are shown in Table A.2.17. The lowest velocity in the sluiceway is the limiting factor for movement of sediment adjacent to the proposed headworks. For all gate sizes evaluated, the lowest velocity was the first cross-section immediately upstream of the sluice gates.

Table A.2.17 Sluice Design Flows and Velocities near Proposed Headworks

# gates	gate size (w x h)	Q total = 9770 cfs		Q total = 14800 cfs		Q total = 23300 cfs	
		Q sluice (cfs)	min velocity (ft/sec)	Q sluice (cfs)	min velocity (ft/sec)	Q sluice (cfs)	min velocity (ft/sec)
6	5x4	1874	5.6	1963	5.3	1979	4.7
6	5x5	2034	6.2	2230	6.2	2322	5.6
4	8x6	2204	6.6	2456	6.7	2688	6.2
4	8x8	2400	7.7	2674	7.9	3050	7.9

The selected sluice uses four gates that are each 8 ft wide by 6 ft in height. With this gate size, velocities upstream of the sluice gates ranged from 6.2 to 6.4 ft/sec. Velocities downstream of the gates in the sluice ranged from 8 to 10 ft/sec. This size was selected because velocities were above the design velocity for all flows.

Downstream Sluiceway To maintain the slope of 0.50%, the rock ramp would have a length of approximately 1800 ft. The downstream end of the sluiceway is located at the base of the rock ramp. The total length of the sluiceway is approximately 2050 ft since the gates are 250 ft upstream of the diversion. The slope of the sluiceway is therefore approximately 0.077% (4.1 ft/mi). This appears to be about the same as the existing Yellowstone River slope. The HEC-RAS model was further refined by placing dividers between the gates for the entire length of the sluiceway. The sluiceway would likely be covered for safety reasons and to prevent Yellowstone River water traveling on the ramp and outside the sluiceway from entering the sluiceway. The water surface elevation in the sluiceway and in the Yellowstone River at the equivalent station is shown in table A.2.18. The total flow in this table (river and sluice) is 23,300 cfs. This would likely limit the rock ramp effectiveness during periods of low flow. In addition, entering river flow could disrupt sediment transport within the sluiceway.

Table A.2.18 - Water Surface Elevations-Sluice and Adjacent Main Channel, Q=23,300cfs.

Yellowstone cross-section	Yellowstone Water Surface Elev.	Sluice cross-section	Sluice Water Surface Elev.
28564	1993.7	2340	1994.2
28278	1993.6	2050	1994.2
27725	1991.2	1491	1990.8
27164	1989.8	932	1990.0
26601	1989.5	373	1989.2
26227	1989.4	0	1988.5

For the conceptual analysis, the downstream sluiceway was assumed to be a constant width for the entire length. The sluiceway downstream of the gates may be designed narrower than the sluice area upstream of the gates. This would increase the velocities and possibly ensure sediment is transported through the sluice more efficiently. Key design considerations include the amount of constriction that can occur before flow through the gates is affected, the transition from the gates into the sluiceway, and the downstream outlet configuration

The recommended sluice would consist of the following:

Number of Boxes: 2
Conduit Size: 20.5 ft wide x 10 ft high (inside dimensions)
Conduit Length: 2,050 ft from the sluice gates to the base of the rock ramp
Invert Slope: 0.077% (4.1 ft/mi)

Design summary details are as follows:

- The previously constructed HEC-RAS model was not updated to include current survey information. The accuracy of the model was assumed appropriate for the conceptual analysis.
- Detailed evaluation is required to determine bed and suspended sediment load and design details of the sluice.
- A HEC-RAS model determined that maintaining a flow velocity of 6 ft/sec within the sluice is feasible.
- Sluice operation time and duration was not evaluated.
- A sluiceway through the existing dam uses four gates that are each 8 ft wide by 6 ft in height.
- The downstream sluiceway within the river was assumed to be covered. This is necessary for safety reasons and to prevent flow transfer from the Yellowstone River.
- The upstream sluiceway training wall requires further evaluation to determine optimum wall height, length, and distance from the headworks structure.
- The downstream sluiceway requires additional evaluation. It is likely that some convergence of the sluiceway is possible without inhibiting the sediment transport.
- The conceptual analysis indicates that it is possible to implement a sluice. Further analysis may determine that operational constraints and Yellowstone River sediment load may severely limit sluice effectiveness.
- This option would require building the sluiceway through the existing dam. There may be issues with partial dam removal and constructability.

Existing Headworks-Culverts The abutment sluiceway concept builds upon the constructive re-use of the existing headworks structure as the gate structure for the sluiceway which would then run along the left bank of the river until it reaches the toe of the proposed rock ramp. The invert of the existing gates is already set at 1983.58 ft and the outlet invert elevation was set at the elevation of the toe of the rock ramp (approximately 1980.0 ft). The sluiceway would utilize four 8-ft wide by 8-ft tall flat, box culverts. The sluiceway downstream from the gates would consist of four 8-ft by 8-ft box culverts extending approximately 1,900 ft downstream to the toe of the rock ramp. Plate A.2.21 illustrates the layout of the proposed abutment closed conduit sluiceway.

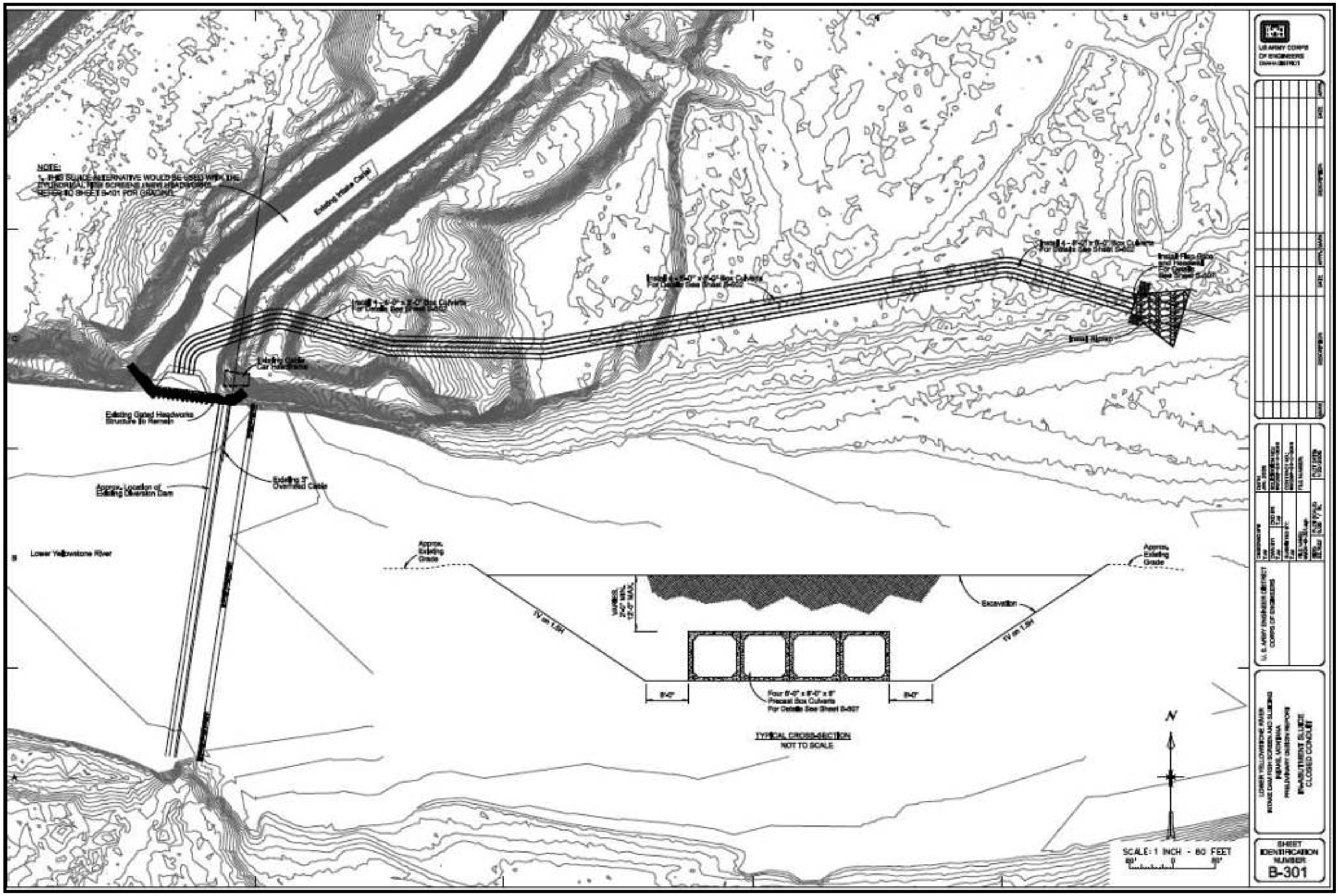

Plate A.2.21 – Abutment Closed Conduit Sluiceway Layout.

Modeling was conducted with HEC-RAS to estimate how much flow could be transported with box culverts of various sizes, from 5x5 ft to 12x12 ft. The length was estimated to be 1,900 ft, to allow for transitions to and from the river. The slope of the sluiceway with this alternative is 0.19% (9.9 ft/mi). The material was assumed to be finished concrete with n=0.015. The flow was modeled as an open channel so the results are equivalent for a partially full closed conduit or open channel. The amount of flow conveyed for each culvert size, the number of culverts required, and the diameter of an equivalent round pipe are shown in table A.2.19. The equivalent diameter for a round pipe carrying the same flow was determined using the procedure found in EM 1110-2-1602 (p. 2-9).

Table A.2.19 Culvert Sizes and Flow-Existing Headworks Sluiceway.

Box culvert size (ft)	Q_{pipe} (cfs)	# culverts required	Flow depth (ft)	Average velocity (ft/sec)	R (ft)	Round pipe equivalent diameter (ft)
5x5	150	11	4.9	6.1	1.7	7
7x7	375	5	6.7	7.7	2.3	10
8x8	500	4	7.5	8.3	2.6	11
10x10	950	2	9.8	9.7	3.3	14
12x12	1600	1	12.1	11.0	4.0	16

The recommended conduit would consist of the following:

Number of Boxes: 4
Conduit Size: 8 ft x 8 ft
Conduit Length: 1,860 ft
Invert Slope: 0.19% (9.9 ft/mi)

Existing Headworks-Open Channel This abutment sluiceway concept again re-uses the existing headworks structure as the gate structure for the sluiceway which would then run along the left bank of the river until it reaches the toe of the proposed rock ramp. The invert of the existing gates is already set at 1983.58 ft and the outlet invert elevation was set at the elevation of the toe of the rock ramp (approximately 1980.0 ft). Instead of a closed box culvert conduit, this sluiceway would utilize trapezoidal open channel. The sluiceway downstream from the gates would consist of a trapezoidal channel with a 30-ft bottom width and 1.5:1 side slopes. The channel would extend approximately 1,900 ft downstream to the toe of the rock ramp (slope 0.19% or 9.9 ft per mile). Plate A.2.22 illustrates the layout of the proposed abutment open channel sluiceway.

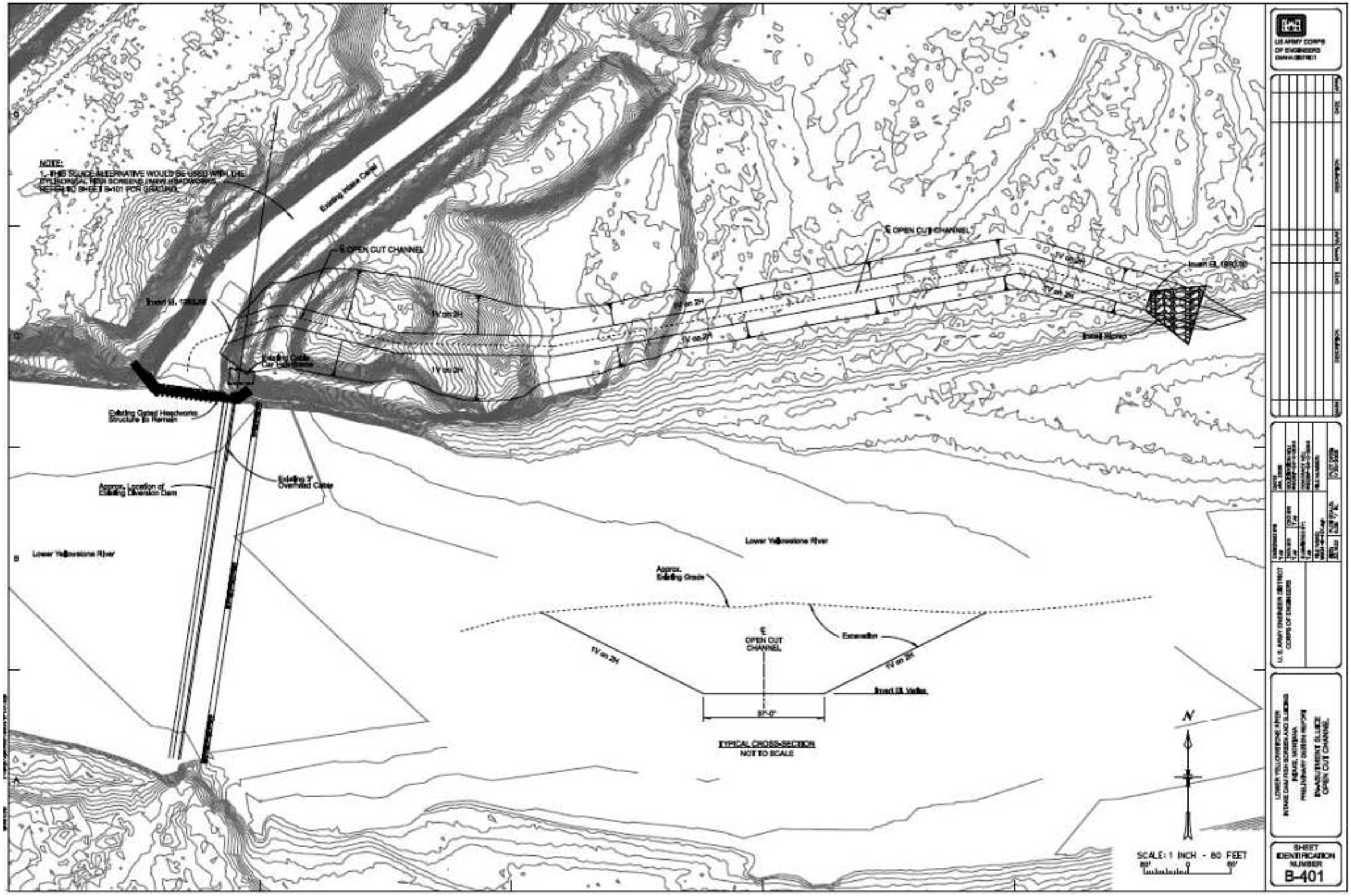

Plate A.2.22 – Abutment Open Channel Sluiceway Layout.

A concrete lined channel may be required to maintain sediment transport through the section. Use of concrete avoids increasing roughness, maintains higher flow velocity, and reduces maintenance for vegetation and bank stability. Using the larger culverts, the flow depth is much greater than the height of the existing gates which are five ft. Construction of a flat bottom open channel may be preferable to provide the required flow area. The channel could be relatively easily constructed wider to allow the same flow with a shallower depth. The open channel would consist of the following:

Bottom Width: 30 ft
Side Slope: 1.5:1
Length: 1,860 ft
Invert Slope: 0.19% (9.9 ft/mi)

For the above geometry, the design flow depth is 5.2 ft and the velocity is 7 ft/sec.

Design summary details for options using the existing headworks as a sluice are as follows:

- Under current conditions, sediment deposition is not occurring in the first few miles of the canal. It is inferred that sediment can be entrained and passed through the existing headworks.
- HEC-RAS modeling was used to estimate the velocity through conduits used as sluiceways.
- Further analysis is required to determine if a gate is required on the downstream end of each sluice option. A gate may be required to prevent river water from entering the sluiceway during non-sluicing operations. It may also be beneficial for maintenance access. The gate selected would likely be a hand operated vertical lift gate.
- Further analysis is required to evaluate if the entire flow of 1400 cfs is required to entrain sediment and move it from in front of the proposed headworks. If less than this flow is necessary, smaller or fewer conduits could be used. This would substantially reduce construction costs.
- Additional analysis is required to evaluate if the sluiceway can be designed using an open channel rather than a closed conduit. The analysis should evaluate lining required for the open channel to maintain sediment transport.
- The conceptual analysis indicates that it is possible to implement a sluice. Further analysis may determine that operational constraints and Yellowstone River sediment load may severely limit sluice effectiveness.

Other Options A rock dike upstream of the proposed headworks and revetment parallel to the headworks may prevent sediment accumulation in front of the headworks. This concept is similar to an ‘L-head’ dike often employed on rivers to alter the sediment deposition pattern, especially for bed load material. Primarily fine grained material would likely deposit behind the rock structure.

Other sediment removal devices such as a siphon or vortex weir should also be investigated. Siphoning could be used to remove the fine grained material from the vicinity of the fish screens. The available hydraulic head and sediment outlet may limit the feasibility of other sediment removal options.

Sluice Outlet Riprap Protection

Riprap stone is placed at the outlet of the both sluice options to reduce the energy of water exiting the sluiceway. The stone was sized using the Ishbash equation for turbulent flow as stated in the procedure outlined in the Hydraulic Design Criteria (Corps 1987). The D_{50} was estimated to be 1.5 ft, and the D_{100} was estimated to be 3.0 ft. The thickness of the stone layer is 4.4 ft and extends 100 ft downstream of the sluice outlet. At the downstream end, the width of the stone is 50% greater than the width at the sluice.

Sluice Gate Operational Considerations

The amount of flow used by the sluice would impact diversion capacity. Sluiceway operation would consider Yellowstone River flow elevation and diversion needs. Some limited operation during high flows may be beneficial to limit sediment accumulation in front of the headworks. Sediment sluicing during low flow periods may not be feasible due to low head and irrigation needs. Sediment would likely accumulate throughout the year, and then would be removed during sluicing operations primarily in the spring before irrigation begins. Sluicing could also occur in the fall after irrigation but before winter ice conditions if flow levels permit.

Additional considerations for sluicing operations:

- Estimate the length of time the sluice gates must be open to move the accumulated sediment.
- Determine preferred sluice operation with respect to Yellowstone River flow, incoming sediment load, and irrigation canal diversion.

References

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Appendix B – Clean Water Act

Introduction

This appendix documents Intake Project compliance with the Section 404(b)(1) of the Clean Water Act and includes the permit application and *Federal Register* notice. The public notice expiration date was extended to December 31, 2009.

Revised: 7/2/2008 (310 form 270)
Form may be downloaded from:
www.dnrc.mt.gov/permits/default.asp

AGENCY USE ONLY: Application # ________ Date Received ________
Date Accepted ____________ / Initials ____ Date Forwarded to DFWP ________

JOINT APPLICATION FOR PROPOSED WORK IN MONTANA'S STREAMS, WETLANDS, FLOODPLAINS, AND OTHER WATER BODIES

Use this form to apply for one or all local, state, or federal permits listed below. "Information for Applicant" includes agency contacts and instructions for completing this application. **To avoid delays**, submit all required information, including **a project site map and drawings.** Incomplete applications will result in the delay of the application process. **Other laws may apply.** It is the applicant's responsibility to obtain all permits and landowner permission, when applicable, before beginning work.

✓	PERMIT	AGENCY	FEE
	310 Permit	Local Conservation District	No Fee
	SPA 124 Permit	Department of Fish, Wildlife and Parks	No Fee
	Floodplain Permit	Local Floodplain Administrator	Varies by city/county ($25 - $500+)
X	Section 404 Permit, Section 10 Permit	U. S. Army Corps of Engineers	Varies ($0 - $100)
	318 Authorization 401 Certification	Department of Environmental Quality	$150 (318); $300 - $10,000 (401)
	Navigable Rivers Land Use License or Easement	Department of Natural Resources and Conservation, Trust Lands Management Division	License $25; Easement $50, plus annual fee

A. APPLICANT INFORMATION

NAME OF **APPLICANT:** US Army Corps of Engineers C/O Tiffany Vanosdall
Has the landowner consented to this project? ☐ Yes ☐ No
Mailing Address: 1616 Capitol Ave Day Phone: 402-995-2695
Physical Address: 1616 Capitol Ave Evening phone:
City/State/Zip: Omaha, NE 68102 E-Mail: tiffany.k.vanosdall@usace.army.mil

NAME OF **LANDOWNER** (if different from applicant): US Bureau of Reclamation C/O Clayton Jordan
Mailing Address: PO Box 30137 Day Phone: 406-247-7665
Physical Address: 2900 4th Ave N Evening Phone:
City/State/Zip: Billings, MT 59107 E-Mail: cjordan@usbr.gov

NAME OF **CONTRACTOR/AGENT (if one is used):**
Mailing Address: Day Phone:
Physical Address: Evening Phone:
City/State/Zip: E-Mail:

B. PROJECT SITE INFORMATION

NAME OF **WATER BODY** at project location Yellowstone River Nearest Town Glendive, MT
Address/Location: Intake Dam Geocode (if available):
___ 1/4 ___ 1/4 SE 1/4, Section 25, Township 18N, Range 56E County Dawson
Longitude 47.284067, Latitude -104.521192

The state owns the beds of certain state navigable waterways. Is this a state navigable waterway? (Yes) or No.
If yes, send copy of this application to appropriate DNRC land office – see Information for Applicant.

ATTACH A PROJECT SITE MAP OR A SKETCH that includes: 1) the water body where the project will take place, roads, tributaries, landmarks; 2) a circled "X" representing the exact project location. IF NOT CLEARLY STATED ON THE MAP OR SKETCH, **PROVIDE WRITTEN DIRECTIONS TO THE SITE:**

This space is for all Department of Transportation and SPA 124 permits (government projects)
Project Name:
Control Number: Contract letting date:
MEPA/NEPA Compliance: ☐ Yes ☐ No If yes, #15 of this application does not apply.

C. PROJECT INFORMATION

1. **TYPE OF PROJECT** (check all that apply)

X Bridge/Culvert/Ford Construction	X Fish Habitat	☐ Mining
☐ Bridge/Culvert/Ford Removal	☐ Recreation (docks, marinas, etc.)	☐ Dredging
☐ Road Construction/Maintenance	☐ New Residential Structure	☐ Core Drill
☐ Bank Stabilization/Alteration	☐ Manufactured Home	X Placement of Fill
☐ Flood Protection	X Improvement to Existing Structure	X Diversion Dam
☐ Channel Alteration	☐ Commercial Structure	☐ Utilities
X Irrigation Structure	X Wetland Alteration	☐ Pond
☐ Water Well/Cistern	X Temporary Construction Access	☐ Debris Removal
☐ Excavation/Pit	☐ Other ____________	

2. **PLAN OR DRAWING** of the proposed project **MUST** be attached. **This plan or drawing must include:**

- a plan view (looking at the project from above)
- dimensions of the project (height, width, depth in feet)
- location of storage or stockpile materials
- drainage facilities
- an arrow indicating north
- a cross section or profile view
- an elevation view
- dimensions and location of fill or excavation sites
- location of existing or proposed structures, such as buildings, utilities, roads, or bridges

3. **IS THIS APPLICATION FOR** an annual maintenance permit? ☐ Yes X No
(If yes, an annual plan of operation must be attached to this application – see "Information for Applicant")

4. **PROPOSED CONSTRUCTION DATE.** Include a project timeline. Start date 10 / 01 /2010
Finish date 04 / 01 /2013 Is any portion of the work already completed? ☐ Yes X No
(If yes, describe the completed work.)

5. **WHAT IS THE PURPOSE** of the proposed project?
The purpose of the proposed action is to correct unsatisfactory passage conditions for endangered pallid sturgeon and other native fish in the lower Yellowstone River and reduce entrainment of fish into the Lower Yellowstone Project main canal.

6. **WHAT IS THE CURRENT CONDITION** of the proposed project site? Include a description of the existing vegetation, bank condition, bank slope, and height. What other structures are nearby?

Please see Existing Condition in the draft EA.

7. **PROVIDE A BRIEF DESCRIPTION** of the proposed project.
The project proposes to replace the existing Intake Diversion Dam structure with a concrete dam and rock ramp to: (1) raise the surface elevation of the Yellowstone River for diversion into the main canal, (2) improve fish passage, and (3) contribute to ecosystem restoration. A new main canal headworks structure with removable rotating drum screens to minimize entrainment also would be constructed. Please see the draft EA for a more detailed description

8. **PROJECT DIMENSIONS.** How many linear feet of bank will be impacted? How far will the proposed project encroach into and extend away from the water body?
Please See draft EA

9. **VEGETATION.** What type and how much vegetation will be removed or covered with fill material?

10. **MATERIALS.** Describe the materials to be used and how much.

Cubic yards/Linear feet	Size and Type	Source
Please See draft EA		

11. **EQUIPMENT**. What equipment is proposed to be used for the work? Where and how will the equipment be used on the stream bank and/or the waterbody?
Please See draft EA

12. **CONSIDER THE IMPACTS** OF THE PROPOSED PROJECT, EVEN IF TEMPORARY. Describe planned efforts during and after construction to:

- Minimize erosion, sedimentation, or turbidity?
- Minimize stream channel alterations?
- Minimize effects to stream flow or water quality caused by materials used or removal of ground cover?
- Minimize effects on fish and aquatic habitat?
- Minimize risks of flooding or erosion problems upstream and downstream?
- Revegetate/protect existing vegetation and control weeds?

13. **WHAT ARE THE NATURAL RESOURCE BENEFITS** of the proposed project?

Please See draft EA

14. **LIST ALTERNATIVES** to the proposed project. Why was the proposed alternative selected?

Please See draft EA

D. ADDITIONAL INFORMATION FOR SECTION 404, SECTION 10, AND FLOODPLAIN PERMITS. If applying for a Section 404 or Section 10 permit, fill out questions 1-3. If applying for a floodplain permit, fill out questions 3-6. (Additional information is required for floodplain permits – See "Information for Applicant.")

1. Will the project involve placement of fill material in a wetland? If yes, describe. How much wetland area will be filled? Calculate the area impacted by fill activity or other disturbance. Note: A delineation of the wetland may be required.

Please See draft EA

2. If there is a plan for compensatory mitigation, describe the location, type, and amount of proposed mitigation. Attach additional sheet if necessary.

3. List the names and address of landowners adjacent to the project site. This includes properties adjacent to and across from the project site. (Some floodplain communities require certified adjoining landowner lists).

   Dennis Scarnecchia, PO Box 3192, Moscow, ID 83843

4. List all applicable local, state, and federal permits and indicate whether they were issued, waived, denied, or pending. Note: All required local, state, and federal permits, or proof of a waiver, must be issued prior to the issuance of a floodplain permit.

5. Floodplain Map Number ______________

6. Does this project comply with local planning or zoning regulations? ☐ Yes ☐ No

E. SIGNATURES/AUTHORIZATIONS

Each agency must have original signatures signed in blue ink.

After completing the form, make the required number of copies and **then sign each copy.** Send the copies with original signatures and additional information required directly to each applicable agency.

The statements contained in this application are true and correct. I possess the authority to undertake the work described herein or I am acting as the duly authorized agent of the landowner. I authorize inspection of the project site after notice by inspection authorities.

APPLICANT: US Army Corps of Engineers
Print Name: Tiffany Vanosdall

LANDOWNER: BUREAU OF RECLAMATION
Print Name: CLAYTON JORDAN

[signature] 8/24/09
Signature of Applicant Date

[signature] 8/24/09
Signature of Landowner Date

*CONTRACTOR/AGENT:
Print Name: ______________

____
Signature of Contractor/Agent Date
*Contact agency to determine if contractor signature is required.

US Army Corps of Engineers ®
Omaha District

PUBLIC NOTICE

Application No: NWO-2008-02556-MTB
Applicant: US Army Corps of Engineers
Waterway: Yellowstone River
Issue Date: September 4, 2009
Expiration Date: September 25, 2009

21 DAY NOTICE

Billings Regulatory Office | Post Office Box 2256 | Billings, Montana 59103

JOINT PUBLIC NOTICE
FOR PERMIT APPLICATION SUBMITTED TO
U.S. ARMY CORPS OF ENGINEERS
AND
MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY

Under the provisions of Federal regulations 33 C.F.R. 335-337 and instructions from the Office, Chief of Engineers, Washington, D.C., relative to Federal projects involving the discharge of dredged or fill material in waters of the United States, notice is hereby issued to advise interested parties of a proposed Intake Dam modification project on the Yellowstone River near Intake in Dawson County, Montana.

Sections 313 and 404 of the Clean Water Act (33 U.S.C. 1323 and 1344) require each agency of the Federal Government engaged in any activity resulting in, or which may result in the discharge or runoff of pollutants, to comply with Federal, State, or interstate and local requirements respecting the control and abatement of water pollution to the same extent as any person or entity is subject to such requirements. In accordance with 33 C.F.R. 335-337, activities involving the discharge of dredged or fill material to be performed by the Corps of Engineers will be subject to public review procedures that are followed in processing applications for Section 404 permits.

The proposed project is located on the Yellowstone River in Section 25, Township 18 North, Range 56 East, Dawson County, Montana. Construction of the Lower Yellowstone Project began in 1905 under the Reclamation Act of 1902 and included Intake Diversion Dam – a 12-foot high wood and stone structure that spans the Yellowstone River and raises the water level for diversion of water into the main canal. Intake Diversion Dam likely has impeded upstream migration of pallid sturgeon, an endangered species, and other native fish for more than 100 years. The dam is likely a total barrier to several fish species, including pallid sturgeon, due to increased turbulence and velocities associated with the rocks at the dam downstream.

The purpose of the project is to correct unsatisfactory passage conditions for endangered pallid sturgeon and other native fish in the lower Yellowstone River and reduce entrainment of fish into the Lower Yellowstone Project main canal. The proposed project is needed to:

a. Improve upstream and downstream fish passage for adult pallid sturgeon and other native fish in the lower Yellowstone River.

b. Minimize entrainment of pallid sturgeon and other native fish into the Lower Yellowstone Project main canal.

c. Continue effective operation of the Lower Yellowstone Project in compliance with the Endangered Species Act (ESA).

d. Contribute to restoration of the lower Yellowstone River ecosystem.

Many alternatives were considered as a means to solve the fish passage problem at the dam. The following alternatives were identified for further study:

Take no Federal action involves continuing the present operation of the Lower Yellowstone Project. This alternative will continue to create a barrier to pallid sturgeon and other fish species and does not meet the project purpose.

Relocating the main channel would move the main channel of the Yellowstone River from its current location to bypass the existing Intake Diversion Dam. The relocated channel would have a steeper slope than the natural riverbed in order to reliably divert flow into the main canal without pumping. The relocated channel would be paired with a new headworks and removable rotating drum screens to prevent entrainment of fish into the main canal. It would also allow regulation of diversion flows into the Lower Yellowstone Project. This alternative is not the least costly or the least environmentally damaging alternative.

Construction of a rock ramp would replace the existing timber and rock Intake Diversion Dam with a concrete dam that would have a shallow-sloped ramp to provide fish passage. The rock ramp is designed to mimic natural river function and would lower velocities and turbulence so that migrating fish could seamlessly pass over the dam. The new dam and rock ramp would be paired with a new headworks with rotating removable drum screens, which would minimize entrainment of fish into the main canal and regulate irrigation diversions. This alternative best meets the project purpose and is the least environmentally damaging alternative. Therefore, the rock ramp alternative is the recommended plan for construction.

The replacement concrete dam would be located downstream of a new headworks to create sufficient water height to divert 1,374 cfs into the main canal. This concrete dam would replace an existing timber and rock-filled dam providing long-term durability lacking in the current structure.

A rock ramp would be constructed downstream of the replacement dam by placing rock and fill material in the river channel to shape the ramp, and then it would be covered with rock riprap. The ramp would provide flow characteristics that meet the swimming abilities of the pallid sturgeon, so the endangered fish would have unimpeded access to habitat upstream of the dam. The rock ramp would be constructed to be relatively flat (approximately 0.5% slope) over much of its width to keep flow velocities as low as possible. The final configuration of the rock ramp would be optimized for pallid sturgeon passage using ongoing computer and physical scale modeling.

The new rock ramp would be constructed over the site of the existing Intake Diversion Dam, preserving most of the historic dam in place. Because the existing dam's rock field has washed downstream, part of the existing dam crest might be removed and rock moved to accommodate construction of a ramp. The rock ramp would include at least one low flow channel in conjunction with the low flow channel on the crest, which would allow fish migration during low flows. The rocks in the ramp would be sized to withstand high flows and ice jams and would range from one to four feet in diameter. The largest rocks would be placed near the crest to resist ice forces. Approximately 400,000 tons of rock and fill would be needed to construct the ramp. The rock should be available from existing commercial quarries in Glendive or Limestone, Montana, and would be transported to the project site by truck or rail depending on the source.

The rock ramp alternative would include excavation of a new segment of the main canal to connect the new headworks structure to the existing canal. The new canal extension would mimic the existing main canal geometry. The location of the new canal extension would correspond with a relatively high bank and hillside along the north bank of the Yellowstone River. Material excavated during construction of the new canal would be used to fill the existing canal behind the current headworks. Any excess material would be used as fill for the rock ramp and/or to build cofferdams needed to control water during construction. The new canal embankments would include access roads along each side for maintenance purposes and for stabilization of the cut slope.

A new headworks structure would control diversion of water into the canal extension, and rotating removable drum screens would be installed in the new headworks to minimize entrainment of fish into the canal. The new headworks and fish screen facility for this alternative would need 14 gates with rotating removable cylindrical screens.

A location map is attached to this notice. Drawings showing the areas of impact and extent of the project are available at https://www.nwo.usace.army.mil/html/od-rmt/pn/pn.html.

Impacts to wetland areas and existing streams were avoided and minimized by locating access roads and other features of the project outside of wetland areas and by pursuing the action alternative with the least impact on the Yellowstone River. No mitigation is proposed at this time. The construction of the rock ramp alternative will benefit aquatic species by greatly improving passage conditions at the site and by minimizing entrainment into the canal.

The Montana Department of Environmental Quality, 1520 East 6th Avenue, PO Box 200901, Helena, Montana 59620-0901 will review the proposed project with the intent to certify in accordance with the provisions of Section 401 of the Clean Water Act. The certification, if issued, will express the State's opinion that the operations undertaken by the applicant will not result in a violation of applicable water quality standards. The Montana Department of Environmental Quality hereby incorporates this public notice as its own public notice and procedures by reference thereto.

The Corps of Engineers, Omaha District will comply with the National Historic Preservation Act of 1966, as amended. Inventories of the site found that there are 13 cultural resources within or adjacent to the project area. Of the 13 resources, six are significant and eligible for listing on the National Register of Historic Places, and the significance of one prehistoric archaeological site has not been determined. Before the project is constructed, consultation will be completed with the Montana State Historic Preservation Officer and other interested parties, as appropriate, to assess the effects of the proposed project on the identified historic properties and resolve potential adverse effects under Section 106 of the National Historic Preservation Act.

This project is in the known range of the endangered **Pallid Sturgeon** (*Scaphirhynchus albus*), **Interior Least Tern** (*Sterna antillarum athalassos*), and **Whooping Crane** (*Grus americana*). In compliance with the Endangered Species Act, a preliminary "may affect, not likely to adversely affect" determination has been made for the pallid sturgeon and Interior least tern; and a "no effect" determination has been made for the whooping crane. Coordination with the U.S. Fish and Wildlife Service and other interested agencies will be completed to determine the effects on these species or their critical habitat.

The decision whether to authorize the project will be based on an evaluation of the probable impacts, including cumulative impacts, of the proposed activity on the public interest. That decision will reflect the national concern for both protection and utilization of important resources. The benefits which reasonably may be expected to accrue from the proposed activity must be balanced against its reasonably foreseeable detriments. All factors which may be relevant to the proposal will be considered, including the cumulative effects thereof; among those are conservation, economics, aesthetics, general environmental concerns, wetlands, historic properties, fish and wildlife values, flood hazards, floodplain values, land use, navigation, shoreline erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs, considerations of property ownership and, in general, the needs and welfare of the people. In addition, the evaluation of the impact of work on the public interest will include application of the guidelines promulgated by the Administrator, Environmental Protection Agency, under authority of Section 404(b) of the Clean Water Act (40 C.F.R.; Part 230).

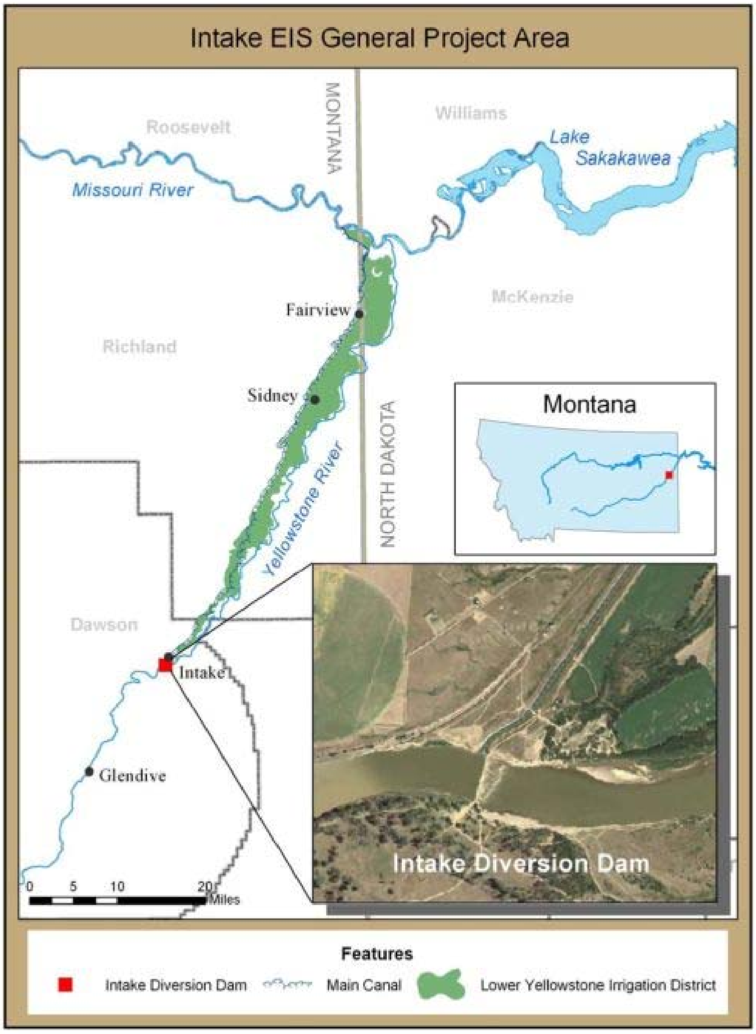
The Corps of Engineers is soliciting comments from the public; Federal, state, and local agencies and officials; Indian Tribes; and other interested parties in order to consider and evaluate the impacts of this proposed activity. Any comments received will be considered by the Corps of Engineers to determine whether to issue, modify, condition or deny a permit for this proposal. To make this decision, comments are used to assess impacts on endangered species, historic properties, water quality, general environmental effects, and the other public interest factors listed above. Comments are used in the preparation of an Environmental Assessment and/or an Environmental Impact Statement pursuant to the National Environmental Policy Act. Comments are also used to determine the need for a public hearing and to determine the overall public interest of the proposed activity. All public notice comments will be considered public information and will be subject to review by the applicant.

Any person may request, in writing and within the comment period specified in this notice, that a public hearing be held for the purpose of gathering additional information. Requests for public hearings must be identified as such and shall state specifically the reasons for holding a public hearing and what additional information would be obtained. The request must be submitted to the U.S. Army Corps of Engineers, 10 West 15th Street, Suite 2200, Helena, Montana 59626. If it is decided that additional information is required and that a public hearing should be held, interested parties will be notified of the date, time and location.

Any interested party (particularly officials of any town, city, county, state, or Federal agency; Indian tribe; or local association whose interests may be affected by the work) is invited to submit to this office written facts, arguments, or objections on or before the expiration date listed on the front of this notice. Any agency or individual having an objection to the work should specifically identify it as an objection with clear and specific reasons. Comments, both favorable and unfavorable, will be accepted, made a part of the record and will receive full consideration in subsequent actions on this application. All replies to the public notice should be addressed to the **U.S. Army Corps of Engineers, Post Office Box 2256, Billings, Montana 59103**. **Please reference the Application Number found on the first page of this notice in any correspondence.** Cathy Juhas, telephone number (406) 657-5910, may be contacted for additional information. You may also fax your comments to (406) 657-5911, or email to: **Catherine.d.juhas@usace.army.mil**

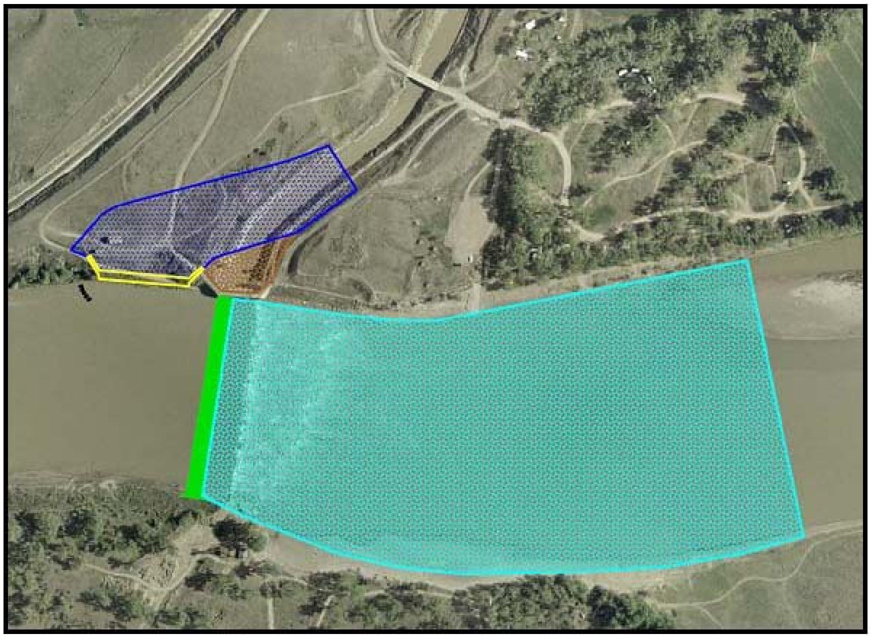
Comments postmarked after the expiration date of this public notice will not be considered. Comments left on our voicemail system will not be considered.

Figure 1: Site Map 2008-02556



5

Figure 2: Rock Ramp 2008-02556 (dam shown in green, ramp in turquoise, canal extension in blue, new headworks in yellow, and existing headworks in brown, and bollards in black).



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File No. NWO-2008-02556-MTB
Corps of Engineers
Intake Dam Modification
Yellowstone River
Dawson County, Montana

Section 404(b)(1) Guidelines [40 CFR Part 230]

Physical and Chemical Characteristics (Subpart C)

Physical Substrate (230.20). Long-term effects of the rock ramp consist of an improvement in the slope of the diversion dam in the area of the existing Intake Diversion Dam and associated features. The slope of the proposed rock ramp will be more gradual than the existing diversion dam and will more closely emulate natural channel characteristics. The project would permanently affect 32 additional acres in the channel migration zone and decrease the amount of bank stabilizing structures by 168 ft when compared to existing conditions. The rock ramp will restore hydrologic and biological connectivity of the Yellowstone River and contribute to ecosystem restoration. The result of dumping rock at the existing dam for over 100 years has resulted in a degraded riverbed that is impassable by indigenous aquatic species. The rock ramp will mimic a more natural substrate locally and will restore spawning and rearing migratory access for aquatic species in 165 additional miles of the Yellowstone River, as well as many miles of tributary streams such as the Tongue and Powder Rivers.

Suspended Particulates and Turbidity (230.21). Project construction will result in short term increases in turbidity that are expected to be temporary. Special conditions will be developed and enforced so that all work in the waterway is performed in such a manner that minimizes increases in suspended solids and turbidity. This will minimize degradation of water quality and limit damage to aquatic life outside the immediate area of operation.

Water (230.22). Direct, indirect, and long-term impacts of the work on water clarity, nutrients and chemical content, physical and biological content, dissolved gas levels, pH, and temperature are not expected. Short-term construction related impacts will result in temporary impacts to water clarity. No long-term changes in water quality are anticipated as a result of the project.

Current Patterns and Water Circulation (230.23). One intended purpose of the project is to alter the flow characteristics at the site, ultimately ending up with flow conditions that are conducive to the upstream migration of a range of aquatic species. The hydrologic and geomorphic performance of the Yellowstone River will be altered and improved by allowing aquatic organism passage above and below the Intake Diversion Dam. This will benefit many aquatic species that utilize the habitat both upstream and downstream of the dam. Impacts of the work on current patterns and water circulation include the short-term, temporary disruption of the existing flow patterns in the waterways as the project is constructed. The project is designed to sufficiently transmit expected high flows.

Normal Water Fluctuations (230.24). The timing and seasonal variation of flow in the Yellowstone River is not related to existing structures or to the proposed project. The rock ramp will not impact the seasonal timing of flow in the river. No upstream or downstream flooding will occur or be created by the construction activities of this project. Overall, the same amount of irrigation water will be withdrawn from the Yellowstone River at this location, and the amount of water that flowed past the diversion prior to this project will remain unchanged.

Salinity Gradients (230.25). The Yellowstone River is an inland, non-coastal waterway. No impacts are expected on Salinity Gradients.

Biological Characteristics (Subpart D).

Threatened and Endangered Species (230.30). Federally listed, proposed, or candidate species that could occur in the project vicinity include the following: pallid sturgeon (*Scaphirhynchus albus*), interior least tern (*Sterna anitllarum athalassos*), and whooping crane (*Grus americana*).

In a letter dated December 28, 2009, the U.S. Fish and Wildlife Service (FWS) concurred with the Corps' determination that the project is not likely to adversely affect the whooping crane, pallid sturgeon, and interior least tern. This determination was based on the *Biological Assessment for the Intake Diversion Dam Modification, Lower Yellowstone Project* prepared by Reclamation. This document can be found in Appendix D of the Environmental Assessment (EA). This concluded informal consultation with the FWS.

Fish and Other Aquatic Organisms (230.31). Construction on the riverbank could result in the loss of mussels living there. Two mussel species occur at the project site, the native fatmucket mussel and the introduced mapleleaf mussel. Neither species is a State species of special concern. Rock ramp placement could cover mussel beds below the Intake Diversion Dam, and the headworks construction could affect approximately 24 mussels, which is insignificant. With special conditions to minimize effects, the long-term impacts of construction activities on macroinvertebrate assemblages would be minor. Because large, stable substrates such as boulders and cobbles support larger, more productive invertebrate populations than do unstable gravel and sand substrates, creation of the rock ramp will minimally improve the diversity of the macroinvertebrate community. The rock ramp project, when compared to the existing diversion dam, will benefit fish by improving upstream passage of fish and reducing entrainment of fish into the irrigation canal network. The rock ramp will have lower velocities and greater depth than flow across the existing dam, improving fish passage. In essence, the rock ramp will function as a long riffle, allowing passage and providing foraging and spawning habitat for a variety of fish and other aquatic species. Additionally, there will be less staging of fish, including pallid sturgeon and paddlefish, below the diversion dam, which should reduce mortality by natural predators and anglers.

Other Wildlife (230.32). Wildlife within the area consists of white-tailed deer, mule deer, least chipmunk, ground squirrels, voles, and field mice. Birds that likely occur in the area include meadowlarks, red-winged blackbirds, eagles, waterfowl, and marsh wrens.

The project will have no new permanent adverse effects on species indigenous to the area. There may be adverse effects during construction, but these effects will be temporary and short-term.

Special Aquatic Sites (Subpart E).

Sanctuaries and Refuges (230.40). None present.

Wetlands (230.41). None present.

Mud Flats (230.42). None present.

Vegetated Shallows (230.43). None present.

Coral Reefs (230.44). None present.

Riffle and Pool Complexes (230.45). None present.

Human Use Characteristics (Subpart F).

Municipal and Private Water Supplies (230.50). The proposed project will have no impact on municipal or private water supplies. The proposed project will continue to deliver the same amount of irrigation water for agriculture as the existing diversion dam.

Recreational and Commercial Fisheries (230.51). During project construction anglers using either side of the river might experience short-term impacts when access to the river is temporarily restricted within the construction zone. Construction activities in the river will also restrict fishing opportunities temporarily. Fishing outside the construction zone will still be available.

During and after project construction, snagging for paddlefish could be impacted. Project construction activities may alter paddlefish concentrations at the dam site discouraging paddlefish from lingering below the dam. This may reduce the number of paddlefish snagged at the Intake Fishing Access Site (FAS). However, this could increase overall snagging opportunities if more paddlefish migrate up river. Historically, the paddlefish season at Intake is closed when a designated number of paddlefish are snagged. This often occurs before the season’s established closing date. Without the high numbers of paddlefish snagged at Intake, the yearly quota might not be filled as quickly, and the season might stay open longer affording anglers more days to snag paddlefish until the quota is either met or the season officially ends.

Once project construction is completed, paddlefish will be less inclined to congregate or linger at the Intake FAS due to improved upstream passage conditions across the new rock ramp. This will likely reduce paddlefish snagging opportunities at the FAS and replace that with more dispersed snagging opportunities further up river. Paddlefish may benefit from additional spawning areas up river and in large tributaries, which could improve reproduction and increase populations.

The commercial fishery onsite is a byproduct of the recreational paddlefish fishery on the lower Yellowstone River. The Glendive Chamber of Commerce and Agriculture (Chamber of Commerce) administers the Yellowstone Caviar program. Before and after project construction anglers will be able to donate roe from paddlefish snagged between Glendive and the Montana/North Dakota State line to the Chamber of Commerce; and, the Chamber of Commerce will be able to accept and process the donated paddlefish roe into caviar. Project construction should not reduce the number of paddlefish in the Yellowstone River or the quota for the number of paddlefish to be taken. However, during and after Intake Project construction the Yellowstone Caviar program could be impacted by a number of factors. Most of the donated roe comes from paddlefish that are currently snagged below the Intake Dam. Impacts from restricted angler access to the river or reduced numbers of paddlefish snagged at the FAS could result in less paddlefish roe donated to the program, unless the Chamber of Commerce maximizes its authorized opportunities to collect paddlefish snagged between Glendive and the North Dakota-Montana state line.

Water-Related Recreation (230.52). Once project construction activities begin, the boat ramp will be closed periodically. After project completion, the boat ramp will be closed permanently. This will impact recreationists wishing to launch boats at Intake FAS for boating, fishing, or hunting activities on the river.

The lack of a concrete boat ramp may result in fewer yearly visitors to the FAS, until a new boat ramp is constructed at or near the Intake FAS. Reclamation and the FWP will evaluate and the Corps will construct either a new boat ramp at the existing Intake FAS, a new boat ramp immediately adjacent to the existing Intake FAS, or a new boat ramp at a site near the existing Intake FAS on the west side of the Yellowstone River and accessible by Highway 16.

There are several other locations of boat ramps above and below the Intake FAS. Boaters would have to travel greater distances to access a concrete boat ramp. The “water taxi” that operates during the paddlefish season would launch and be retrieved further downstream. There is a “primitive” ramp at the Elk Island FAS, a distance of 20 miles downstream. If the water taxi needs to launch from a concrete ramp, the boat would have to be launched at the Sidney Bridge FAS, a distance of 41 miles downstream.

Any action that reduces access to the river could impact hunting and fishing activities at and around the FAS. A 20 mile upstream boat trip from Elk Island would be a difficult trip for most boaters. Reducing boat access to the river for fishing may also impact the Yellowstone Caviar program. Anglers cannot fish or snag for paddlefish or any other species from a boat within ¼ mile downstream of Intake Dam. However, this existing restriction does not prevent boaters from launching at Intake FAS and boating below the closed area to snag paddlefish.

The project will change the grade of the dam at Intake FAS. A gentler slope with a higher river level over the dam could allow for greater boat traffic up river and down river of the FAS.

Aesthetics (230.53). The project will have a minimal permanent effect on the visual characteristics of the area. The proposed project will not be a substantial visual change from the existing site conditions. Aesthetics analyses are somewhat of a subjective realm of evaluation, and whether or not the visual impacts are seen as beneficial or adverse typically varies amongst individuals.

Contaminant Evaluation and Testing (Subpart G). Between Intake and the North Dakota border, the river is classified as “fully supporting” the use of water use for agriculture, drinking water, industrial uses, and primary contact recreation. Beneficial use for aquatic life and warmwater fisheries are classified as “partially supporting,” with impairments related to elevated concentrations of some trace elements and nutrients, pH, unnatural sedimentation, and total dissolved solids (TDS) (Montana DEQ 2006). Exceedances of most water quality standards are uncommon, but when they do occur they are often naturally caused. In addition, Intake Diversion Dam is listed as a probable source of impairment for the indigenous warmwater fishery and other aquatic species related to the inability of fish and other organisms to migrate upstream past the diversion dam. The Yellowstone River reach from the mouth of the Powder River (located upstream) to Intake is also listed as 'partially supporting" for warmwater fisheries due to impaired fish passage at Intake. Warmwater fisheries resources, including the listed pallid sturgeon, would benefit from improved fish passage at the Intake Diversion Dam.

Permit conditions will require care in use of petroleum products within and in the vicinity of the river. See Chapter 3 of the EA for more information on contaminant evaluation and testing.

Actions to Minimize Adverse Effects (Subpart H). Over 100 alternatives were examined for the Intake Diversion Dam modification project. These alternatives were evaluated based on factors including practicability and environmental impact. Three alternatives were carried into the EA. These three alternatives were No Action, Channel Relocation, and the Rock Ramp. Neither the No Action alternative nor the Channel Relocation alternative were chosen because of their inability to meet the project purpose and because of their ongoing or new adverse environmental impacts.

The rock ramp requires approximately 38 acres of fill material placed on the bed of the Yellowstone River. The current boulder field below the dam covers approximately 6 acres. The irrigation district has been dumping rock onto the crest of the dam for over 100 years. Much of this rock has been migrating downstream creating an impassable barrier for many aquatic species. The rock ramp will simulate a more natural river bed than what currently exists. The net improvement in aquatic resource function and services offsets the adverse impacts related to construction of the project. Any adverse impacts on the biological integrity of the Yellowstone River are expected to be offset by vastly improved upstream passage for the listed pallid sturgeon and other indigenous aquatic species. Entrainment of many fish species into the irrigation canal system will also be greatly reduced. Additionally, implementation of the proposed project will restore spawning and rearing access for several aquatic species in at least 165 miles of the Yellowstone River, as well as many miles of tributary streams.

The environmental commitments listed in Appendix N of the EA will ensure environmental protection measures such as erosion control and water quality protection are implemented, and will ensure the project is not contrary to the public interest.

Secondary and Cumulative Impacts.

Secondary impacts are the effects on an aquatic ecosystem that are associated with a discharge of dredged or fill material, but do not result from the actual placement of the dredged or fill material. Secondary effects are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. There will likely be secondary impacts associated with increased spawning for aquatic species and access to at least 165 more miles of Yellowstone River and miles of tributaries. These impacts will likely be beneficial. Currently unforeseeable secondary impacts will be identified and addressed by the Adaptive Management Strategy (Appendix J of the EA). Because the site has been degraded by operation of the existing Intake Diversion Dam, secondary effects are not expected to be adverse or significant. Reconstruction of this diversion dam will not increase the amount of water diverted into the irrigation canal. The proposed work will not result in more or less acres of land being irrigated. The proposed project will not alter land use in the lower Yellowstone River valley that it serves. Recreational boat traffic may increase as a result of the proposed work.

Cumulative impacts are the changes in an aquatic ecosystem that are attributable to the collective effect of a number of individual discharges of dredged or fill material. Although the impact of a particular discharge may constitute a minor change in itself, the cumulative effect of numerous separate actions can result in a major impairment of the water resources and interfere with the productivity and water quality of existing aquatic ecosystems. Cumulative effects attributable to the discharge of dredged or fill material in waters of the United States should be predicted to the extent reasonable and practicable.

Past: The table below shows the permits that have been issued in the drainage since 1976. The query was performed for work within a 5-mile radius of the project site.
Present: This project is the only pending application within the search area as of January 19, 2010.
Reasonably Foreseeable Future: There will likely be construction of at least one new boat ramp in this area. It is reasonably foreseeable that there will be additional requests for waterway manipulations associated with recreation. It is also reasonably foreseeable that any authorized wetland/riverine fills will be compensated through standard methods accepted by the Corps of Engineers. This project will result in no net loss of wetland area and function. This project will result in an increase in riverine function.

Description of past permits taken from the ORM2 database within a 5-mile radius of the proposed project site.

Corps File Number	Last Name	Permit Type	Impacts	Mitigation
NWO-1500-00271	Gentry	NP	unknown	unknown
NWO-1600-00759	Gentry	NP	unknown	unknown
NWO-1983-05110	Intake Water Company	IP	unknown	unknown
NWO-1983-05122	Intake Water Company	IP	unknown	unknown
NWO-1983-05125	Intake Water Company	IP	unknown	unknown
NWO-1990-12725	Temple Farms	LOP	unknown	unknown
NWO-1990-15611	Gentry	LOP	0.001 acres	0
NWO-1990-15927	Temple Farms	NP	unknown	unknown
NWO-1991-76693	Little	NP	0.006 acres	0
NWO-1996-90573	MT Fish, Wildlife, & Parks	RGP	91.7 cubic yards	0
NWO-1999-90673	Dawson County	NP	unknown	unknown
NWO-2000-90668	Burlington Northern Santa Fe Railway	NP	300 cubic yards	0
NWO-2002-90102	Burlington Northern Santa Fe Railway	NP	300 cubic yards	0
NWO-2002-90239	MT Dept. of Transportation	NW23	unknown	unknown
NWO-2002-90723	MT Dept. of Transportation	NP	unknown	unknown
NWO-2005-90268	MT Fish, Wildlife, & Parks	NP	0	0
NWO-2009-02863	MT Dept. of Transportation Site 1	NW23	243 feet	0
NWO-2009-02863	MT Dept. of Transportation Site 2	NW23	331 feet	0
NWO-2009-02863	MT Dept. of Transportation Site 3	NW23	0.109 acres	0
NWO-2009-02863	MT Dept. of Transportation Site 4	NW23	0.042 acres	0

Permit Type:
NW23 – Approved Categorical Exclusions
NP – Unknown Nationwide Permit
IP – Individual Permit
RGP – Regional General Permit
LOP – Letter of Permission

Total Impacts within the Assessment Area:
Linear Feet: 574
Acres: 0.152
Cubic Yards: 691.7

The issuance of Nationwide Permits issued since 1976 have contributed to incremental losses within the search area. However, some impacts are temporary; especially those permitted under NW33. Additionally, impacts reported under NW3 are generally for areas that have been previously impacted and maintenance is necessary. Those projects do not necessarily impact additional resources. Although the database does not specify which Nationwide Permits were issued for some projects, it is possible that some may be NW3 or NW33. Projects authorized by NWP 23 are categorically excluded from environmental documentation because they are included within a category of actions which neither individually nor cumulatively have a significant effect on the environment. If there have been any wetland and riverine losses due to previous projects in this area, they have been minimal.

Based on information from the Lower Yellowstone Project, repairs to the Intake Diversion Dam have been done without authorization from the Corps. While three permits were issued for the Intake Water Company in 1983, no permits have been issued for the dam since that time. The proposed Intake Diversion Dam modification project will mitigate for impacts associated with maintenance activities and operation of the Intake Diversion Dam.

I have concluded, based on best available information that this project will not have an adverse cumulative impact to this area.

Appendix C – List of Federally Listed Species and State Species of Special Concern

Introduction

This appendix lists status and common and scientific names used of federally listed species and species of special concern discussed in the EA and in the appendixes. Names appear alphabetically by common name, followed by scientific name.

Table C.1 - Species of Concern				
Common Name	**Scientific Name**	**MT[1]**	**ND[2]**	**ESA**
Bald eagle	*Haliaeetus leucocephalus*	X	X	
Baird's sparrow	*Ammodramus bairdii*	X	X	
Blue sucker	*Cycleptus elongatus*	X	X	
Bobolink	*Dolichonyx oryzivorus*	X		
Bractless blazingstar	*Mentzelia nuda*	X		
Brimstone clubtail	*Stylurus intricatus*	X		
Chestnut collared longspur	*Calcarius ornatus*	X		
Dwarf shrew	*Sorex nanus*	X		
Golden eagle	*Aquila chrysaetos*		X	
Grasshopper sparrow	*Ammodramus savannarum*	X		
Hayden's yellowcress	*Rorippa calycina*		X	
Lake chub	*Couesius plumbeus*		X	
Least tern	*Sterna antillarum*		X	MT and ND
Loggerhead shrike	*Lanius ludovicianus*	X		
Long-billed curlew	*Numenius americanus*	X		
Mayfly sp.	*Lachlania saskatchewanensis*	X		
Mayfly sp.	*Homoeoneuria alleni*	X		
Mayfly sp.	*Macdunnoa nipawinia*			
Meadow jumping mouse	*Zapus hudsonius*	X		
Milksnake	*Lampropeltis triangulum*	X		
Narrowleaf penstemon	*Penstemon angustifolius*	X		
Nine-anther prairie clover	*Dalea enneandra*	X		
Paddlefish	*Polyodon spathula*	X		
Pale-spike lobelia	*Lobelia spicata*	X		
Pallid Sturgeon	*Scaphirhynchus albus*			MT and ND
Poison suckleya	*Suckleya suckleyana*	X		
Prairie goldenrod	*Oligoneuron album*	X		
Preble's shrew	*Sorex preblei*	X		
Red-headed woodpecker	*Melanerpes erythrocephalus*	X		
Sagebrush lizard	*Sceloporus graciosus*	X		
Sauger	*Sander canadensis*	X		
Short-horned lizard	*Phrynosoma hernandesi*	X		
Sicklefin chub	*Macrhybopsis meeki*	X	X	
Silky Prairie-clover	*Dalea villosa*	X		
Snapping Turtle	*Chelydra serpentina*	X		
Sprague's pipit	*Anthus spragueii*	X		

Spiny Softshell	Apalone spinifera	X		
Sturgeon chub	*Macrhybopsis gelida*	X		
Townsend's big-eared bat	*Corynorhinus townsendii*	X		
Western Hog-nosed Snake	*Heterodon nasicus*	X		
Whooping Crane	*Grus americana*			MT and ND

1 MT species of special concern include taxa that are at-risk or potentially at-risk due to rarity, restricted distribution, habitat loss, and/or other factors. Data for the Project area comes from Montana Natural Heritage Program database as of January 2009. These data are not exhaustive or comprehensive inventories of rare species.

2 Species ranked as by the North Dakota Natural Heritage Program as S1, S2, and S3. Data for the Project area comes from North Dakota Natural Heritage Program database as of February 2009. These data are not exhaustive or comprehensive inventories of rare species.

Appendix D – Biological Assessment for Construction Activities Associated With the Intake Diversion Dam Modification, Lower Yellowstone Project and U.S. Fish & Wildlife Service Concurrence

Introduction

This appendix is a Biological Assessment (BA) for Endangered Species Act (ESA) Section 7 consultation for the proposed Intake Diversion Dam Modification, Lower Yellowstone Project (Intake Project). It also contains detailed information to support the Federally-Listed Species and State Species of Special Concern section in chapter four of the Intake Project Environmental Assessment (Intake EA). Where appropriate, this BA incorporates by reference details in the Intake EA.

The U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and the U.S. Army Corps of Engineers (Corps) are proposing to modify Intake Diversion Dam to improve passage for the endangered pallid sturgeon and other native fish and to reduce entrainment of fish into the Lower Yellowstone Project's main canal at Intake, Montana (see Intake EA chapter one, figure 1.1). The Intake EA analyzes and discloses effects associated with construction of the proposed modifications to the Intake Diversion Dam and Lower Yellowstone Project's main canal headworks. Reclamation and the Corps are joint-lead agencies for preparation of the Intake EA. Reclamation is the administrative lead agency for the National Environmental Policy Act (NEPA) activities associated with the proposed Intake Project.

On May 12, 2009, Reclamation, the Corps, and the U.S. Fish and Wildlife Service (Service) reached an agreement that informal Section 7 consultation is appropriate for the construction of the proposed Intake Project, so long as concurrent formal Section 7 consultation continues on operations of the Lower Yellowstone Project. The formal Section 7 consultation addresses operation of the new proposed Intake Project structures, in addition to operation of the overall Lower Yellowstone Project. Therefore, this BA focuses only on construction of the proposed fish passage and entrainment protection structures.

Background and History

Federal Action History and Project Section 7 Consultation History

Identification of the Rock Ramp Alternative as the preferred alternative in the Intake Project EA was a result of Section 7 consultation that began in 1992 and Intake EA preparation that began in September 2008. The pallid sturgeon was listed as endangered in 1990. This Section 7 consultation history is briefly discussed in chapters one and five of the Intake EA. Important milestones in Reclamation's Section 7 consultation with the Service are listed in table D.1.

A number of important ESA consultation documents are referred to in table D.1 and in this BA. The first is the *Draft Biological Assessment: Future Operation of the Lower Yellowstone Project with Proposed Conservation Measures* prepared by Reclamation in 2005 (Lower Yellowstone Project Operation BA). The second is the *Biological Opinion on Missouri River Operations* prepared by the Service in 2000 (Missouri River BO). Third is the BA presented in this Appendix, *Biological Assessment for the Intake Diversion Dam Modification, Lower Yellowstone Project* (Intake Project BA).

Table D.1 - History of Reclamation Actions Taken During Section 7 Consultation on Lower Yellowstone Project.

Date	Report Name	Author	Summary
September 1992	Memorandum	Service	Documented Service staff conversation with Reclamation staff that Section 7 consultation should be initiated on fish passage issues at Intake Diversion Dam.
November 1993	*Pallid Sturgeon Recovery Plan*	Service	*The Pallid Sturgeon Recovery Plan* report prepared by a multi-disciplinary recovery team includes an introduction on pallid sturgeon issues, recovery objectives, and implementation schedule. It recommends federal agencies address passage and entrainment issues.
February 1996	Memorandum	Reclamation	Reclamation requested Service provide a species list for potential title transfer at Intake.
February 1996	Memorandum	Service	Service transmitted list of species to be included in consultation on title transfer of the Lower Yellowstone Project.
1997	*Lower Yellowstone River Fish Passage and Protection Study,* (Reclamation and Montana Fish, Wildlife & Parks (FWP) 1997)	Reclamation and FWP	Cooperative effort between Reclamation and FWP to address fish passage at Intake, Montana.
1997	*Fish Passage and Protection Program in the Yellowstone River Basin, Montana. Literature Summaries for Key Fish Species*	Reclamation	Reclamation synthesized available fisheries data.

Date	Report Name	Author	Summary
September 1999	Interagency Meeting	Service and Reclamation	Discussed the need to recognize fish passage and entrainment as significant issues to be addressed through Section 7 consultation.
Fall 1999	Memorandum with preliminary draft Lower Yellowstone Operation BA	Reclamation	Shared preliminary draft Lower Yellowstone Operation BA with the Service.
November 1999	Memorandum	Service	Service commented on preliminary draft stating that the project at Intake is "likely to adversely affect" pallid sturgeon, sturgeon chub (candidate species), and sicklefin chub (candidate species). Requested modifying the Lower Yellowstone Operation BA on operations to include fish passage and protection.
December 1999	Fax	Reclamation	Sent Service's comments to Intake Board of Control
January 2000	*Intake Diversion Dam Fish Protection and Passage Concept Study Report*	Reclamation	Summarized baseline fishery data, as well as entrainment fish data, to identify future headwork modifications.
February 2000	Memorandum with final Lower Yellowstone Operation BA	Reclamation	Identified adverse impacts to pallid sturgeon, sicklefin chub and sturgeon chub
March 2000	Memorandum	Service	Acknowledged receipt of Lower Yellowstone Operation BA and estimated that a biological opinion (BO) on the Lower Yellowstone Project would be completed by August 2000.
April 2000	*Fish Entrainment at the Lower Yellowstone Diversion Dam, Intake Canal, Montana 1996-1998*	Reclamation	Analyzed fishery data collected on the lower Yellowstone River and entrained fish data to use in modifying the Lower Yellowstone Project main canal headworks. From 1996 to 1998 fish entrained into the Intake main canal were sub-sampled and enumerated.
May 2000	Field Trip	Reclamation and Board of Control	Site visits to Yakima, Washington, and Redding, California, to look at fish screen and passage options.
July-August 2000	Telephone call and Site visit	Reclamation and Service	Service requested extension of consultation deadline and a site visit to the Intake Diversion Dam site.
August 2000	Memorandum	Reclamation	Notified Service that timeline is critical to the title transfer process and set deadline for BO by September 2000.
August 2000	Meeting	Reclamation and Service	Initiated internal discussions of whether to amend the Lower Yellowstone Operation BA to include fish screen and passage as proposed actions. Service agreed to provide supporting information and that amending the Lower Yellowstone Operation BA could be done by letter to the Service.

Date	Report Name	Author	Summary
September 2000	Memorandum	Service	Provided data supporting the need for fish passage and entrainment protection and requested Reclamation modify the Lower Yellowstone Operation BA, understanding that the Service would wait for Reclamation to decide whether to amend the BA before proceeding with preparation of a BO.
November 2000	Meeting	Reclamation, Service, and Board of Control	Discussed the Lower Yellowstone Operation BA, need for fish passage and protection, and Reclamation's decision to include conservation measures.
November 2000	*Biological Opinion on Missouri River Operations*	Service	Service completed and transmitted BO on Missouri River Operations to Corps of Engineers that included recommendation to work with Reclamation on modifying the Intake Diversion Dam.
January 2001	Meeting	Reclamation and Corps	Discussed development of fish passage alternatives with Corps write-in budget.
March 2001	Letter	Reclamation	Sent Board of Control amended draft Lower Yellowstone Operation BA for review that included conservation measures to build a rock fishway and flat plate linear screen.
March 2001	Memorandum	Reclamation	Sent the Service draft Lower Yellowstone Operation BA amended to include conservation measures to build rock fishway and flat plate linear screen.
April 2001	Meeting	Service and Reclamation	Status check on ESA issues in Montana including Intake Project.
May 2001	Memorandum	Service	Provided comments to Reclamation on Lower Yellowstone Operation BA. Recommended format change, proposed including fish passage and entrainment modifications as proposed action and doing effects analysis. Also asked for additional operational guidelines, analysis of efficiency of the system, genetic analysis between pallid and shovelnose sturgeon, and recommended additional discussion regarding the rock that has been displaced downstream creating a passage impediment.
May 2001	Meeting	Reclamation and the Corps	Discussed coordination of fish passage and protection concept development. The Corps agreed to fund a sturgeon swim study. Proposed looking at a wide range of fish passage alternatives, including Obermeyer weirs, as requested by the Service.
July 2001	Letter	Reclamation	Requested final comments on revised Lower Yellowstone Operation BA from the Board of Control.

Date	Report Name	Author	Summary
July 2001	Letter	Board of Control	Sent letter to Reclamation on Lower Yellowstone Operation BA including questions about the Service's concerns that rock displacement below the dam impedes fish passage.
August 2001	Memorandum with final Lower Yellowstone Operation BA	Reclamation	Transmitted Lower Yellowstone Operation BA including modifications to the Intake Project.
November 2001	Memorandum	Reclamation	Requested the Service suspend work on formal consultation due to new information being developed on fish passage and protection concepts.
January 2001	Meeting	Reclamation, Corps, and Service	Discussed pallid sturgeon swim study.
January 2002	*Assessment of Behavior and swimming Ability of the Yellowstone River Sturgeon for Design of Fish Passage Devices*	Reclamation	Reclamation prepared report to help in alternative design for fish passage.
June 2002	*Lower Yellowstone River Intake Dam Fish Passage Alternatives Study*	Corps	The Corps completed an alternative analysis for fish passage at Intake Diversion Dam.
July 2002	*Value Engineering Final Report: Intake Diversion Dam Fish Protection and Passage Concept Design, Lower Yellowstone*	Reclamation	The Value Study Team developed several preliminary proposals for improving fish screening and passage at Intake Diversion Dam.
February 2003	Meeting	Reclamation, Service, FWP, and Western Area Power Administration	Discussed research to determine available pallid sturgeon habitat above Intake Diversion Dam.
May 2003	*Test Results of Intralox Traveling Screen Material*	Reclamation	Intralox, Inc., requested that a section of their conveyor belt material be tested in Reclamation's Water Resources Research Laboratory to determine if it would be suitable for use as a vertical traveling positive fish screen barrier.
October 2003	Staff communications	Reclamation and Service	Concern raised that Obermeyer weir would not provide sufficient passage. Service preferred Obermeyer weir over uncertainties associated with a rock ramp.
April 2004	*Intake Diversion Dam Fish Protection and Passage Concept Study Report II*	Reclamation	This report evaluated additional concepts that were not included in the January 2000 *Intake Diversion Dam Fish Protection and Passage Concept Study Report.*
March 2004	Staff communication	Reclamation and Service	Concerns discussed about screen bypass working under high flows. Service suggested 80,000 cubic feet/second as criteria for screen bypass to function.

Date	Report Name	Author	Summary
March 2005	Meeting	Reclamation, Corps, FWP, Service, and the Nature Conservancy	Established partnership with MOU signed in July 2005.
April 2005	Conference	Reclamation, Corps, FWP, Service, and the Nature Conservancy	Public announcement of partnership to resolve fish passage and entrainment issues at Intake.
April 2005	*Draft Biological Assessment: Future Operation of the Lower Yellowstone Project with Proposed Conservation Measures*	Reclamation	Reclamation prepared a Lower Yellowstone Project Operation BA to evaluate the potential effects of future operation of the Lower Yellowstone Project on federally-listed threatened or endangered species and designated critical habitat. It included proposed conservation measures.
May 2005	Meeting	Corps, FWP the Nature Conservancy, Reclamation, and others	Agencies expressed concern for effectiveness of proposed fishway. Reclamation and partners agreed to take another in-depth look at fish passage alternatives and to develop other alternatives.
August 2005	*Lower Yellowstone Fish Passage Alternatives Value Planning Study*	Reclamation	Completed value planning report on the riprap channel fishway with boulder weirs along the right abutment. The team included staff from Reclamation, Corps, Service, District, and The Nature Conservancy. Concepts included L-shape dam, create island, widen fishway, multiple pumping stations, use natural side channel, move intake upstream, rock ramp, collapsible dam, and electric pumping station.
2005	*Inspection of Proposed Rock Source for Riprap - Lower Yellowstone Project, Yellowstone River, Montana.*	Reclamation	Reclamation fieldwork for potential alternatives.
September 2005	Meeting	Reclamation, Corps, FWP, Service, Board of Control, and the Nature Conservancy	Agreed on plan to move forward with NEPA analysis of fish passage alternatives.
October 2005	Memorandum	Reclamation	Agreed with Service to look at other alternatives, including open river channel alternatives, through partnership effort and requested comments on other sections of the draft Lower Yellowstone Project BA sent in April 2005.
November 2005	Memorandum	Reclamation	Transmitted Value Planning analysis matrix to Service.

Date	Report Name	Author	Summary
November 2005	Meeting	Reclamation, Corps, Service, FWP, Board of Control, and the Nature Conservancy	Met to identify best alternatives. Alternatives identified were the rock ramp, pumping plant, and move diversion upstream.
July 2006	*Lower Yellowstone River Intake Dam Fish Passage and Screening Preliminary Design Report*	Corps	Developed concepts to address fish passage and entrainment protection at the Lower Yellowstone Intake Diversion Dam and main canal headworks.
September 2006	*Summary of the Biological Review Team's Comments on Lower Yellowstone River Intake Dam Fish Passage and Screening Preliminary Design Report*	Service	Summarized comments and suggestions from a panel of experts convened by the Service to review the July 2006 *Lower Yellowstone River Intake Dam Fish Passage and Screening Preliminary Design Report*
February 2007	*Appendix I: Additional Ramp Alternative, Lower Yellowstone Project Fish Passage and Screening Preliminary Design Report, Intake Diversion Dam*	Corps	Written after the initial report was finalized, the appendix included a preliminary design of additional rock ramp alternatives for the Lower Yellowstone Project. Evaluated 0.5% and 1% slopes.
October 2007	Meeting	Reclamation, Corps, FWP, Service, Board of Control, and the Nature Conservancy	Discussed revisiting the entrainment proposal (fish screen) and agreed to consider an on-river fish screen (one structure instead of two) and introduced retractable fish screens option.
November 2007	*Intake Diversion Dam: Evaluation of Fish Screens for Protecting Early Life Stages of Pallid Sturgeon*	Reclamation	Reclamation prepared report on best available screening technology.
January 2008	Intake Diversion Dam Assessment of High Elevation Intake Gates	Reclamation	Assessed the viability of adding high elevation intakes in the existing canal headworks structure.
February 2008	*Lower Yellowstone Project Fish Screening and Sediment Sluicing Preliminary Design Report Appendix A: Hydraulics Appendix B: Geotechnical Appendix C: Engineering Design Appendix D: Cost*	Corps	Developed appraisal level designs and estimated costs for installing a combination fish screen and canal headworks structure on the Lower Yellowstone Project main canal.
February 2008	*Intake Diversion Dam Trashrack Appraisal Study for Intake Headworks*	Reclamation	Addressed the Biological Review Team's recommendation to install a removable 2-inch bar mesh trashrack and self-cleaning mechanism on the riverside of the canal intake to prevent entrainment.
February 2008	*Lower Yellowstone River Intake Diversion Dam Canal V Configuration Fish Screen Concept Fish Screen Operation and Maintenance*	Reclamation	Described operation and maintenance of the in-canal V-Shaped fish screen.

Date	Report Name	Author	Summary
March 2008	*Summary of the Biological Review Team's comments of Lower Yellowstone River Irrigation Project Fish Screening Preliminary Design*	Service	Summarized the comments and suggestions from a panel of experts re-convened by the Service related to review the February 2008 *Intake Diversion Dam Trashrack Appraisal Study for Intake Headworks & Lower Yellowstone Project Fish Screening and Sediment Sluicing Preliminary Design Reports*
March 2009	*Summary of the Biological Review Team's comments of Lower Yellowstone River Irrigation Project Fish Passage and Screening Alternatives and Alternative Scoring Criteria*	Service	Made specific recommendations on the Rock Ramp, Relocate Main Channel, and Multiple Pumping Station Alternatives. A scoring system evaluated alternatives.
May 2009	Meeting	Reclamation, Corps, and Service	Agreed to prepare an Intake Project BA on construction of the proposed Intake Project and to update the Lower Yellowstone Project Operation BA to address incidental take for operations of the Lower Yellowstone Irrigation Project and the Intake Project. Concurred that formal Section 7 consultation would be completed on Lower Yellowstone Project operations before operating the new Intake Project features.

Description of the Proposed Federal Action and Action Area

Project Description

The purpose of the proposed action is to correct unsatisfactory passage conditions for endangered pallid sturgeon and other native fish in the lower Yellowstone River and reduce entrainment of fish into the Lower Yellowstone Project main canal.

The underlying need for the proposed action is that Reclamation needs to comply with the ESA by completing consultation under Section 7(a) (2) for continued operation of Intake Diversion Dam and the Lower Yellowstone Project. If Reclamation does not initiate and successfully complete consultation, then Reclamation's ability to continue to operate the dam and headworks to deliver project water to the Lower Yellowstone Project could be severely constrained or limited in the future. Reclamation has contractual obligations to water users to deliver Project water that it needs to fulfill. Project water is needed to continue viable and effective operation of the Lower Yellowstone Project.

The proposed action is needed to:

- Improve upstream and downstream fish passage for adult pallid sturgeon and other native fish in the lower Yellowstone River,

- Minimize entrainment of pallid sturgeon and other native fish into the Lower Yellowstone Project main canal,
- Continue effective operation of the Lower Yellowstone Project in compliance with the ESA, and
- Contribute to restoration of the lower Yellowstone River ecosystem.

The EA describes the reasonable alternatives developed to meet the purpose and need for this project in chapter two and Appendixes A.1 and A.2. The EA discusses the proposed Intake Project, including specifics of the preferred alternative – the Rock Ramp Alternative and rotating removable drum screens in a new headworks. This Intake BA describes the effects to listed species that would result from the construction of the preferred alternative, as evaluated in the Intake EA.

Legal Authority

Construction of the Lower Yellowstone Project was authorized by the Secretary of the Interior (Secretary) on May 10, 1904, under the Reclamation Act/Newlands Act of June 17, 1902 (Public Law 57-161). The Lower Yellowstone Project is authorized as a single-purpose project for irrigation. Project facilities are owned by the United States under the jurisdiction of Reclamation.

Under the authority of Section 5 of the Reclamation Extension Act of August 13, 1914, and subsection 9 of the December 5, 1924, Fact Finders' Act, operation and maintenance of the diversion and supply works were transferred to the Lower Yellowstone Districts in 1926, to Intake Irrigation District in 1945, and to Savage Irrigation District in 1951. The Districts are required to maintain the transferred works in full compliance with Reclamation laws and the regulations of the Secretary.

By policy, Reclamation is required to inspect the facilities every 6 years. Should the irrigation districts fail to maintain the facilities in compliance with Reclamation law, Reclamation will resume operations and maintenance and charge the irrigation districts for any costs incurred. Reclamation retains ownership of the Lower Yellowstone Project facilities, but the facilities are operated and maintained by the Board of Control of the Lower Yellowstone Project under contract with Reclamation. The contracts are as follows:

- ✓ Contract ILR-103, September 23, 1926, with Lower Yellowstone Irrigation District #1
- ✓ Contract ILR-104, Nov. 2, 1926, with Lower Yellowstone Irrigation District #2
- ✓ Contract ILR-1436, on March 30, 1945, with Intake Irrigation District
- ✓ Contract ILR-1525, on July 14, 1948, with Savage Intake Irrigation District

The Lower Yellowstone Project provides water service for irrigation to the districts through contract with Reclamation. Water rights for the water supply delivered to these lands are jointly held by the irrigation districts and Reclamation. Lower Yellowstone Districts 1 & 2 and Intake Irrigation District have repayment contracts and have met their full financial obligation for repayment of the diversion and supply works for the Project. Savage Irrigation District is scheduled to repay their financial obligation in 2010. With the exception of Savage Irrigation

District, the repayment contracts have no expiration dates. The Savage water service contract is anticipated to be renewed for water service with no capital cost once their repayment obligation has been completed.

Reclamation has also been delegated much of the authority of the Secretary of the Interior under the Fish and Wildlife Coordination Act, 16 U.S.C. 661 et seq., as is necessary to provide assistance, through grants or cooperative agreements, to public or private organizations for the improvement of fish and wildlife habitat associated with water systems or water supplies affected by Reclamation projects (Reclamation 1996).

Section 7 of the Endangered Species Act (Act) and the requirements of the Act's implementing regulations set out in 50 CFR Part 402 apply to all actions in which there is discretionary federal involvement or control. Section 7 (a) (1) does not confer any additional statutory authority on Reclamation. Rather, it is a direction from Congress to exercise existing authorities to further the purposes of the Act.

Reclamation and the Corps have worked cooperatively on this project. The Corps is a joint lead agency for the Intake EA, because the Service suggested in their Missouri River Master Manual BO (2000 and 2003 amendment) that the Corps work with Reclamation to provide passage for pallid sturgeon at Intake Diversion Dam as a conservation recommendation and as an adaptive management action for Missouri River recovery. Section 3109 of the 2007 Water Resources Development Act authorizes the Corps to use funding from the Missouri River Recovery and Mitigation Program to assist Reclamation in compliance with federal laws, and in the design, and construction of modifications to the Lower Yellowstone Project for the purpose of ecosystem restoration.

Alternatives Evaluated

Two action alternatives, the Relocate Main Channel Alternative and Rock Ramp Alternative, as well as a No Action Alternative were evaluated. These are discussed in chapter two and in Appendixes A.1 and A.2 of the Intake EA.

Proposed Federal Action

The proposed federal action is to construct the rock ramp alternative described in the Intake EA. Reclamation and the Corps propose to replace the existing timber and rock Intake Diversion Dam with a concrete dam that would have a shallow-sloped ramp to provide fish passage. The rock ramp is designed to mimic natural river function and would lower velocities and turbulence so that migrating fish could seamlessly pass over the dam. The new dam and rock ramp would be paired with new headworks with screens, which would minimize entrainment of fish into the main canal and regulate irrigation diversions.

The Rock Ramp Alternative would have the following features:

- Concrete dam to replace the existing timber and rock dam;
- Rock ramp for fish passage;
- Irrigation canal extension; and
- New headworks with screens to minimize entrainment.

This proposed action, including construction activities necessary to implement the alternative, is described in detail and identified as the preferred alternative in the Intake EA.

Environmental Commitments

The following commitments have been considered in the EA and the following commitments will be implemented to avoid adverse impacts to resources:

Whooping Crane

- Monitoring of whooping crane sighting reports by the Service will be conducted to ensure that whooping cranes are not in the action area (project area) during construction. If any are sighted within the Intake Project area, Reclamation will consult with the Service regarding appropriate actions.

Interior Least Tern

- Visual surveys will be conducted weekly from May 15 to August 15 at all potential least tern nesting areas (sparsely vegetated sandbars) within line of site of the construction area.
- All surface-disturbing and construction activities will be seasonally restricted from May 15 to August 15 within 0.25 mile or the line of site of any active interior least tern nest.

Pallid Sturgeon

- The construction activities within the wetted perimeter of the active channel will be observed and monitored by a qualified fisheries biologist to avoid direct impacts to adult or juvenile fish. In-stream construction activities will cease if the fisheries monitor determines there is potential for direct harm or harassment of pallid sturgeon, until the potential for direct harm or harassment has passed. This will include coordination with FWP to make sure radio-tagged pallid sturgeon and other monitored native fish continue to be monitored, especially during the construction season.
- All pumps will use intakes screened with no greater than ¼" mesh when dewatering cofferdam areas in the river channel. Pumping will continue until water levels within the contained areas are suitable for salvage of any juvenile or adult fish occupying these areas. All fish will be removed by methods approved by the Service and FWP prior to final dewatering.
- Reclamation will consult with FWP to ensure that adequate flows comparable to environmental baseline are maintained during construction to support the fishery during low-flow periods (late summer/early autumn).
- Care will be taken to prevent any petroleum products, chemicals, or other harmful materials from entering the water.
- All work in the waterway will be performed in such a manner to minimize increases in suspended solids and turbidity that could degrade water quality and damage aquatic life outside the immediate area of operation.
- All areas along the bank disturbed or newly created by the construction activity will be seeded with vegetation indigenous to the area for protection against subsequent erosion and the establishment of noxious weeds.
- Clearing vegetation will be limited to that which is absolutely necessary for construction of the project.

- Any in-stream construction activity will be conducted during periods most likely to minimize the potential impact to the pallid sturgeon. The months to avoid and/or minimize impacts to pallid sturgeon are June and July.
- To avoid impacts, sheet pile installation and in-stream heavy equipment activity will be coordinated with fishery experts from the Service, FWP, Reclamation and the Corps to avoid and or minimize potential impacts.

Action Area

The action area is defined as that reach of the Yellowstone River and it's tributaries from the Cartersville diversion dam at river mile 237 (river kilometer 381) downstream to its confluence with the Missouri River, the Missouri River downstream to Lake Sakakawea in North Dakota, and associated riverine and riparian habitats within 0.25 miles in the line of sight of the maximum construction footprint as defined in Chapter 2 of the EA and illustrated in Figure 2.11.

Environmental Baseline

The environmental baseline is a "snapshot" of a species health at a specified point in time. This section defines the environmental baseline including the effects of past and ongoing human and natural factors leading to the current status of the species, their habitats (including federally designated critical habitat), and ecosystems in the action area.

Previous and Ongoing Projects in the Action Area

Yellowstone River Basin

Past and Present Federal, State, or Private Actions

Existing conditions in the action area are described in chapter three of the Intake EA. The Yellowstone River is essentially free-flowing. The river is not impounded by storage reservoirs, and the mainstem of the river is not regulated. However, there are six diversion dams in addition to the one at Intake on the Yellowstone River downstream from Billings, Montana (Figure D.1). The uppermost is Billings Big Ditch Dam. Huntley diversion is federally-owned, while the middle four (Waco, Rancher's Ditch, Yellowstone, and Cartersville) are privately-owned and managed by local irrigation districts. All six dams present some degree of impediment to fish passage. The extent of fish blockage at these dams seems to depend on river stage and the swimming ability of the various species trying

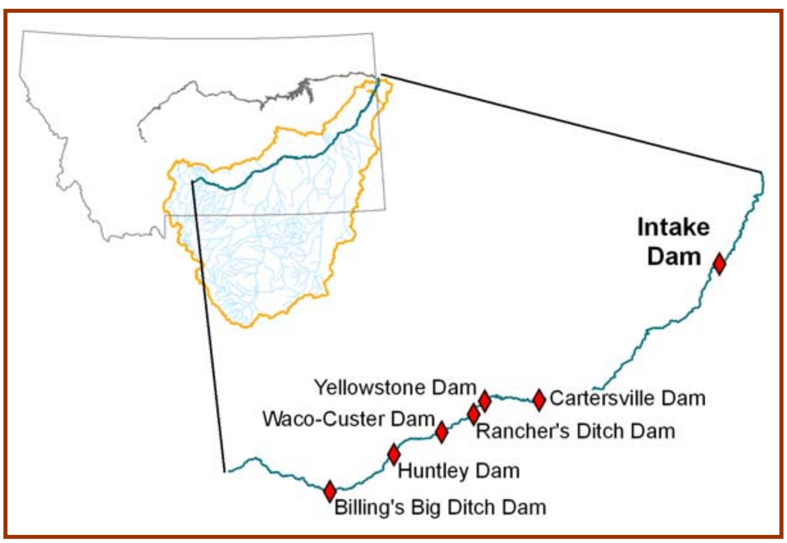

Figure D.1 - Diversion Dams along the Yellowstone River (adapted from Jenkins 2007).

to negotiate the dams. Huntley has a riprap-lined fish bypass channel built to help fish migrate around the dam when water conditions permit. Currently several agencies are working on resolving fish passage issues at Cartersville Dam and are considering modifications at Huntley.

Bank stabilization projects have proliferated over the years, but many require permitting by the Corps of Engineers under Section 404 of the Clean Water Act. Permitting is also required by Section 10 under the Rivers and Harbors Act, because the Yellowstone River is classified as a navigable water. Therefore, any future bank stabilization projects requiring a permit under section 404 of the Clean Water Act or section 10 under the River and Harbors Act would be subject to Section 7 consultation between the permitting agency and the Service. The action area has a total of four man-made structures that stabilize the river channel near the Project area. These structures are the existing headworks, Intake Diversion Dam, the boulder field, and a boat ramp.

Riparian management of the Yellowstone River ecosystem has been a concern for conservation groups and others. They have been working with landowners to conserve and restore riparian areas.

Recently the Corps has been requiring screening to minimize larval fish entrainment in irrigation intakes along the Yellowstone River. However, many older irrigation projects have unscreened intakes. Changes are presently being considered at the Buffalo Rapids Intake to minimize fish entrainment.

The Natural Resource Conservation Service continues to work with landowners adjacent to the Yellowstone River on a wide variety of conservation efforts, including water conservation and natural resource conservation.

Proposed Federal Projects with Section 7 Consultation Reclamation is currently engaged in informal consultation with the Service regarding the effects to listed species from the continued operation of the Lower Yellowstone Project (see Table D.1). Reclamation will continue to work with the Service to complete this Section 7 consultation process prior to the end of the construction of the fish passage and protection measures.

Yellowstone and Missouri Rivers

Although construction of the Intake Project is on the Yellowstone River, the pallid sturgeon population under consideration is part of a larger population in the Missouri River Basin. More specifically the Intake Project would affect pallid sturgeon in RMPA 2, which includes the Missouri River below Fort Peck Dam to the headwaters of Lake Sakakawea and the lower Yellowstone River up to the confluence of the Tongue River, Montana (figure D.2). The same connection to the Missouri River can be said for nesting interior least terns and migrating whooping cranes. Therefore, a reference to both of these rivers when considering the environmental baseline is appropriate.

Past and present impacts on the Missouri River Basin, which includes the Yellowstone River, have been well described in previous BAs (Corps 1998 and 2003; Reclamation and Service

2006) and subsequent BOs (Service 2000a; Service 2003 and amendments; Service 2006a) and will not be reiterated here. Table D.2 displays reports documenting environmental baseline actions/impacts for other resources important to the species being considered.

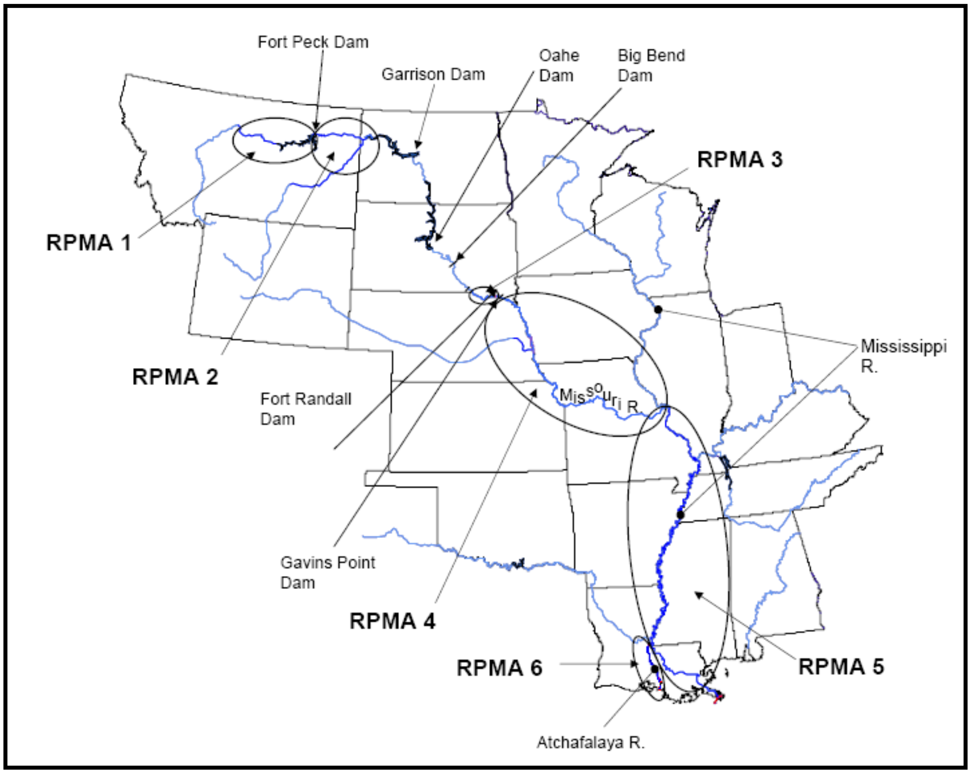

Figure D.2 - Recovery Priority Management Areas Identified for the Pallid Sturgeon (adapted from Service 2007).

Table D.2 - Research on the Yellowstone and Missouri Rivers Contributing to the Environmental Baseline for the Federal Action Area.

Resource	River	Report Title (year)[1]
Aquatic Invertebrates	Yellowstone	Aquatic Invertebrates of the Yellowstone River Basin, Montana: Montana (1977)
Bank stabilization and wildlife	Yellowstone	Toward Assessing the Effects of Bank Stabilization Activities on the Wildlife Communities of the Upper Yellowstone River, USA. (2001)
Bed sediments	Yellowstone	Element Concentrations in Bed Sediment of the Yellowstone River Basin, Montana, North Dakota, and Wyoming - A Retrospective Analysis (1999)
Birds	Yellowstone	Avian Communities of the Middle and Lower Yellowstone River: A Pilot Study (2006)
Birds	Yellowstone	The Affect of Altered Streamflow on Migratory Birds of the Yellowstone River Basin, Montana (1977)
Channel migration	Yellowstone	Yellowstone River Channel Migration Zone Mapping (2008)
Environmental setting	Yellowstone	Environmental Setting of the Yellowstone River Basin, Montana, North Dakota, and Wyoming (1999)

Resource	River	Report Title (year)[1]
Fish communities	Missouri and Yellowstone	Ecology and Structure of Fish Communities in the Missouri and Lower Yellowstone Rivers (2000)
Fish communities	Missouri and Yellowstone	Fish Distribution and Abundance (2004)
Fish communities	Missouri and Yellowstone	Spatial Patterns of Physical Habitat (2001)
Fish communities	Yellowstone	The Yellowstone River: Its Fish and Fisheries (Unknown)
Fish communities	Yellowstone	The Affect Of Altered Streamflow on Fish of the Yellowstone and Tongue Rivers, Montana (1977)
Flows	Missouri and Yellowstone	Classification of Reaches in the Missouri and Lower Yellowstone Rivers Based on Flow Characteristics (2002)
Geomorphic	Yellowstone	Geomorphic Reconnaissance and GIS Development Yellowstone River, Montana (2004)
Geomorphology and flows	Yellowstone	The Effect of Altered Streamflow on the Hydrology and Geomorphology of the Yellowstone River Basin, Montana (1977)
Hydrologic modeling	Yellowstone	Future Development Projections and Hydrologic Modeling in the Yellowstone River Basin, Montana (1977)
Irrigation Projects	Yellowstone and Missouri (statewide inventory)	Irrigation in Montana: A Preliminary Inventory of Infrastructure Condition (2009)
Pallid sturgeon	Yellowstone	Assessment of Pallid Sturgeon Restoration Efforts in the Lower Yellowstone River - Annual Report for 2007 (2007)
Riparian and wildlife	Yellowstone	Riparian Habitat Dynamics and Wildlife along the Upper Yellowstone River (2003)
Riparian and wetlands	Yellowstone River	Yellowstone River Wetland/Riparian Change Detection Pilot Study (2006)
Walleye and Sauger	Yellowstone	Assessment and Requirements of Sauger and Walleye Population in the Lower Yellowstone River and Its Tributaries (1992)
Water quality	Yellowstone	Environmental Setting of the Yellowstone River Basin, Montana, North Dakota, and Wyoming (1999)
Water quality	Yellowstone	Organic Compounds and Trace Elements in Fish Tissue and Bed Sediment from Streams in the Yellowstone River Basin, Montana and Wyoming, 1998 (2000)
Water quality	Yellowstone	Water-Quality Assessment of the Yellowstone River Basin, Montana and Wyoming—Water Quality of Fixed Sites, 1999-2001 (2005)
Water quality	Yellowstone	Water Quality in the Yellowstone River Basin, Wyoming, Montana, and North Dakota, 1999–2001 (2004)
Water quality	Yellowstone	The Effect of Altered Streamflow on the Water Quality of the Yellowstone River Basin, Montana (1977)

[1]These articles are in the literature cited section at the end of this appendix.

Habitat Restoration

Habitat restoration programs are ongoing on both the Yellowstone and Missouri rivers. The Corps has been working with the Service and other federal agencies, states, and tribes on restoration efforts on the Missouri River, while others have been working on restoration efforts on the Yellowstone River through the Yellowstone River Conservation District Council. This Council was formed to address conservation issues on the entire river. As a result there are several ongoing actions on both rivers that would benefit the pallid sturgeon, interior least tern, and whooping crane. Different activities on both rivers include habitat resoration, fish hatchery supplementation, fish passage, fish entrainment protection, riparian resoration, bank stabilization studies, flow modeling, and water conservation

Status of Species

Species List from the U.S. Fish and Wildlife Service

In response to a request by Reclamation, the Service provided a list of endangered, threatened, and candidate species and their designated critical habitat that may be present in the action area. This list was most recently confirmed at the May 12, 2009, meeting among Reclamation, the Corps, and the Service. The Service identified the **whooping crane, interior least tern, and pallid sturgeon.**

Recovery Plans Overview

Recovery plans are available for all listed species covered in this document at http://ecos.fws.gov/tess_public/SpeciesRecovery.do?sort=1. The recovery plan for the whooping crane was updated in 2007, but the plans for the least tern and pallid sturgeon are outdated, i.e. greater than five years old. The Service is currently working on a status report for the least tern and is in the process of updating the recovery plan for the pallid sturgeon.

The recovery plans for the interior least tern, piping plover, and pallid sturgeon all include recovery goals for habitats on the Yellowstone River. The recovery plan for the whooping crane requires protection of this species' habitat, including migratory habitat in Montana. However, whooping crane recovery goals are more focused and specific to maintaining and increasing breeding populations.

The biological and life requirements for the species covered in this BA have been described in previous BAs (Corps 1998 and 2003; Reclamation and Service 2006) and subsequent BOs (Service 2000a; Service 2003 and amendments; Service 2006a). A brief summary of the status of the species is included in this document with an emphasis on their status rangewide and in the action area.

Interior least tern (photo courtesy of www.fws.gov)

Interior Least Tern (Endangered)

Rangewide Status The interior least tern nests on the Mississippi, Missouri, Arkansas, Red, Rio

Grande, Kansas, Platte, Loup, Niobrara, Canadian, Cheyenne, Ohio, and Yellowstone rivers. Rangewide estimates from 1999 were about 7,400 birds (Service 2000a). More recent estimates by the Service (2005) report a considerable increase of up to about 12,000 birds. It is important to note that this does not represent a complete census, because segments of some rivers are surveyed in one year but not in another. The Service (2005) reports that the total estimate is likely a minimum estimate.

Rangewide numbers have increased in the 1999-2003 period. The interior least tern recovery plan established a goal of 7,000 terns rangewide maintained for 10 consecutive years. The current estimate of over 12,000 terns greatly exceeds this goal; however, recovery plan goals for least terns in all drainage basins have not been reached, and most areas have not been monitored for 10 years. The recovery plan has not been revised since it was written in 1990, and recovery goals may need to be updated.

In 2005, the first complete rangewide survey for interior least terns was conducted (Lott 2006). A total of 17,587 interior least terns were counted in association with 491 different colonies. Just over 62% of these birds were on the lower Mississippi River (10,960 birds on 770+ river miles). Four additional river systems accounted for 33.9% of the remaining least terns, with 12.1% on the Arkansas River system, 10.4% on the Red River system, 7.1% on the Missouri River system, and 4.3% on the Platte River system. Smaller numbers were counted on other rivers, including the Ohio River system (1.5%), the Trinity River system in Texas (1.5 %), the Rio Grande/Pecos river system in New Mexico and Texas (0.8%), and the Kansas River system (0.5%) (Lott 2006).

Local Status Interior least terns nest on sparsely vegetated sandbars on the Missouri and Yellowstone rivers in Montana and North Dakota. On the Yellowstone River, nesting is on bare sands and gravels on the upstream portions of vegetated channel bars below Miles City (Bacon and Rotella 1998). Most breeding sites on the Yellowstone River are in a section where channel meandering increases, and there are more channel bars and islands (Service 2003). Interior least terns feed mostly on small fish. Their breeding season lasts from May through August, with peak nesting occurring from mid-June to mid-July.

Typical interior least tern nesting habitat, Yellowstone River, Montana (photo courtesy of FWP)

Although least terns in Montana represent a small proportion of interior least terns throughout their range, Montana's Yellowstone and Missouri rivers offer suitable habitat for breeding birds during years when more southern reaches have abnormal weather and river conditions (Atkinson and Dood 2006). The recovery plan goal for this species is 50 birds for the state of Montana.

Probably the most intensive survey of the Yellowstone River was conducted during the 1994-1996 breeding seasons by Bacon (1997). During this time the river reach between Miles City and Seven Sisters Recreation Area supported an average of 27 birds (Atkinson and Dood 2006).

This represents the highest number of terns reported along the Yellowstone River since the birds were federally listed. Since 1997, fewer adult birds have been recorded along this section of the Yellowstone than were recorded during the intensive survey years of 1994 -1996, but numbers between years have remained stable (1997-2005 mean =16.6) (Atkinson and Dood 2006). While surveys conducted prior to 1994 did not cover the entire reach, the high numbers of terns recorded between 1994-1996, compared to those reported more recently may be, as is often the case, associated with sampling intensity (Atkinson and Dood 2006).

More recent least tern surveys (A. Dood FWP- Helena, Montana, personal communication) for the Yellowstone River are as follows:

- 2006 - 10 adults (surveys conducted June 12-13 when river was high with little suitable habitat)
- 2007 - 11 adults (surveys conducted June 26-28)
- 2008 - 5 adults (surveys conducted July 16-18, the river was very high and no habitat was available in June)

Using a 10-year trend average, as set forth in the Interior Least Tern Recovery Plan (1990), Montana has averaged 72.9 birds (ranging from 40-181) (Atkinson and Dood 2006). However, Montana has elected to use a 5-year running average for trend analysis and management planning. The population over the past 5-year period (2001-2005) averaged 51.6 birds ranging from 49-58. The state has met and/or exceeded its specific recovery goal of 50 adult birds in the past 20 years when counting birds both on the Yellowstone and Missouri rivers (Atkinson and Dood 2006).

Recovery Plan The recovery plan for the interior least tern recommends removal of this species from the endangered species list if essential habitat throughout its range is properly protected and managed and the species distribution and population goals are reached and maintained for 10 years (Service 1990). Recovery goals for the entire population are habitat protection, management, and attaining a population of 7,000 birds distributed across specific areas, including the Missouri River system. Recovery goals for the Missouri River system are habitat protection and reaching population levels of 2,000 adults in specific distributions assigned by state.

In 2005 a range-wide survey was conducted that provides the first complete summary of the distribution and abundance of the interior population of the least tern, since this species was originally listed as endangered almost 20 years ago (Lott 2006). This 2005 survey counted 17,591 interior least terns, of which 1,217 birds were counted in the “upper” Missouri River (above Sioux City, Iowa) and its tributaries (Lott 2006). On the Missouri River 904 adults were counted, while tributaries accounted for the remainder, including 289 on the Niobrara and smaller numbers on the Cheyenne (4) and Yellowstone (16) rivers (Lott 2006).

The range-wide survey would suggest that overall the interior population of the least tern has surpassed the 7,000 birds recovery goal but that the distribution of those numbers and management of those areas is not yet as envisioned by the Service when the recovery plan was written. Populations have apparently increased over time in some areas, e.g., the Mississippi

River system, while others have declined, e.g., the Platte River. The rangewide fluctuation has been suggested by some to be the result of immigration of least terns to the lower Mississippi River and low fledgling success (Kirsch and Sidle 1999).

While questions remain on the status of interior least terns, an Interior Least Tern Working Group was formed to address these concerns and to work toward developing a range-wide strategy for monitoring population status and trends. This group includes 91 members representing 11 Corps districts, 4 Service regions, 14 state wildlife agencies, 8 academic institutions, 4 U.S. Geological Survey science centers, 3 joint ventures, and several non-profit groups. A monitoring program coordinator position was created by American Bird Conservancy, with the support of the Corps, to coordinate range-wide monitoring efforts.

Recent and ongoing recovery efforts on the Missouri River by the Corps should assist in the continued recovery of this species. The recent signing of the Platte River Recovery Implementation Program by the Secretary of the Interior and the Governors of Colorado, Nebraska, and Wyoming should also boost recovery actions for the interior least tern on the Platte River system.

Whooping Crane (Endangered)

Rangewide Status The species lives exclusively in North America. Historically these birds bred primarily in wetlands of the northern tall- and mixed-grass prairies and aspen parklands of the northern Great Plains. Their principal nesting area is in Wood Buffalo National Park, Canada. They winter on and near the Aransas National Wildlife Refuge along the Texas gulf coast. That population is referred to as the Aransas-Wood Buffalo population, and it migrates through the action area twice each year. During migration, the birds use a variety of feeding and roosting habitats, including croplands, marshes, shallow reservoirs and sheet-water areas, and submerged sandbars in rivers along the migration route. Approximately 343 individuals live in the wild at 3 locations, and 135 whooping cranes are in captivity at 9 sites. Only the Aransas-Wood Buffalo National Park population is self-sustaining with approximately 220 in the flock (Canadian Wildlife Service and Service 2007).

Whooping Crane
(whoopers.usgs.gov)

Local Status The whooping crane passes through Montana and North Dakota during both spring (April-mid-June) and fall migration (late August to mid- October). These migration flights are between its breeding territory in northern Canada and wintering grounds on the Gulf of Mexico. Frequently, whooping cranes migrate with sandhill cranes. Whooping cranes inhabit shallow wetlands but may also be found in upland areas, especially during migration. The whooping crane prefers freshwater marshes, wet prairies, shallow portions of rivers and reservoirs, grain and stubble fields, shallow lakes, and wastewater lagoons for feeding and loafing during migration.

Whooping crane sightings have been recorded in adjacent Richland County, Montana. The sightings were in areas outside of the proposed construction zone (M. Tacha - Fish and Wildlife Service Grand Island, Nebraska, personal communication). The peak of spring migration in Montana is April 26, while the peak of fall migration is October 22 (Austin and Richert 2000). Austin and Richert (2000) also reported that spring observations are more common than fall and that riverine habitats have accounted for only 36% of the sightings in Montana. No whooping crane sightings have ever been recorded on the Yellowstone River, but have been recorded on the Missouri and Poplar rivers (M. Tacha - Fish and Wildlife Service Grand Island, Nebraska, personal communication).

Recovery Plan Whooping crane recovery efforts have made great strides over the years with new populations being established in Florida and Wisconsin. The Aransas-Wood Buffalo population that migrates through the proposed action area is also doing favorably. There was a successful breeding season at Wood Buffalo National Park in 2006, which resulted in record numbers on the wintering grounds at Aransas National Wildlife Refuge.

The newly revised recovery plan (Canadian Wildlife Service and Service 2007) includes scientific information about the species and provides objectives and actions needed to down-list the species. Recovery actions designed to achieve these objectives include protection and enhancement of the breeding, migration, and wintering habitat for the Aransas-Wood Buffalo National Park population to allow the wild flock to grow and reach ecological and genetic stability; reintroduction and establishment of geographically separate self-sustaining wild flocks to ensure resilience to catastrophic events; and maintenance of a captive breeding flock to protect against extinction that is genetically managed to retain a minimum of 90% of the whooping crane's genetic material for 100 years.

Pallid Sturgeon (Endangered)

Rangewide Status The pallid sturgeon is native to the Missouri River, the lower reaches of the Platte, Kansas, and Yellowstone rivers, the Mississippi River below its confluence with the Missouri River, and the Atchafalaya River. Although the species' range is large, catch records are rare, with few captures of sub-adults in recent years. Pallid sturgeon observations have been reported on the Missouri River between the Marias River and Fort Peck Reservoir, between Fort Peck Dam and Lake Sakakawea, within the lower 70 miles of the Yellowstone River to downstream of Fallon, Montana, in the headwaters of Lake Sharpe, and near Plattsmouth, Nebraska (Jordan 2006).

Pallid Sturgeon (photo courtesy of the Service)

The species appears to be nearly extirpated from large segments of its former range and may be close to extinction (Service 1993). Population size in the upper Missouri River Basin above Gavins Point Dam is estimated to be between 325 and 550 adult fish, with an aging population and no indication of recruitment at that time (Duffy et al. 1996).

Although critical habitat has not been designated, six Recovery-Priority Management Areas (RPMAs) were identified in the Recovery Plan (figure D.2). Four of these RPMAs are on the Missouri River (Service 1993). However, the Pallid Sturgeon Recovery Team (Service 2006b) replaced the RPMA concept with Management Units, which are based on genetic data and biogeographical data (figure D.4). Because past research used the RPMA system and it is more specific to the action area, both the RPMA and Management Units will be used in this document to avoid confusion.

Local Status Pallid sturgeon occupy the Missouri and Yellowstone rivers in Montana and North Dakota. These sturgeon use the Missouri River year round and the Yellowstone River primarily during spring and summer spawning. Adults primarily move into the Yellowstone River in the spring and summer. Jaeger et al. (2008) found reaches of the Yellowstone River to be suitable rearing habitat for hatchery-reared juvenile pallid sturgeon that were likely used year-round.

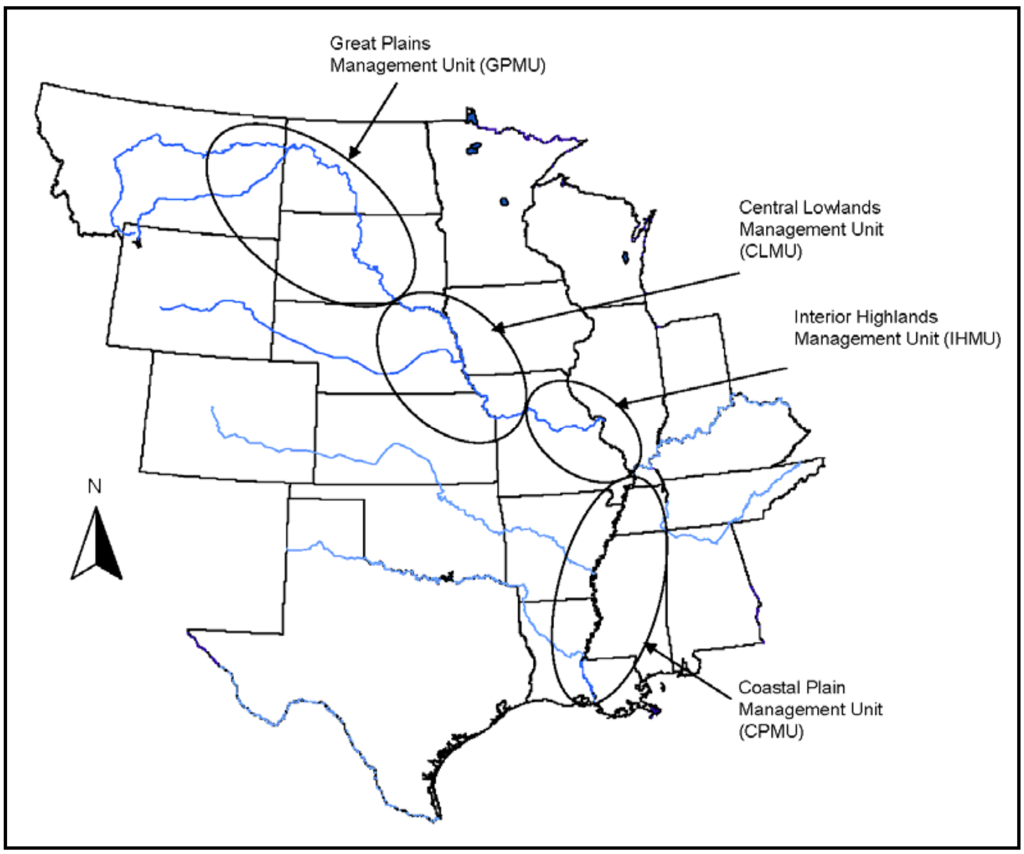

Figure D.3 - Management Units identified by the Pallid Sturgeon Recovery Team (Service 2006).

The proposed action area is in the Great Plains Management Unit (GPMA). This unit includes the Missouri River from Great Falls, Montana, to Ft. Randall Dam, South Dakota (figure D.3). This unit includes the former RPMA 2 (figure D.3). The lower Yellowstone River in RPMA 2 (GPMU) is believed to have high potential reproductive habitat for the pallid sturgeon.

While there are documented recent occurrences of natural reproductive success in RPMAs 2, 4, and 5, there are little to no data indicating substantial natural recruitment of pallid sturgeon in RPMAs 1, 2, 3, and 4 (Service 2007). Linear regression of population declines indicate that the pallid sturgeon population in RPMA 2 will likely be extinct between 2018 and 2024, but extirpation could occur sooner, as individuals reach an old-age threshold (Kapuscinski 2003a; 2003b, and Klungle and Baxter 2005).

Kapuscinski (2003a) estimated the pallid sturgeon population in RPMA 2 at 151 adult fish, down from 255 adult fish in 1991. Klungle and Baxter (2005) estimated 158 wild adult pallid sturgeon inhabit RMPA 2. Bramblett (1996) documented that pallid sturgeon prefer the Yellowstone River over the Missouri River below Fort Peck under contemporary flow regimes. Evidence from Bramblett (1996) strongly suggests that pallid sturgeon spawning occurs in the lower Yellowstone River below Intake Dam. This evidence includes many fish moving into the lower Yellowstone River during spawning season, ripe fish in the Yellowstone River, and fish aggregating during the spawning season (late May and early June).

According to the Service (2007) the wild pallid sturgeon population in RPMA 2 continues to decline. The Service (2007) reported that data compiled from the National Pallid Sturgeon Database showed 245 unique individual pallid sturgeon (essentially all adults) were collected during 16 years of sampling (1990-2006). Klungle and Baxter (2005) estimated 158 wild adult pallid sturgeons inhabit RMPA 2. The population is being supplemented with hatchery-reared fish to prevent local extirpation (Service 2006c). The Service (2007) reports that pallid sturgeon from all stocking events have produced recaptures and are contributing to the current population structure. From 1998-2007, over 11,000 pallid sturgeon have been stocked on the Yellowstone River (Krentz et. al. 2005; Upper Basin Pallid Sturgeon Recovery Workgroup 2007). Recapture has been as high as 6% and included five year classes (Jaeger et al. 2006).

Spawning has occurred in the Yellowstone River, but there is no evidence that the resulting young survive to adulthood and reproduce (Bergman et al. 2008; (reported as M. Jaeger and D. Fuller personal communication in 2009 Draft Recovery Plan for the Pallid Sturgeon)). In addition, although larvae were collected in RPMA 2 in 2002, their post-hatch drift may carry them into the lentic waters of Lake Sakakawea, which does not provide the necessary habitat for rearing (cited in Jordan 2006 as S. Krentz, Service, personal communication 2003).

Pallids in the Yellowstone River prefer sandy substrates and deep channels and select reaches with numerous islands (Bramblett and White 2001). Pallids primarily inhabit about a 70-mile stretch of river below Intake Diversion Dam. More recently radio-tagged hatchery-reared pallid sturgeon have been placed above the dam (Jaeger et al. 2005). Most of these fish stayed above the Intake Diversion Dam, but some were entrained and found in the main canal of the Lower Yellowstone Project (Jaeger et al. 2004).

Spawning substrate has not been specifically identified in the upper Missouri River Basin including the Yellowstone River. While detailed spawning behavior and substrate requirements for pallid sturgeon are poorly understood, inferences can be drawn from other sturgeon species. In general, sturgeon species of the United States spawn over hard substrates;

- Short nose sturgeon (*Acipenser brevirostrum*) spawn over rubble (Taubert 1980),
- Lake sturgeon (*A fulvescens*) spawn over coarse gravel and rounded cobble (Manny and Kennedy 2002) and where substrates are predominantly cobble (Chiotti et al. 2008),
- White sturgeon (*A. transmontanus*) spawn over a diversity of substrates including boulder, bedrock, cobble, and sand (Parsley et a. 1993; Perrin et al. 2003),
- Gulf sturgeon (*A. oxyrinchus*) spawning areas consist of hard substrates and gravel (Heise et al. 2004).

This has led to the general conclusion that pallid sturgeon most likely spawn over hard substrates. This is supported by telemetry data from the middle and lower Missouri River where female pallid sturgeon in spawning condition are believed to have spawned over or adjacent to coarse substrates in relatively deep water, on outside bends, where flows converge (Aaron DeLonay, U.S. Geological Survey (USGS), Personal Communication). The predominant substrate types upstream of Intake Dam are coarse sand, sand gravel and gravel-cobble (Bramblett and White 2001). On the Yellowstone River there are over 4,000 acres of bluff pool habitats (Jaeger et al. 2008). These habitats are characterized by deeper water, convergent flows along outside bends along eroding terraces with bottom composition in these pools being predominantly bedrock or boulder materials (Bramblett and White 2001). Given the association of sturgeon spawning with hard substrates and the abundance of hard substrates and habitat diversity upstream of Intake Dam, it is reasonable to infer that suitable spawning substrate for the species exists upstream of Intake Dam.

Historically, pallid sturgeon have been documented at least 112 miles upstream of Intake, Montana, or about 267 miles above the present headwaters of Lake Sakakawea. Pallid sturgeon were observed at this location during times of the year when spawning is known to occur (Brown 1955; Brown 1971). Watson and Stewart (1991) captured a pallid sturgeon near Fallon, Montana in 1991 in conjunction with studies associated with the Tongue River Project. There are other reports from the 1920s and 1930s that document pallid sturgeon above Intake Dam and in the vicinity of the Tongue River (Service 2000b). Historic data also cites fifteen occurrences of pallid sturgeon at Intake Dam between 1977 and 1994, with all of these confirmed captures in May or June (Service 2000b).

Growth and survival of drifting larvae depend on them being transported to suitable rearing habitats with abundant nutritional food and relatively benign environmental conditions (Wildhaber et al 2007). The Service (2000 and 2003) stressed the importance of shallow water habitats for larval rearing. FWP (Matt Jaeger, personal communication) has estimated that there are there are about 5,000 acres of shallow water rearing habitat between Intake and Cartersville diversions near baseflow conditions when this habitat type is important for rearing larvae. Jaeger et al. (2008) further indicated that spawning and rearing habitats upstream of Intake Diversion are suitable for pallid sturgeon restoration efforts.

Like most sturgeon species, pallid sturgeon move upstream to spawn and spawning is believed to occur at or near the summit of this movement (Aaron DeLonay, USGS, personal communication). Yellowstone River telemetry data indicates that pallid sturgeon will move into the Yellowstone River in the spring, some will move upstream to Intake Dam but not above and that the majority of study fish remained in the lower Yellowstone River (Bramblett and White 2001). None of these fish were of known reproductive condition. Subsequent work studying fish in known spawning condition documented at least one gravid female pallid sturgeon moving up to Intake Dam and then moving back downstream (Matt Jaeger, unpublished data).

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

Braaten et al. (2008) suggests larval drift distance available below Intake Dam is insufficient in length and settling habitat. If these young fish reach the lake environment, their survival rate is believed to be very low because of unsuitable habitat (Kynard et al. 2007). Biologists also suspect that pallid sturgeon larvae are intolerant of sediments in the river-reservoir transition zone (Wildhaber et al. 2007). The cause of larval deaths in the reservoir is unknown but could be the lack of food, predation, or related to sedimentation in reservoirs (Bergman et. al. 2008). The Garrison reach of the Missouri River is outside the recovery priority areas identified in the Pallid Sturgeon Recovery Plan (Service 1993). Reaches outside the recovery priority areas are not excluded from recovery actions but are designated as lower priority because these areas have been altered to the extent that major modifications would be needed to restore natural physical and hydrologic characteristics.

Recovery Plan The Service, along with many state game and fish departments, have coordinated efforts to help recover pallid sturgeon. Other federal agencies like the Corps and Reclamation have also been involved with priority recovery activities. A monitoring and assessment program for pallid sturgeon on the Missouri River has been established among the recovery agencies.

Avoidance of extirpation over the next 50 years in the upper Missouri River Basin may depend largely on the success of the pallid sturgeon artificial propagation program. These efforts are a part of the Pallid Sturgeon Recovery Plan and are assuming increasing importance because of the general absence of natural reproduction or recruitment in the upper Missouri River during the past 30 years (Jordan 2006). Both state and federal hatcheries are involved in these efforts. The Pallid Sturgeon Recovery Team and the Service completed a Pallid Sturgeon 5-year Review in 2007 (Service 2007). The Service has also been working with the Upper, Middle, and Lower

Basin Pallid Sturgeon workgroups in developing recovery tasks and drafting a new and revised Pallid Sturgeon Recovery Plan. A draft plan may be available for public review by the end of 2009. The draft Plan (G. Jordan - Service Pallid Sturgeon Recovery Coordinator, Billings, Montana, personal communication) recommends reclassification of pallid sturgeon status when identified threats are sufficiently reduced such that a self-sustaining and genetically diverse population is achieved within each management unit. Delisting will be considered when identified threats are alleviated and a self sustaining genetically diverse population is achieved within each management unit for 3 generations (36-60 years). In this context, the population data must reflect year class strength, survival to age, and mortality rates sufficient to maintain long-term population stability sustained through natural reproduction.

Effects of the Proposed Action

The term "effects of the action" refers to the direct and indirect effects of a proposed action on listed species and designated critical habitat, together with the effects of other activities that are interrelated or interdependent with that action that will be added to the environmental baseline (50 CFR §402.2). Reclamation reviewed the action area settings, life history, habitat information, and environmental baseline for each of the federally listed species to evaluate potential effects.

The Service has identified 3 potential conclusions regarding analyses for impacts on listed species or critical habitat:

- *No effect* - the appropriate conclusion when the action agency determines its proposed action will not affect listed species or critical habitat, or
- *Is not likely to adversely affect* – the appropriate conclusion when effects on listed species are expected to be discountable, or insignificant, or completely beneficial.
    - *Beneficial effects* are contemporaneous positive effects without any adverse effects to the species.
    - *Insignificant effects* relate to the size of the impact and should never reach the scale where take occurs.
    - *Discountable effects* are those extremely unlikely to occur.
- *Likely to adversely affect* – the appropriate conclusion if any adverse effect to listed species may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions, and the effect is not discountable, insignificant, or beneficial.

Whooping Crane

Direct Effect and Indirect Effects

Reclamation did not identify any impacts associated with proposed construction activity and historic migratory stopover sites for whooping cranes. Based on a review of past locations of this species, it would be unlikely that migrating whooping cranes would be near or on the proposed action area. Furthermore, environmental commitments identified in the Intake EA would avoid potential adverse effects by conducting pre-construction surveys and monitoring local whooping crane sightings. Reclamation is unaware of any interrelated or interdependent actions that would adversely affect the whooping crane in the action area.

Summary of Effects
The proposed action is not likely to adversely affect the whooping crane.

Interior Least Tern
Direct and Indirect Effects
Analyses of impacts to resources (hydrology, surface water quality, and lands and vegetation) were used to identify potential impacts to federally protected species (see chapter four of the EA). Reclamation did not identify any impacts associated with proposed construction activity and nesting interior least terns. Based on a review of past locations of this species, the potential for least terns to be near or on proposed action construction sites would be considered rare. Furthermore, environmental commitments identified in the EA would be incorporated to further avoid potential adverse effects by conducting surveys and monitoring during the least tern nesting season. Reclamation is not aware of any interrelated or interdependent actions that would adversely affect the interior least tern in the action area.

Summary of Effects
The proposed action is not likely to adversely affect the interior least tern.

Pallid Sturgeon
Direct and Indirect Effects Analyses of impacts to resources (hydrology, surface water quality, and lands and vegetation) were used to identify potential impacts to federally protected species (see chapter four of Intake EA and Appendix J: Adaptive Management Strategy). Reclamation has reviewed the proposed construction activities for this project and identified some direct and indirect effects to pallid sturgeon impacts due to construction. These impacts could include:

- Water quality issue related to temporary sediment dispersal and turbidity during construction.
- Dewatering for the installation of cofferdams that could leave fish stranded.
- Instream construction activity could impact fish directly or indirectly.
- Transition issues related to staging the construction and operation of the Intake Project.

However, implementation of environmental commitments noted above in the Project Description section would reduce any impacts of construction-related activities to less than significant. Furthermore, the overall purpose of the Intake Project will benefit pallid sturgeon recovery by allowing fish passage and minimizing entrainment. The overall effect of the Intake Project would provide future long-term benefits that would more than offset minor short-term impacts caused by construction. Any potential effect would be considered insignificant and discountable. Reclamation is unaware of any interrelated or interdependent actions that would adversely affect the pallid sturgeon in the action area. Incidental take is not anticipated.

Summary of Effects
The proposed action is not likely to adversely affect the pallid sturgeon.

Conclusions

With the implementation of the environmental commitments identified in this Intake Project BA and Intake Project EA, and in view of the previous discussion of potential impacts, Reclamation has determined that the construction activities associated with this proposed federal action are not likely to adversely affect the interior least tern, whooping crane, or pallid sturgeon. The overall effect of the Intake Project would provide future long-term benefits for pallid sturgeon recovery by allowing fish passage and minimizing entrainment. Furthermore, Reclamation will continue Section 7 consultation on the continued operations of the Lower Yellowstone Project and will work with the Service to complete that Section 7 consultation process. Based on the foregoing analysis, Reclamation requests written concurrence from the Service that the proposed action is not likely to adversely affect the whooping crane, interior least tern, or pallid sturgeon.

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M.04 – BR Informal
Lower Yellowstone Project

Memorandum

To: Manager, Resources Management Division, U.S. Bureau of Reclamation, Montana Area Office, Billings, Montana
(Attn: Mr. Jeff Baumberger)

From: Supervisor, Montana ES Field Office, Helena, Montana R. Mark Wilson

Subject: Biological Assessment for Construction Activities Associated With The Intake Diversion Dam Modification, Lower Yellowstone Project

This memo responds to your March 18, 2010 request for concurrence with the Bureau of Reclamation (Reclamation)/U.S. Army Corps of Engineers' (COE) effects determination contained in the *Biological Assessment for Construction Activities Associated with the Intake Diversion Dam Modification, Lower Yellowstone Project* (BA). The project proposal consists of constructing a new irrigation water intake containing a fish screen, along with a rock-lined ramp around the existing diversion dam for fish passage purposes. This response is provided by the U.S. Fish and Wildlife Service (Service) under the authority of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531-1543), the Migratory Bird Treaty Act (16 U.S.C. 703-712), and the Bald and Golden Eagle Protection Act (16 U.S.C. 668 et seq.).

Under the authority of the National Environmental Policy Act (NEPA) (2 U.S.C. 4321) and as a cooperating agency, the Service has fulfilled its duty to comment (40 CFR 1503.2) and utilized its expertise to assist the action agencies full consideration of fish and wildlife needs. Under the authority of the Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.), Reclamation and COE have incorporated our recommended means and measures to fully consider wildlife conservation. Reclamation's *Draft Environmental Assessment for the Intake Diversion Dam Modification, Lower Yellowstone Project* (Intake Draft EA) documents our long consultation history and the inclusion of Federal and State wildlife considerations.

On May 12, 2009, Reclamation, the COE, and the Service reached an agreement that informal Section 7 consultation is appropriate for the construction of the proposed Intake Project, so long as concurrent formal Section 7 consultation continues on operations of the Lower Yellowstone

Project. The formal Section 7 consultation addresses operation of the new proposed Intake Project structures, in addition to operation of the overall Lower Yellowstone Project. Therefore, the BA is only focused on construction of the proposed fish passage and entrainment protection structures.

This project is in the known range of the endangered pallid sturgeon (*Scaphirhynchus albus*), Interior least tern (*Sterna antillarum athalassos*), and whooping crane (*Grus americana*). Reclamation has determined that the construction activities associated with this proposed federal action are not likely to adversely affect the interior least tern, whooping crane, or pallid sturgeon. The Service concurs with Reclamation's determination, and that the overall effect of the Intake Project would provide future long-term benefits for pallid sturgeon recovery by allowing fish passage and minimizing entrainment.

Reclamation and COE are proposing to modify Intake Diversion Dam to improve passage for the endangered pallid sturgeon and other native fish and to reduce entrainment of fish into the Lower Yellowstone Project's main canal at Intake, Montana. The Intake Draft EA analyzes and discloses effects associated with construction of the proposed modifications to the Intake Diversion Dam and Lower Yellowstone Project's main canal headworks. Reclamation and the Corps are joint-lead agencies for preparation of the Intake EA. Reclamation is the administrative lead agency for the NEPA activities associated with the proposed Intake Project.

The proposed project is located on the Yellowstone River in Section 25, Township 18 North, Range 56 East, Dawson County, Montana. Construction of the Lower Yellowstone Project began in 1905 under the Reclamation Act of 1902 and included Intake Diversion Dam – a 12-foot high wood and stone structure that spans the Yellowstone River and raises the water level for diversion of water into the main canal. Intake Diversion Dam likely has impeded upstream migration of pallid sturgeon, an endangered species, and other native fish for more than 100 years. The dam is a total barrier to several fish species, including pallid sturgeon, due to increased turbulence and velocities associated with the rocks at the dam downstream.

The purpose of the project is to correct unsatisfactory passage conditions for endangered pallid sturgeon and other native fish in the lower Yellowstone River and reduce entrainment of fish into the Lower Yellowstone Project main canal. The proposed project is needed to:

a. Improve upstream and downstream fish passage for adult pallid sturgeon and other native fish in the lower Yellowstone River.
b. Minimize entrainment of pallid sturgeon and other native fish into the Lower Yellowstone Project main canal.
c. Continue effective operation of the Lower Yellowstone Project in compliance with the ESA.
d. Contribute to restoration of the lower Yellowstone River ecosystem.

Many alternatives were considered as a means to solve the fish passage problem at the dam. Construction of a rock ramp would replace the existing timber and rock Intake Diversion Dam with a concrete dam that would have a shallow-sloped ramp to provide fish passage. This alternative best meets the project purpose and is the least environmentally damaging alternative. Therefore, the rock ramp alternative is the preferred plan for construction. The rock ramp is designed to mimic natural river function and would lower velocities and turbulence so that migrating fish could seamlessly pass over the dam. The new dam and rock ramp would be paired with new headworks with rotating removable drum screens, which would minimize entrainment of fish into the main canal and regulate irrigation diversions.

The replacement concrete dam would be located downstream of a new headworks to create sufficient water height to divert 1,374 cfs into the main canal. This concrete dam would replace an existing timber and rock-filled dam providing long-term durability lacking in the current structure.

A rock ramp would be constructed downstream of the replacement dam by placing rock and fill material in the river channel to shape the ramp, and then it would be covered with rock riprap. The ramp would provide flow characteristics that meet the swimming abilities of the pallid sturgeon, so the endangered fish would have unimpeded access to habitat upstream of the dam. The rock ramp would be constructed to be relatively flat (approximately 0.5% slope) over much of its width to keep flow velocities as low as possible. The final configuration of the rock ramp would be optimized for pallid sturgeon passage using ongoing computer and physical scale modeling.

The new rock ramp would be constructed over the site of the existing Intake Diversion Dam, preserving most of the historic dam in place. Because the existing dam's rock field has washed downstream, part of the existing dam crest might be removed and rock moved to accommodate construction of a ramp. The rock ramp would include at least one low flow channel in conjunction with the low flow channel on the crest, which would allow fish migration during low flows. The rocks in the ramp would be sized to withstand high flows and ice jams and would range from one to four feet in diameter. The largest rocks would be placed near the crest to resist ice forces.

The rock ramp alternative would include excavation of a new segment of the main canal to connect the new headworks structure to the existing canal. The new canal extension would mimic the existing main canal geometry. The location of the new canal extension would correspond with a relatively high bank and hillside along the north bank of the Yellowstone River. Material excavated during construction of the new canal would be used to fill the existing canal behind the current headworks. Any excess material would be used as fill for the rock ramp and/or to build cofferdams needed to control water during construction. A new headworks structure would control diversion of water into the canal extension, and rotating removable drum screens would be installed in the new headworks to minimize entrainment of fish into the canal.

Impacts to wetland areas and existing streams were avoided and minimized by locating access roads and other features of the project outside of wetland areas and by pursuing the action alternative with the least impact on the Yellowstone River. No mitigation is proposed at this time.

The Final Intake EA will identify a number of Intake Project design features, best management practices, and environmental commitments that will avoid, reduce, or eliminate adverse environmental effects which may otherwise result from construction and operation of the proposed Intake Project. These features were detailed in the Intake Draft EA, BA, *Appendix J – Draft Adaptive Management Strategy* (DAMS), and the *Draft Lower Yellowstone Project Adaptive Management Plan* (DAMP). Based on the information found in the Intake Draft EA, BA, DAMS and DAMP for the Intake Diversion Dam Modification, the Service concurred with Reclamation's determination of effects on listed species. The environmental commitments were summarized in the Draft Finding of No Significant Impact Intake Diversion Dam Modification, Lower Yellowstone Project. Those commitments are in part:

- Reclamation and the Corps recognize that there is uncertainty in addressing natural resource issues. To manage this uncertainty Reclamation and the Corps will develop an adaptive management plan. The plan will be developed in accordance with the Department of the Interior Policy guidance (Order 3270) and the report *Adaptive Management, The U.S. Department of Interior Technical Guide 2007*.
- Reclamation and the Corps will follow the Adaptive Management Strategy in appendix J, including development of a MOU with joint-lead agencies, cooperating agencies, and the Board of Control to implement adaptive management practices. Prior to Intake Project construction, a specific Adaptive Management Plan for the selected alternative will be completed under the terms in the MOU.
- All constructed features will be monitored for no longer than 8 years in accordance with an adaptive management plan to ensure that these are operating as designed to improve fish passage and reduce entrainment.
- To ensure that Intake Project activities are completed concurrently and in full compliance with all environmental commitments, an Environmental Review Team will be formed. Members of the team, mostly state and federal agencies, will be established to review and assist Reclamation and the Corps on Intake Project actions during implementation of the environmental commitments.
- River morphology will be monitored to assess changes to the stream channel resulting from construction of the selected alternative. The Environmental Review Team will be consulted regarding specific measures to mitigate impacts if substantive changes are determined to have been caused by the Intake Project.
- A water quality monitoring program will be established for ensuring that water quality standards are not violated during construction activities..
- Discharges of fill material into waters of the U.S. will be carried out in compliance with provisions of Section 404 of the Clean Water Act and the permit requirements of the Corps.
- Erosion control measures will be employed where necessary to reduce wind and water erosion. Erosion and sediment controls will be monitored daily during construction for effectiveness, particularly after storm events, and the most effective techniques will be used.
- To avoid erosion and minimize hydrologic function impacts, construction methods that temporarily block natural flows will be limited in duration. If temporary blocks are necessary, flexible water barriers or a similar technique will be used.
- Silt barriers, fabric mats, or other effective means will be placed on slopes or other eroding areas where necessary to reduce sediment runoff into stream channels and wetlands until vegetation is re-established. This will be accomplished as soon as practical after disturbance activities.
- All work in the waterway will be performed in such a manner to minimize increases in suspended solids and turbidity, which may degrade water quality and damage aquatic life outside the immediate area of operation.
- All areas along the bank disturbed by construction will be seeded with vegetation indigenous to the area to minimize erosion.
- To avoid erosion and minimize hydrologic function impacts, construction methods that temporarily block natural flows would be limited in duration. If temporary blocks are necessary, flexible water barriers or similar technique will be used.
- To avoid impacts to fish, coffer dam construction and in-stream heavy equipment activity will be coordinated with fishery experts from the Service, Montana Fish, Wildlife and Parks (FWP), Reclamation and the COE to avoid and or minimize potential impacts.

- All pumps will use intakes screened with no greater than ¼" mesh when dewatering cofferdam areas in the river channel. Pumping will continue until water levels within the contained areas are suitable for salvage of juvenile or adult fish occupying these areas. Fish will be removed by methods approved by the Service and FWP prior to final dewatering.
- Reclamation will consult with FWP to ensure that adequate flows comparable to environmental baseline are maintained during construction to support the fishery during low-flow periods (late summer/early autumn).
- Reclamation will monitor the Service's whooping crane sighting reports to ensure that whooping cranes are not in the Intake Project area during construction. If any are sighted within the Intake Project area, Reclamation will consult with the Service regarding appropriate actions.
- Visual surveys for Interior Least Tern will be conducted weekly from May 15 to August 15 at all potential least tern nesting areas (sparsely vegetated sandbars) within line of site of the construction area.
- All surface-disturbing and construction activities will be seasonally restricted from May 15 to August 15 within 0.25 mile or the line of site of any active interior least tern nest.
- A physical model of the rock ramp will be constructed to provide additional velocity and turbulence data needed for final design of an effective ramp.
- The construction activities within the wetted perimeter of the active channel will be observed and monitored by a qualified fisheries biologist to avoid direct impacts to adult or juvenile pallid sturgeon. In-stream construction activities will cease if the fisheries monitor determines there is potential for direct harm or harassment of pallid sturgeon, until the potential for direct harm or harassment has passed. This will include coordination with FWP to make sure radio-tagged pallid sturgeon and other monitored native fish continue to be monitored, especially during the construction season.
- Any in-stream construction activity will be conducted during periods most likely to minimize the potential impact to the pallid sturgeon. The months to avoid and/or minimize impacts to pallid sturgeon are June and July.

This concludes informal consultation pursuant to regulations in 50 CFR 402.13 implementing the Endangered Species Act of 1973, as amended. This project should be re-analyzed if new information reveals effects of the action that may affect threatened, endangered or proposed species, if the project is modified in a manner that causes an effect not considered in this consultation, or if the conservations measures stated in the Draft EA, BA, DAMS, and DAMP for the Intake Diversion Dam Modification will not be implemented.

Please contact Lou Hanebury, Fish and Wildlife Biologist, at (406) 247-7367 if additional information is needed.

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Appendix E – Hydraulic Analysis and Pallid Sturgeon Evaluation

Introduction

This appendix presents a relative comparison of the action alternatives by evaluating the potential ability of alternatives to facilitate pallid sturgeon passage. This analysis is strictly a comparative analysis of the function of the alternatives to meet specific pallid sturgeon criteria (Service 2009). Each of the action alternatives was designed to allow upstream passage of fish (access to 165 miles of habitat) and meet specific pallid sturgeon criteria. These criteria provided a range of function while that habitat output for each alternative is the same. Thus, this analysis evaluates the differences in how each action alternative would function to restore pallid sturgeon access to 165 miles of river.

The Service's Biological Review Team (BRT) was tasked with analyzing how well the hydraulic performance of the alternatives met the swimming abilities of pallid sturgeon. The analysis uses scoring criteria developed by the BRT (2009) and hydraulic modeling (Corps 2009) to score alternatives on relative comparison scales. The BRT's scoring criteria are based on pallid sturgeon biology and a range of function for those criteria. The Corps (2009) report summarizes the results of hydraulic modeling used to evaluate pallid sturgeon fish passage for two alternatives, the Rock Ramp and the Relocate Main Channel.

The benefits for this project are river miles of habitat, and an incremental analysis of the alternatives against a constant habitat value simplifies to a least cost analysis. Nothing in the performance evaluation presented here should be construed to constitute an incremental analysis but rather is more appropriately viewed as a reliability analysis to aid in assuring that either alternative would perform as needed.

Methods

Biological Review Team Scoring Criteria

BRT Criterion 1

This criterion evaluates the ability of an alternative to provide passage for juvenile and adult pallid sturgeon based on percentage of the time that velocity targets would be met (tables E.1 and E.2). For juveniles the target is ≤ 1-2 ft/second flow velocity during the months of April – September.

Table E.1 – Juvenile Fish Passage Flow Velocity Scoring.

% of Period Criteria Are Met	Score
100	100
75	75
50	50
25	25
0	0

For adults the target is ≤ 4 ft/second flow velocity during April – June.

Table E.2 – Adult Fish Passage Flow Velocity Scoring.

% of Period Criteria Are Met	Score
100	100
99 - 75	50
<75	0

BRT Criterion 2

This criterion assesses the ability of an alternative to provide passage for juvenile and adult pallid sturgeon based upon the percentage of the proposed structure that would meet the flow velocity requirements of pallid sturgeon juveniles and adults. It is based on a scale of 100 points.

For juveniles the target is ≤ 1-2 ft/second flow velocity during April – September (table E.3).

Table E.3 - Percentage of the Proposed Structure Meeting Juvenile Target Velocity Scoring.

% of Structure Meeting Criteria	Score
>/= 30	100
30 - 20	50
<20	0

For adults the target is ≤ 4 ft/second flow velocity during April – June (table E.4).

Table E.4 - Percentage of Proposed Structure Meeting Adult Target Velocity Scoring.

% of Structure Meeting Criteria	Score
>/=50	100
<50	0

BRT Criterion 3

This criterion scores how well the structure meets minimum depth requirements, as well as velocity specifications previously listed (tables E.5 and E.6). It is based on a scale of 100 points.

Table E.5 – Structure Depth Plus Velocity for Juveniles Scoring.

Depth	Score
> 1m	100
.99-0.5 m	50
<0.5 m	0

Table E.6 – Structure Depth Plus Velocity for Adults Scoring.

Depth	Score
> 1m	100
.99-0.5 m	50
<0.5 m	0

BRT Criterion 4

Criterion 4 addresses the presence of vertical sills greater than 0.3m either designed or likely to occur. It is based on a scale of 100 points.

Table E.7 – Vertical Sills Scoring.

Vertical Sill > 0.3 m	Score
No	100
Yes	0

BRT Criterion 5

To address adaptive management, the 5th criterion scores the potential for fine-tuning or modifying the structure to improve passage if needed (table E.8). It is based on a scale of 100 points.

Table E.8 – Adaptive Management.

Ability to modify structure	Score
Easy	100
Moderately difficult to modify	50
Very difficult to modify	0

BRT Criterion 6

The degree of uncertainty of success associated with an alternative is based upon a 100 point scale (table E.9).

Table E.9 – Degree of Uncertainty of Success.

Level of Uncertainty	Score
Low	100
Medium	50
High	0

Hydraulic Modeling

Different models were used to evaluate the two alternatives. The Relocate Main Channel Alternative was modeled using a one-dimension Hydrologic Engineering Center-River Analysis System (HEC_RAS). However, because the rock ramp configuration is more complex, it did not lend itself to a one-dimensional model. Therefore, a two-dimensional hydraulic model, ADaptive Hydrodynamics/Hydrology (ADH), was used to model the rock ramp.

While two different models were used for evaluating the two alternatives, the results for both alternatives are based on the following assumptions:

- April through September is the critical period for fish passage on the lower Yellowstone River. This was the period modeled.
- Monthly flow-duration curves were used to select representative flows. Three discharges (7,000 cfs, 15,000 cfs, and 30,000 cfs) were selected to represent the months April - September based on the 50% (exceeded by duration) flow.
    - 7,000 cfs April, August, and September.
    - 15,000 cfs for May and July.
    - 30,000 cfs for June.
- A matrix of velocity and depths was developed based on the BRT criteria.
- Four discharges were modeled for both alternatives (see above). From the model results, the percentage of area on the ramp or channel that met specified velocity/depth ranges was computed. Computation of the area-percentages was external to the hydraulic models.
- All reported velocities are depth averaged. Flow velocity is reduced near the bottom. Future evaluations will use physical model output, Acoustic Doppler Current Profiler survey information, and available guidance from literature to establish an appropriate relationship between depth averaged and near-bottom velocities.

Results

Tables E.10 and E.11 compare the Relocate Main Channel Alternative to the Rock Ramp Alternative using the hydraulic modeling and BRT scoring criteria.

Scores

Tables E.10 and E.11 present modeling results for evaluating the alternatives using BRT Criteria 1 and 3. For BRT Criterion 1, highlighted in tan, the percent of channel was added for each month for appropriate velocities (tables E.10 and E.11). The scores were then added together and an average score was calculated for the time period. BRT Criterion 3, highlighted in turquoise, was more complex, because the criteria addressed velocities as well as specific depths.

The other criteria were not modeled so they are not included in tables E.10 and E.11, but their values are incorporated in table E.12. BRT Criterion 2 could not be measured without a physical model, which is being developed for the preferred alternative (Rock Ramp Alternative). BRT Criterion 4 was based on the presence or absence of vertical sills. BRT Criterion 5 addresses the ability to tune or modify the structure to meet the needs of the pallid sturgeon. BRT Criterion 6 regards the degree of uncertainty associated with the alternative.

Table E.10 - Evaluation of the Relocate Main Channel Alternative Using Hydraulic Modeling and Pallid Sturgeon BRT Criteria.

Relocate Main Channel																
		7,000 cfs (April/August/Sept)					15,000cfs (May/July)					30,000cfs (June)				
		Percent (by area) of channel in specified depth/velocity range														
Depth range		Velocity range (ft/sec)[1]					Velocity range (ft/sec)					Velocity range (ft/sec)				
(m)	(ft)	0-2	2-4	4-6	6-8	>8	0-2	2-4	4-6	6-8	>8	0-2	2-4	4-6	6-8	>8
0-0.5	0-1.64	**0.7**					**1.8**									
0.5-1	1.64-3.28	**5.6**	**63.0**				**0.5**					**18.9**				
>1	>3.28	**1.0**	**29.7**				**1.1**	**78.7**	**18.0**			**2.0**	**13.1**	**65.7**		**0.3**
Total % of channel		**7.3**	**92.7**				**3.4**	**78.7**	**18.0**			**20.9**	**13.1**	**65.7**		
BRT-1 Juvenile Score		**100**					**82.1**					**34**				
BRT-1 Adult Score		**100**					**100**					**99.7**				
BRT-3 Juvenile and Adult Score		**100**					**100**					**100**				

[1]The velocity range is an average velocity from a column of water, so the velocity at the bottom of the river could actually be less because of bottom roughness.

Table E.11 - Evaluation of Rock Ramp Alternative Using Hydraulic Modeling and Pallid Sturgeon BRT Criteria.

Rock Ramp																
		7,000 cfs (April/August/Sept)					15,000cfs (May/July)					30,000cfs (June)				
		Percent (by area) of channel in specified depth/velocity range														
Depth range		Velocity range (ft/sec) [1]					Velocity range (ft/sec)					Velocity range (ft/sec)				
(m)	(ft)	0-2	2-4	4-6	6-8	>8	0-2	2-4	4-6	6-8	>8	0-2	2-4	4-6	6-8	>8
0-0.5	0-1.64		**35.3**	**0.1**				**0.4**					**0.0**	**0.0**		
0.5-1	1.64-3.28		**27.8**	**3.9**				**24.3**	**9.3**	**0.0**			**0.2**	**0.0**		
>1	>3.28		**19.0**	**13.2**	**0.0**			**21.4**	**33.8**	**10.6**			**7.6**	**38.5**	**48.7**	**4.9**
Total % of channel		**0**	**82.1**	**17.2**			**0**	**46.1**	**43.1**			**0**	**7.8**	**38.5**		
BRT-1 Juvenile Score		**82.1**					**46.1**					**7.8**				
BRT-1 Adult Score		**99.3**					**89.2**					**46.3**				
BRT-3 Juvenile and Adult Score		**100**					**100**					**100**				

[1]The velocity range is an average velocity from a column of water, so the velocity at the bottom of the river could actually be less because of bottom roughness. This will be further evaluated by the physical model.

Results of the evaluation and scoring are in table E.12. The total score for the Relocate Main Channel Alternative was 382.1. The total score for the Rock Ramp Alternative was 485.46.

Table E.12 - Scoring Results of Evaluating Alternatives Using Hydraulic Modeling and Pallid Sturgeon BRT Criteria.

BRT Criteria	Relocate Main Channel Alternative Score	Rock Ramp Alternative Score
BRT - 1 Juveniles	**57.2**	**57.2**
BRT -1 Adults	**99.9**	**78.26**
BRT - 2 Juveniles and Adults	requires physical model	requires physical model
BRT - 3 Juveniles and Adults	**100**	**100**
BRT - 4	**0**	**100**
BRT - 5	**75**	**100**
BRT - 6	**50**	**50**
TOTAL	**382.1**	**485.46**

Note: BRT 1 through 3 are averages for April through September flows. BRT 4 through 5 are scores from BRT criteria. BRT 6 represents the degree of uncertainty with the alternative.

Summary

The Corps hydraulic modeling of the alternatives was used to evaluate the two action alternatives using pallid sturgeon biological criteria developed by the Services' BRT. Each of the action alternatives was designed to allow upstream passage of fish to 165 miles of habitat. The scoring system developed by the BRT was used for a relative comparison of the alternatives' ability to provide passage. The Rock Ramp Alternative scores more favorably for the functional passage of pallid sturgeons than the Relocate Main Channel Alternative.

Additional studies will be performed to further guide engineering design of pallid sturgeon passage, including a physical model. In addition, the Corps conducted riffle surveys of selected areas along the Yellowstone River in the spring of 2009. This information will be used to develop a better understanding of existing Yellowstone River velocity and depth conditions.

Literature Cited

Corps. 2009. Intake Dam Modification Project Hydraulic Modeling in Support of Fish Passage Evaluation. Omaha District, Omaha, Nebraska.

Service. 2009. Summary of the Biological Review Team's Comments on the Lower Yellowstone River Irrigation Project Fish Passage and Screening Alternatives, and Alternative Scoring Criteria. Yellowstone River and Pallid Sturgeon Recovery Coordinator. Billings, Montana.

Appendix F – Species Common and Scientific Names

Introduction

This appendix lists common and scientific names used of species discussed in the EA and in the appendixes. The names are organized according to the following categories: mammals, birds, reptiles and amphibians, fish, macroinvertebrates, mollusks, plants, and noxious weeds. Names appear alphabetically by common name, followed by scientific name. Species with a special status are noted in the third column, and a key of status categories appears at the end of this appendix. For more information on special status species, see Appendix D (biological assessment).

Table F.1 – Common and Scientific Names Used.

Common Name	Scientific Name	Status
Mammals		
Antelope	*Antilocapra americana*	NS
Badger	*Taxidea taxus*	NS
Beaver	*Castor canadensis*	NS
Big brown bat	*Eptesicus fuscus*	NS
Desert cottontail	*Sylvilagus audubonii*	NS
Dwarf shrew	*Sorex nanus*	MT S
Eastern cottontail	*Sylvilagus floridanus*	NS
Eastern fox squirrel	*Sciurus niger*	NS
Eastern red bat	*Lasiurus borealis*	NS
Mountain cottontail	*Sylvilagus nuttallii*	NS
Hayden's shrew	*Sorex haydeni*	NS
Hoary bat	*Lasiurus cinereus*	NS
Least weasel	*Mustela nivalis*	NS
Long-eared myotis	*Myotis evotis*	NS
Little brown myotis	*Myotis lucifugus*	NS
Long-legged myotis	*Myotis volans*	NS
Long-tailed weasel	*Mustela frenata*	NS
Meadow vole	*Microtus pennsylvanicus*	NS
Meadow jumping mouse	*Zapus hudsonius*	MT S
Mink	*Mustela vison*	NS
Mule deer	*Odocoileus hemionus*	NS
Muskrat	*Ondatra zibethicus*	NS
Olive-backed pocket mouse	*Perognathus fasciatus*	NS
Ord's kangaroo rat	*Dipodomys ordii*	NS
Porcupine	*Erethizon dorsatum*	NS
Prairie vole	*Microtus ochrogaster*	NS
Preble's shrew	*Sorex preblei*	MT S
Northern Pocket Gopher	*Thomomys talpoides*	NS
Raccoon	*Procyon lotor*	NS
Silver-haired bat	*Lasionycteris noctivagans*	NS
Snowshoe hare	*Lepus americanus*	NS

Common Name	Scientific Name	Status
Striped skunk	*Mephitis mephitis*	NS
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	NS
Townsend's big-eared bat	*Corynorhinus townsendii*	MT S
Western jumping mouse	*Zapus princeps*	NS
Western small-footed myotis	*Myotis ciliolabrum*	NS
White-tailed deer	*Odocoileus virginianus*	NS
White-tailed jackrabbit	*Lepus townsendii*	NS
Birds		
American redstart	*Setophaga ruticilla*	
American robin	*Turdus migratorius*	
Bald eagle	*Haliaeetus leucocephalus*	ND C MN S
Baird's sparrow	*Ammodramus bairdii*	ND C MN S
Black-billed magpie	*Pica hudsonia*	
Black-capped chickadee	*Poecile atricapillus*	
Black-headed grosbeak	*Pheucticus melanocephalus*	
Bobolink	*Dolichonyx oryzivorus*	MT S
Brown-headed cowbird	*Molothrus ater*	
Chestnut-collared longspur	*Calcarius ornatus*	MT S
Common Crow	*Corvus brachyrhynchos*	
Downy woodpecker	*Picoides pubescens*	
Golden eagle	*Aquila chrysaetos*	ND C
Grasshopper sparrow	*Ammodramus savannarum*	MT S
Great horned owl	*Bubo virginianus*	
Hairy woodpecker	*Picoides villosus*	
Horned lark	*Eremophila alpestris*	
Interior least tern	*Sterna antillarum*	US F
Lazuli bunting	*Passerina amoena*	
Least flycatcher	*Empidonax minimus*	
Loggerhead shrike	*Lanius ludovicianus*	MT S
Long-billed curlew	*Numenius americanus*	ND C
Northern flicker	*Colaptes auratus*	
Ovenbird	*Seiurus aurocapilla*	
Red-eyed vireo	*Vireo olivaceus*	
Red-headed woodpecker	*Melanerpes erythrocephalus*	MT S
Red-tailed hawk	*Buteo jamaicensis*	
Sharp-tailed grouse	*Tympanuchus phasianellus*	
Sprague's pipit	*Anthus spragueii*	MT S
Spotted towhee	*Pipilo maculatus*	
Warbling vireo	*Vireo gilvus*	
Western meadowlark	*Sturnella neglecta*	
Whooping crane	*Grus americana*	US F
Yellow warbler	*Dendroica petechia*	
Reptiles and Amphibians		
Boreal chorus frog	*Pseudacris maculata*	NS
Common gartersnake	*Thamnophis sirtalis*	NS
Eastern racer	*Coluber constrictor*	NS
Milksnake	*Lampropeltis triangulum*	MT S
Painted turtle	*Chrysemys picta*	NS
Plains gartersnake	*Thamnophis radix*	NS
Sagebrush lizard	*Sceloporus graciosus*	MT S
Snapping turtle	*Chelydra serpentine*	MT S
Spiny softshell turtle	*Apalone spinifera*	MT S
Tiger salamander	*Amystoma tigrinum*	NS

Common Name	Scientific Name	Status
Western hog-nose snake	*Heterodon nasicus*	MT S
Woodhouse's toad	*Bufo woodhousii*	NS
Fish		
Bighead carp	*Hypophthalmichthys nobilis*	
Bigmouth shiner	*Notropis dorsalis*	
Black bullhead	*Ameiurus melas*	
Black crappie	*Pomoxis nigromaculatus*	
Blackside darter	*Percina maculata*	
Blue gill	*Lepomis macrochirus*	
Blue sucker	*Cycleptus elongatus*	MT S, ND C
Bluntnose minnow	*Pimephales notatus*	
Brook stickleback	*Culaea inconstans*	
Brook trout	*Salvelinus fontinalis*	
Brown bullhead	*Ameiurus natalis*	
Brown trout	*Salmo trutta*	
Common carp	*Cyprinus carpio*	
Channel catfish	*Ictalurus punctatus*	
Chinook salmon	*Oncorhynchus tshawytscha*	
Cisco	*Coregonus artedi*	
Common shiner	*Luxilus cornutus*	
Crappie	*Pomoxis spp.*	
Creek chub	*Semotilus atromaculatus*	
Dace	*Rhinichthys spp.*	
Emerald shiner	*Notropis atherinoides*	
Fathead minnow	*Pimephales promelas*	
Flathead chub	*Platygobio gracilis*	
Gizzard shad	*Dorosoma cepedianum*	
Goldeye	*Hiodon alosoides*	
Golden redhorse	*Moxostoma erythrurum*	
Hornyhead chub	*Nocomis biguttatus*	
Iowa darter	*Etheostoma exile*	
Jonny darter	*Etheostoma nigrum*	
Lake chub	*Couesius plumbeus*	ND C
Lake trout	*Salvelinus namaycush*	
Largemouth bass	*Micropterus salmoides*	
Least darter	*Etheostoma microperca*	
Logperch	*Percina caprodes*	
Longnose dace	*Rhinichthys cataractae*	
Mooneye	*Hiodon tergisus*	
Muskellunge	*Esox masquinongy*	
Northern pike	*Esox lucius*	
Northern redbelly dace	*Phoxinus eos*	
Orangespotted sunfish	*Lepomis humilis*	
Pallid sturgeon	*Scaphirhynchus albus*	US F
Paddlefish	*Polydon spathula*	MT S
Pearl dace	*Margariscus margarita*	ND C
Pugnose shiner	*Notropis anogenus*	
Pumpkinseed sunfish	*Lepomis gibbosus*	
Rainbow smelt	*Osmerus mordax*	
Rainbow trout	*Oncorhynchus mykiss*	
River carpsucker	*Carpiodes carpio*	
Rock bass	*Ambloplites rupestris*	
Shiner	*Notropis sp.*	
Sand shiner	*Notropis stramineus*	
Sauger	*Sander canadense*	MT S
Shorthead redhorse	*Moxostoma macrolepidotum*	

Common Name	Scientific Name	Status
Shovelnose sturgeon	*Scaphirhynchus platorynchus*	
Sicklefin chub	*Macrhybopsis meeki*	MT S, ND C
Silver chub	*Macrhybopsis storeriana*	Can F
Smallmouth bass	*Micropterus dolomieu*	
Spotfin shiner	*Cyprinella spiloptera*	
Sturgeon	*Acipenser sp.*	
Sturgeon chub	*Macrhybopsis gelida*	MT S
Sucker	*Catostomus sp.*	
Sunfish	*Lepomis sp.*	
Tiger muskie	*Esox masquinongy x Esox lucius*	
Utah chub	*Gila atraria*	
Walleye	*Stizostedion vitreum*	
White bass	*Morone chrysops*	
White crappie	*Pomoxis annularis*	
White sucker	*Catostomus commersoni*	
Yellow bullhead	*Ameiurus natalis*	
Yellow perch	*Perca flavescens*	
Zander	*Stizostedion lucioperca*	
Macroinvertebrates		
Brimstone clubtail	*Stylurus intricatus*	MT S
Caddisflies	*Trichoptera*	
Mayfly sp.	*Lachlania saskatchewanensis*	
Mayfly sp.	*Homoeoneuria alleni*	MT S
Mayfly sp.	*Macdunnoa nipawinia*	MT S
True flies	*Diptera*	
Non-biting midges	*Chironomidae*	
Sand-dwelling mayfly	*Homoeoneuria alleni and Macdunnoa nipawinia*	MT S
Stoneflies	*Plecoptera*	
True bugs	*Hemiptera*	
Water beetles	*Coleoptera*	
Midges	*Chironomidae*	
Mollusks		
Fatmucket	*Lampsilis siliquoidea*	
Mapleleaf	*Quadrula quadrula*	
Plants		
Box elder	*Acer negundo*	NS
Bractless blazingstar	*Mentzelia nuda*	MT S
Buffaloberry	*Shepherdia argentea*	NS
Buffalo grass	*Buchloe dactyloides*	NS
Chokecherry	*Prunus virginiana*	NS
Cottonwood	*Populus deltoides*	NS
Green ash	*Fraxinus pennsylvanica*	NS
Hayden's yellowcress	*Rorippa calycina*	MT S
Juniper	*Juniperus scopulorum or J. virginiana*	NS
Little blue stem	*Schizachyrium scoparium*	NS
Narrowleaf penstemon	*Penstemon angustifolius*	MT S
Needle and thread grass	*Stipa comata*	NS
Nine-anther prairie clover	*Dalea enneandra*	MT S
Pale-spike lobelia	*Lobelia spicata*	MT S
Poison suckleya	*Suckleya suckleyana*	MT S
Ponderosa pine	*Pinus ponderosa*	NS
Prairie goldenrod	*Oligoneuron album*	MT S
Russian olive	*Elaeagnus angustifolia*	NS

Common Name	Scientific Name	Status
Silky Prairie-clover	*Dalea villosa*	MT S
Silver sagebrush	*Artemisia cana*	NS
Threadleaf sedge	*Carex filifolia*	NS
Wheatgrass	*Pascopyrum smithii*	NS
Willows	*Salix spp.*	NS
Noxious Weeds		
Absinth wormwood	*Artemisia absinthium*	NX - ND
Canada thistle	*Cirsium arvensis*	NX - ND, MT
Common tansy	*Tanacetum vulgare*	NX - MT
Dalmation toadflax	*Linaria dalmatica*	NX - MT
Dyers woad	*Isatis tinctoria*	NX - MT
Field bindweed	*Convolvulus arvensis*	NX - MT
Hoary cress	*Cardaria draba*	NX - MT
Houndstongue	*Cynoglossum officinale*	NX - MT
Leafy spurge	*Euphoria esula*	NX - MT, ND
Musk thistle	*Cardus nutans*	NX - ND
Purple loosestrife	*Lythrum salicaria, L. virgatum* or hybrids	NX - MT
Russian knapweed	*Centaurea repens*	NX - MT, ND
Salt cedar	*Tamarix sp*	NX - MT, ND
Spotted knapweed	*Centaurea maculosa*	NX - MT, ND
Yellow toadflax	*Linaria vulgaris*	NX - MT

Key to Status:
US F- United States Federally Listed
MT S- Montana Species of Special Concern
ND C- North Dakota Species of Conservation Priority
NS – no status
NX – noxious weed

Appendix G – National Historic Preservation Act Consultation

Introduction

Consultation with the Montana State Historic Preservation Office (SHPO) began with a request for a search of files to identify any historic properties previously recorded within the area of potential effects of the Intake Project (table G.1). This file search request was e-mailed on May 1, 2009. The SHPO responded on May 11, 2009 with a list of determinations of eligibility, previously recorded sites, and a list of cultural resources reports in the area of potential effects.

On October 15, 2009, Reclamation sent a letter to the SHPO continuing consultation on the Intake Project (see below). The letter enclosed detailed information about the location of the proposed federal undertaking, identification of historic properties, and effects determination, and proposed mitigation measures. In addition, Reclamation offered to meet to discuss the proposed federal undertaking.

The Montana SHPO concurred with Reclamation's October 15, 2009, consultation letter on November 4, 2009. Consultation on preparation of a formal memorandum of agreement regarding mitigation of adverse effects and treatment of historic properties is ongoing.

Table G.1 – File Search Request Sent to Montana SHPO on May 1, 2009.

STATE HISTORIC PRESERVATION OFFICE

1410 8th Ave., P.O. Box 201202, Helena, MT 59620-1202
Phone: (406)-444-7767
Email: dmurdo@mt.gov
Attn: Damon Murdo

File Search Request Form

Please complete this form and attach a copy of the appropriate USGS Quad map showing the project location. All fields must be completed in order for your file search request to be processed. The form and accompanying map can be returned to the address above, emailed, or brought directly to the office.

Individuals Name	J. Signe Snortland		
Organization (Agency/Company)	U.S. Department of the Interior, Bureau of Reclamation		
Street	P.O. Box 1017 or 304 East Broadway Avenue		
City	Bismarck	State: ND	Zip:58502
Telephone #	701-221-1278	Fax: 701-250-4590	
Project Name	Intake Diversion Dam Modification, Lower Yellowstone Project		
Government Agency Involved	Bureau of Reclamation and U.S. Army Corps of Engineers, Omaha District		
Describe the project. Please identify any work that will involve ground disturbance, or the demolition and modification of existing buildings. If none of these are to occur, please indicate.	Reclamation and the Corps are proposing to modify Intake Diversion Dam to improve passage for the endangered pallid sturgeon and reduce unintended entrapment of fish in an unscreened irrigation canal system. The two action alternatives under consideration are to: 1) replace the existing historic dam with a concrete weir and rock ramp and the unscreened historic intake with a new screened intake or 2) relocate the main channel of the Yellowstone River around the historic dam and move the irrigation main canal upstream and build a new screened headworks. A No Action Alternative, the future without the proposed federal undertaking, is also under consideration in an environmental assessment.		
Describe any previous disturbance and the current land use.	The area of potential effects is currently used for by the Lower Yellowstone Project irrigation districts. Beside the irrigation project intake and main canal is a state-operated recreation area, Intake Fishing Access Site.		
Approximate date of proposed project initiation.	If an action alternative is selected, construction of a fish screen and headworks would begin in September 2010, and construction of fish passage would start in March 2011.		
Land Ownership (Private, State, Federal, etc.)	Mixed - some land is federal (Reclamation), some state, and some private. A real estate plan is being developed.		
Remarks/ Special Requests	Remarks - Most of the area of potential effects has been surveyed previously by the University of North Dakota, as documented in "Lower Yellowstone Irrigation Project, 1996 and 1997 Cultural Resources Inventory, Dawson and Richland Counties, Montana, and McKenzie County, North Dakota" by Cynthia Kordecki, Mary McCormick, Carrie F. Jackson, and Jennifer Bales and Renewable Technologies, Inc. Special Requests – If possible, please check to see if consensus determinations have been completed the results of these determinations for 24DW287, 24DW298, 24DW299, 24DW300, 24DW430, 24DW431, 24DW433, 24DW434, 24DW436, 24DW437, 24DW443, 24DW444, 24DW447, and isolated find BA1-29.		

Project Area Location Information (add on if necessary) Projects in cities also require TRS.

TOWNSHIP	RANGE	SECTION	COUNTY
T18N	R56E	Sections 25, 35, and 36	Dawson
T18N	R57E	Sections30 and 31	Dawson
T17N	R56E	Sections 1 and 2	Dawson
T17N	R57E	Section 6	Dawson

United States Department of the Interior

BUREAU OF RECLAMATION
Great Plains Region
Montana Area Office
P.O. Box 30137
Billings, Montana 59107-0137

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
MT-227
ENV-3.00

OCT 15 2009

Dr. Mark Baumler
State Historic Preservation Office
P.O. Box 201202
1410 8th Ave.
Helena, MT 59620 - 1202

Subject: Consultation on Intake Diversion Dam Modification, Lower Yellowstone Project, and Notification of Potential Adverse Effects on Historic Properties
SHPO Project Designation Number: 2009051102

Dear Dr. Baumler:

In compliance with 36 CFR Parts 800.3, 800.4, and 800.5 the U.S. Department of the Interior, Bureau of Reclamation, is continuing consultation on the Intake Diversion Dam Modification, Lower Yellowstone Project. Reclamation and the U.S. Army Corps of Engineers (Corps) are proposing to modify Intake Diversion Dam. Reclamation is the lead Federal agency and is responsible for compliance with the National Historic Preservation Act (36 CFR Part 800.2[a]) for this proposed Federal undertaking. Reclamation and the Corps are currently preparing a draft environmental assessment for the proposed Federal undertaking.

The proposed Federal undertaking is located at Intake, Dawson County, Montana (see enclosure figure 1). The legal descriptions of the undertaking are Township 18 North, Range 56 East, Sections 25, 35, and 36; Township 18 North, Range 57 East, Sections 30 and 31; Township 17 North, Range 56 East, Sections 1 and 2; and Township 17 North, Range 57 East, Section 6 (see enclosure figure 1). Ownership of land in the area of potential effects (APE) is a mixture of federal, state, and private (see enclosure figure 2).

The proposed action is needed to:

- Improve upstream and downstream fish passage for adult pallid sturgeon and other native fish in the lower Yellowstone River,
- Minimize entrainment of pallid sturgeon and other native fish into the Lower Yellowstone Project main canal,
- Continue effective operation of the Lower Yellowstone Project in compliance with the Endangered Species Act, and
- Contribute to restoration of the lower Yellowstone River ecosystem.

Three alternatives are being evaluated in the Intake Diversion Dam Modification, Lower

Yellowstone Project, Draft Environmental Assessment (Intake EA), as described in the enclosure. The Rock Ramp is the preferred alternative, and without mitigation, will result in Adverse Effects to several historic properties. The public has been notified of this proposed Federal undertaking through the National Environmental Policy Act scoping meetings held last fall, and will be given an opportunity to comment on summary cultural resource information in the Intake EA this fall, and to attend public meetings. Along with the public scoping meetings, a total of 25 tribes in the upper Missouri Basin were sent letters notifying them of the proposed project. Follow-up telephone calls were made to each tribe, and none expressed interest in it.

Enclosed is detailed information about the location of the proposed Federal undertaking, alternatives considered, identification of historic properties, effects determination, and proposed mitigation measures. Reclamation is planning to continue consultation with your office, on preparation of a formal memorandum of agreement stipulating the mitigation and treatment plan. If you have any questions about this proposed Federal undertaking or would like to schedule a meeting to discuss it, please feel free to contact me at 406-247-7666.

Sincerely,

WILLIAM B VINCENT

William Vincent
Area Archaeologist

Enclosure

cc: Ms. Sandy Barnum
U.S. Army Corps of Engineers
1616 Capitol Ave,
Omaha, NE 68102

bc: 84-53000 (Lincoln)
DK-5000 (Snortland)
GP-42000 (Coutant)
MT-200, MT-221, MT-227, MT-745

WBR:WVincent:JJohnson:10/14/2009:406-247-7666
V:\Shared\Correspondence\2009\227\SHPOCondrf#02.doc

2009101613

United States Department of the Interior

BUREAU OF RECLAMATION
Great Plains Region
Montana Area Office
P.O. Box 30137
Billings, Montana 59107-0137

TAKE PRIDE IN AMERICA

IN REPLY REFER TO:
MT-227
ENV-3.00

NOV 09 2009

OCT 15 2009

BY: SHPO
• Josef
• BOR
• Intake Dam Modification Lower YL

Dr. Mark Baumler
State Historic Preservation Office
P.O. Box 201202
1410 8th Ave.
Helena, MT 59620 - 1202

CONCUR
MONTANA SHPO
DATE 4 Nov 09 SIGNED [signature]

Subject: Consultation on Intake Diversion Dam Modification, Lower Yellowstone Project, and Notification of Potential Adverse Effects on Historic Properties
SHPO Project Designation Number: 2009051102

Dear Dr. Baumler:

In compliance with 36 CFR Parts 800.3, 800.4, and 800.5 the U.S. Department of the Interior, Bureau of Reclamation, is continuing consultation on the Intake Diversion Dam Modification, Lower Yellowstone Project. Reclamation and the U.S. Army Corps of Engineers (Corps) are proposing to modify Intake Diversion Dam. Reclamation is the lead Federal agency and is responsible for compliance with the National Historic Preservation Act (36 CFR Part 800.2[a]) for this proposed Federal undertaking. Reclamation and the Corps are currently preparing a draft environmental assessment for the proposed Federal undertaking.

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Yellowstone Project, Draft Environmental Assessment (Intake EA), as described in the enclosure. The Rock Ramp is the preferred alternative, and without mitigation, will result in Adverse Effects to several historic properties. The public has been notified of this proposed Federal undertaking through the National Environmental Policy Act scoping meetings held last fall, and will be given an opportunity to comment on summary cultural resource information in the Intake EA this fall, and to attend public meetings. Along with the public scoping meetings, a total of 25 tribes in the upper Missouri Basin were sent letters notifying them of the proposed project. Follow-up telephone calls were made to each tribe, and none expressed interest in it.

Enclosed is detailed information about the location of the proposed Federal undertaking, alternatives considered, identification of historic properties, effects determination, and proposed mitigation measures. Reclamation is planning to continue consultation with your office, on preparation of a formal memorandum of agreement stipulating the mitigation and treatment plan. If you have any questions about this proposed Federal undertaking or would like to schedule a meeting to discuss it, please feel free to contact me at 406-247-7666.

Sincerely,

William Vincent
Area Archaeologist

Enclosure

cc: Ms. Sandy Barnum
U.S. Army Corps of Engineers
1616 Capitol Ave,
Omaha, NE 68102

Appendix H – Indian Trust Assets

Introduction

This appendix contains the data and analyses used to determine whether alternatives for the Lower Yellowstone Intake Project would impact Indian trust assets (ITA). ITAs are defined as "...legal interests in property held in trust by the United States for Indian tribes or individuals" (Reclamation 1993).

The relationship between the Federal government and tribes is defined in the U.S. Constitution. Article 1, Section 8 gives Congress the authority "[t]o regulate commerce with foreign nations, and among the several states, and with the Indian tribes." Until 1871, this relationship with individual tribes was enumerated through treaties, from which the concept of the "trust relationship" originated. According to the Supreme Court decision in *Cherokee Nation v. Georgia* (1831), Indian tribes are considered to constitute "domestic, dependent nations" whose "relationship to the United States resembles that of a ward to his guardian." This decision established the doctrine of federal trusteeship – the trust relationship – in Indian affairs.

All federal agencies, including Reclamation, have a government-to-government relationship with tribes. Federally recognized tribes are to be respected as sovereign governments and federal agencies have a trust responsibility to respect this sovereignty by protecting and maintaining rights reserved by or granted to tribes or individual Indians by treaties, federal court decisions, statutes, and executive orders. The sovereignty of tribes and this trust relationship have been affirmed through treaties, court decisions, legislation, regulations, and policies. The result is that federal agencies are to assess the impacts of their activities on trust assets, to protect and conserve ITAs to the extent possible. This appendix provides the framework for the identification of ITAs that may possibly be affected by the proposed alternatives. It does not attempt to define, regulate, or quantify ITAs or any rights that tribes are entitled to by treaty or law.

Indian Trust Assets

Examples of possible trust assets include "lands, minerals, hunting and fishing rights, and water rights" (Reclamation 1993). To this extent, this definition of ITAs parallels that of "trust resources" in 25 CFR Part 1000.352:

(a) Trust resources include property and interests in property:
  (1) That are held in trust by the United States for the benefit of a tribe or individual Indians; or
  (2) That are subject to restrictions upon alienation.
(b) Trust assets include:

> (1) Other assets, trust revenue, royalties, or rental, including natural resources, land, water, minerals, funds, property, assets, or claims, and any intangible right or interest in any of the foregoing;
> (2) Any other property, asset, or interest therein, or treaty right for which the United States is charged with a trust responsibility. For example, water rights and off-reservation hunting and/or fishing rights.

Reclamation developed its ITA policy (Reclamation 1993) in response to the statement by former President Bush dated June 14, 1991, affirming the government-to-government relationship between federal agencies and tribal governments. Former President Clinton reaffirmed this policy in a memorandum issued on April 29, 1994. Both were incorporated by the Department of the Interior in "Departmental Responsibilities for Indian Trust Resources" (512 Department of the Interior Manual, Chapter 2):

> It is the policy of the Department of the Interior to recognize and fulfill its legal obligations to identify, protect, and conserve the trust resources of federally recognized Indian tribes and tribal members, and to consult with tribes on a government-to-government basis whenever plans or actions affect tribal trust resources, trust assets, or tribal health and safety.

The Department of the Interior Manual and Reclamation's ITA policy require that potential impacts to ITAs need to be identified, considered, and addressed when planning and implementing federal actions. Effects must be identified and addressed in planning and decision documents, especially those prepared in association with the National Environmental Policy Act (NEPA) process. Reclamation's (draft) NEPA Handbook (Reclamation 2000) specifies that all NEPA documents are to address ITAs and whether the proposed action(s) would have an impact on any such asset(s).

Methods

Consultation with Tribes to Identify ITAs

Tribes were invited to consult throughout preparation of the EA. In October 2008 Reclamation sent letters to 25 tribes in the Upper Missouri River basins. Follow-up telephone calls were made to each tribe. The tribes identified in that plan are listed in table H.1.

The plan identified 25 tribes in the Missouri River Basin (figure H.1). Thirteen of the Missouri River Basin tribes are located directly on the Missouri River, while others are scattered throughout the rest of the basin. All of these tribes could directly or indirectly have historic ties to the Project area (table H.1).

The tribes were contacted in writing, followed by telephone calls. Reclamation requested that the tribes identify any ITAs that could be affected by the Project alternatives and invited them to meet and consult on impacts to any potentially affected ITAs. None of the tribes expressed interest in continuing direct consultations. Some tribes stated they were not interested while others wanted to be kept informed and possibly comment later. Still others did not respond. All of these tribes were sent copies of the scoping package and public notice during the public comment period (see chapter five distribution list).

Table H.1 – Tribes Located within the Area of Potential Effect.

Figure H.1 Location Number	Missouri River Tribes
4	Assiniboine and Sioux Tribes of Fort Peck
13	Cheyenne River Sioux Tribe
14	Crow Creek Sioux Tribe
24	Iowa Tribe of Kansas
15	Lower Brule Sioux Tribe
23	Omaha Tribe
20	Ponca Tribe
25	Sac and Fox Nation
21	Santee Sioux Nation
24	Standing Rock Sioux Tribe
8	Three Affiliated Tribes (Mandan, Hidatsa, and Arikara)
22	Winnebago Tribe
18	Yankton Sioux
Figure H.1 Location Number	**Missouri Basin Tribes**
1	Blackfeet Tribe
2	Chippewa Cree Tribe, Rocky Boy Reservation
5	Crow Tribe
7	Eastern Shoshone Tribe
19	Flandreau Santee Sioux Tribe
3	Fort Belknap Assiniboine and Gros Ventre Tribes
26	Kickapoo Tribe
7	Northern Arapaho Tribe
6	Northern Cheyenne Tribe
16	Oglala Sioux Tribe
27	Prairie Bend of Potawatami Nation
17	Rosebud Sioux Tribe

Treaty Research

The Lower Yellowstone Intake is located in Section 36, Township18 North, Range 56 East of the Montana Meridian. Reclamation purchased the lands from the State of Montana on April 17, 1908. Section 36 was provided to the State of Montana as a school section under its charter of statehood in November 8, 1889.

Historically, many Indian tribes occupied this area for hunting, fishing, gathering and other purposes. These included but are not limited to the Assiniboine, Arapaho, Arikara, Blackfeet, Cheyenne, Crow, Grow Ventre, Mandan, and Sioux or Lakota Nation.

Reclamation reviewed the treaties with the Missouri River Basin tribes to determine if any ITAs were specified in them (cf. Royce 1899). The United States entered into at least 54 treaties with these tribes, many of which applied to multiple tribes (table H.2). Frequently treaties involved land cessions in which the tribes retained certain rights of access, most often for hunting, fishing, and gathering on the ceded lands. U.S. Supreme Court decisions have defined other retained rights not specified in the treaties. These decisions are based on the "reserved rights" doctrine:

"…the treaty was not a grant of rights to the Indians, but a grant of rights from them—a reservation of those not granted" (United States v. Winans 1905).

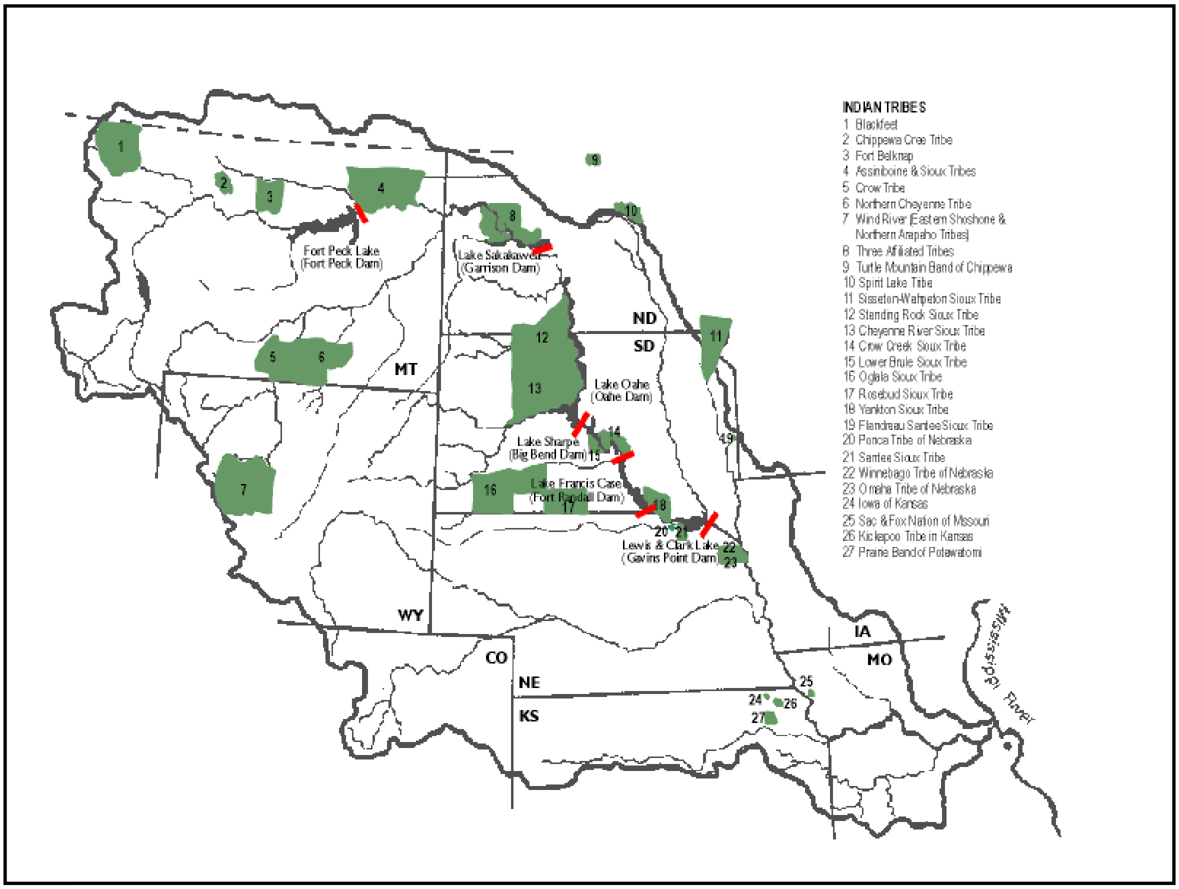


Figure H.1 – Map of Missouri River Basin Indian Tribes.

The following discussion addresses potential treaty rights of tribes in this area. The sources used were Indian Land Cessions in the United States by Charles C. Royce; Master Title plat files, Montana Area Office, Reclamation; and the U.S. Indian Claims Commission website, http://digital.library.okstate.edu/icc/index.html. In addition Joel Ames, Native American Coordinator, Omaha Division, Corp and Brenda Schilf, Bureau of Indian Affairs Realty Specialist provided information.

The Fort Laramie Treaty of 1851 included the area of the Lower Yellowstone in the territories boundaries for several tribes:

- Boundaries of the Gros Ventre, Mandan, and Arikara nations defined as follows: Commencing at the mouth of the Heart River; thence up the Missouri River to the mouth of the Yellowstone River; thence up the Yellowstone River to the mouth of the Powder River, in a southeasterly direction, to the headwater of the Little Missouri River; thence along the Black hills to the head of Heart River; and thence down Heart River to the place of beginning.

- Boundaries of the Assiniboine: Commencing at the mouth of Yellowstone River; thence up the Missouri River to the mouth of the Muscle-shell River; thence from the mouth of the Muscle-shell River in a southeasterly direction until it strikes the head waters of Big Dry Creek; thence down that creek to where it empties into the Yellowstone River, nearly opposite the mouth of the Power River; and thence down the Yellowstone River to the place of beginning.

- The Assiniboine ceded this country by treaty in 1866. This treaty was never ratified, but their acceptance of a home on the reserve for the Blackfeet, Blood, Gros Ventre, Piegan, and River Crow, established April 15, 1874, relinquished it in all practicality.

The Fort Laramie Treaty of 1868 redefined the boundaries of the Sioux Nation and Arapahoe Tribe to assure the undisturbed use and occupation of certain lands. No changes were made in the boundaries of lands for the Gros Ventre, Mandan, Arikara, or Assiniboine as noted in the 1851 Ft. Laramie Treaty.

The Executive Order of April 12, 1870, set aside a reservation at Fort Berthold, Dakota Territory, and redefined the Fort Berthold Reservation as described in the 1851 Fort Laramie treaty by ceding lands south and east of a line extending from the point where the Little Powder River unites with Powder River to a point on the Missouri River 4 miles below the Indian Village of Berthold.

Executive Orders on July 13, 1880, ceded lands around the intake that were formerly reserved to the Arikara, Mandan and Gros Ventre.

An Act of Congress of May 1, 1888, established the Fort Peck and Fort Belknap Reservations for the Gros Ventre and Assiniboine as currently defined and ceded all other lands to the United States.

The Indian Claims Commission addressed tribal land claims during its tenure from 1946 to 1978. Unresolved claims were transferred to the U. S. Court of Claims. There are no known pending cases before the U. S. Court of Claims.

A review of the master title plat files at the Montana Area Office indicates that lands within two miles of the Intake are currently either privately owned or within the jurisdiction of Reclamation.

There are no vacant and unreserved public domain lands or individual Turtle Mountain Chippewa allotments within two miles of the Intake.

Reclamation has consulted with the Rocky Mountain Region of the Bureau of Indian Affairs (BIA) and the Omaha District of the U.S. Army Corps of Engineers (Corps), as well as Reclamation cultural resource specialists. These sources were not aware of any quantified treaty rights in the area of the Intake.

Results

Trust Lands

Trust lands are lands set aside for Indians with "…the United States holding naked legal title and the Indians enjoying the beneficial interest" (Canby 1991). The Bureau of Indian Affairs land database was reviewed, and the tribes listed in table H.1 were contacted to determine if any trust lands were within the areas of potential effect for the Project alternatives. No trust lands were identified in the Intake Project area.

Table H.2 – Treaties of Missouri River Basin Tribes and Retained Rights (Royce 1899).

Tribe	Treaty	Retained Rights
Assiniboine and Sioux Tribes of Fort Peck	1851 Fort Laramie Treaty 1868 Treaty with Sioux Brule/Fort Laramie Treaty 1873 Executive Order established the Fort Peck Reservation 1889 Congress established boundaries	1851-hunting and fishing 1868-hunting
Blackfeet Tribe	1855 Treaty with Blackfeet Sioux	1855-hunting, fishing, gathering, and grazing
Cheyenne River Sioux Tribe	1851 Fort Laramie Treaty 1868 Treaty with Sioux Brule/Fort Laramie Treaty 1889 Congressional Act; Great Sioux Settlement	1851-hunting and fishing 1868-hunting 1889-irrigation
Chippewa Cree Tribe, Rocky Boy Reservation	1825 Treaty with the Sioux 1916 Executive Order establishing the Reservation boundary	1825-reciprocal hunting
Crow Creek Sioux Tribe	1825 Treaty with the Sioux 1851 Fort Laramie Treaty 1863 Executive Order establishing the Reservation boundary 1868 Treaty with Sioux Brule/Fort Laramie Treaty 1889 Congressional Act; Great Sioux Settlement	1825-reciprocal hunting 1851-hunting and fishing 1868-hunting 1889-irrigation
Crow Tribe	1826 Treaty 1851 Fort Laramie Treaty	1851-hunting and fishing
Eastern Shoshone Tribe	1863 and 1868 Fort Bridger Treaty 1872 Brunot Agreement 1898 and 1904 McLaughlin Agreement	

Tribe	Treaty	Retained Rights
Flandreau Santee Sioux Tribe	1851 Fort Laramie Treaty 1858 Treaty with the Sioux 1863 Executive Order 1868 Treaty with Sioux Brule/Fort Laramie Treaty	1851-hunting and fishing 1868-hunting
Fort Belknap Assiniboine and Gros Ventre Tribes	1851 Fort Laramie Treaty 1855 Blackfeet Treaty 1889 Congressional Act; Great Sioux Settlement	1851-hunting and fishing 1855-hunting, fishing, gathering, and grazing 1889-irrigation
Iowa Tribe of Kansas	1825 Treaty with the Sioux 1830 Treaty with Sauk, Foxes	1825-reciprocal hunting
Kickapoo Tribe	1819 Treaty with the Kickapoo 1832 Treaty with the Kickapoo 1854 Treaty with the Kickapoo 1864 Amendment to Treaty with the Kickapoo	
Lower Brule Sioux Tribe	1851 Fort Laramie Treaty 1865 Treaty with Sioux Lower Brule Band 1868 Treaty with Sioux Brule/Fort Laramie Treaty 1889 Congressional Act; Great Sioux Settlement	1851-hunting and fishing 1868-hunting 1889-irrigation
Northern Arapaho Business Council	1863 and 1868 Fort Bridger Treaty 1872 Brunot Agreement 1898 and 1904 McLaughlin Agreement	
Northern Cheyenne Tribe	1851 Fort Laramie Treaty 1868 Treaty with Sioux Brule etc/Fort Laramie Treaty 1884 Executive Order 1889 Congressional Act; Great Sioux Settlement	1851-hunting and fishing 1868-hunting 1889-irrigation
Oglala Sioux Tribe	1851 Fort Laramie Treaty 1868 Treaty with Sioux Brule etc/Fort Laramie Treaty 1889 Congressional Act; Great Sioux Settlement	1851-hunting and fishing 1868-hunting 1889-irrigation
Omaha Tribe	1830 Treaty with Sauk, Foxes 1836 Treaty with the Oto etc. 1854 Treaty with the Omaha	
Ponca Tribe	1817 Treaty with the Ponca 1825 Treaty with the Sioux 1858 Treaty with the Ponca 1865 Treaty with the Ponca 1868 Treaty with Sioux Brule/Fort Laramie Treaty 1881 Act of Congress	 1825-reciprocal hunting 1868-hunting
Prairie Bend of Potawatami Nation	1846 Treaty with the Potawatami Nation	
Rosebud Sioux Tribe	1851 Fort Laramie Treaty 1868 Treaty with Sioux BruleFort Laramie Treaty 1889 Congressional Act; Great Sioux Settlement	1851-hunting and fishing 1868-hunting 1889-irrigation
Sac and Fox Nation	1825 Treaty with the Sioux, 1830 Treaty with Sauk, Foxes. 1832 Treaty of Fort Armstrong	1825-reciprocal hunting

Tribe	Treaty	Retained Rights
Santee Sioux Nation	1825 Treaty with the Sioux 1830 Treaty with Sauk, Foxes 1836 Treaty with the Oto 1851 Fort Laramie Treaty 1867 Treaty with the Sioux Sisseton and Wahpeton Bands 1868 Treaty with Sioux Brule/Fort Laramie Treaty	1825-reciprocal hunting 1851-hunting and fishing 1868-hunting
Standing Rock Sioux Tribe	1851 Fort Laramie Treaty 1868 Treaty with Sioux Brule etc/Fort Laramie Treaty 1882 Agreement with Sioux of various tribes (not ratified) 1889 Congressional Act; Great Sioux Settlement	1851-hunting and fishing 1868-hunting 1889-irrigation
Three Affiliated Tribes (Mandan, Hidatsa, and Arikara)	1851 Fort Laramie Treaty 1866 Fort Berthold Agreement (not ratified) 1868 Treaty with Sioux Brule/Fort Laramie Treaty 1870 Executive Order 1880 Executive Order	1851-hunting and fishing 1868-hunting
Winnebago Tribe	1825 Treaty with the Sioux 1830 Treaty with Sauk, Foxes 1832 Treaty with Winnebago 1837 Treaty with Winnebago 1846 Treaty with Winnebago 1855 Treaty with Winnebago 1859 Treaty with Winnebago 1865 Treaty with Winnebago	1825-reciprocal hunting
Yankton Sioux	1815 Treaty with Yankton Sioux 1825 Treaty with the Teton etc. 1830 Treaty with Sauk, Foxes 1836 Treaty with the Oto 1837 Treaty with Yankton Sioux 1858 Treaty with Yankton Sioux 1865 Treaty with the Sioux Yanktonai 1868 Treaty with Sioux Brule/Fort 1894 Act of Congress reduced reservation	

Hunting, Fishing, and Gathering Rights

According to Reclamation's (1993) ITA policy, hunting and fishing rights and, by extension, gathering rights may qualify as ITAs. This is because in many treaties tribes retained the right to continue hunting, fishing, and gathering on ceded lands (table H.2). However, no court has ruled on whether these activities collectively constitute ITAs although the U.S. Supreme Court ruled in *Minnesota v. Mille Lacs* (1999) that hunting, fishing, and gathering were usufructuary rights.

Usufructuary rights are those rights to obtain food, water, and other necessities on ceded lands, which include the right to use the ceded property to hunt, fish and gather on the land.

Indian Water Rights

The United States government has recognized that tribes in the western United States (west of the Mississippi) may hold rights to water in streams running through or alongside the boundaries of their reservations. The basis for Indian water rights stems from the U. S. Supreme Court decision *Winters v. United States* (1908), which enunciated the Winters Doctrine. According to the Winters Doctrine, implicit in the establishment of an Indian reservation was a reservation of sufficient water to fulfill the purposes for which the reservation was created, with the priority date being the date the reservation was established. As such, Indian water rights for both surface water and groundwater, when quantified, constitute an ITA.

When a reservation is established with expressed or implicit purposes beyond agriculture, such as to preserve fishing, then water may also be reserved in quantities to sustain use. The U.S. Supreme Court upheld this concept in *Arizona v. California* (1963). The Court held that tribes need not confine the actual use of water to agricultural pursuits, regardless of the wording in the document establishing the reservation. However, the amount of water quantified was still determined by the amount of water necessary to irrigate the "practicably irrigable acreage" on a reservation. The Court also held that the water allocated should be sufficient to meet both present and future needs of the reservation to assure the viability of the reservation as a homeland. Case law also supports the premise that Indian reserved water rights are not lost through non-use.

The Winters Doctrine will apply to any Indian water rights in Montana or along the Missouri River.

Surface Water

The Corps is the federal agency responsible for operations of the Missouri River. The Corps has recognized that certain Missouri River Basin tribes are entitled to water rights in streams running through and along their reservations under the Winters Doctrine. Several Missouri River Basin tribes have quantified or are in the process of quantifying their water rights. Currently, the only tribal reserved water rights that have been legally quantified are:

- State of Wyoming settlement with tribes of the Wind River Reservation (adjudicated under the McCarran Amendment)
- Compact between the state of Montana and the tribes of the Fort Peck Reservation (awaiting congressional approval)
- Compact between the state of Montana and the tribes of the Fort Belknap Reservation (ratified by the state legislature)
- Compact between the state of Montana and the Crow tribe (awaiting congressional approval)
- Compact between the state of Montana and the tribes of the Rocky Boys Reservation (Chippewa Cree Tribe of the Rocky Boy's Reservation Indian Reserved Water Rights Settlement and Water Supply Enhancement Act of 1999 [PL 106-163])
- Compact between the State of Montana and the Northern Cheyenne Tribe (The Northern Cheyenne Indian Reserved Water Rights Settlement Act of 1992 [P.L. 102-374])

The Lower Yellowstone Intake is a "run of the river" diversion structure and will continue to function in this capacity upon completion of the project. There will be no change in the amount of water diverted, the time of diversion, the priority date, or the purpose. The only change may be the point of diversion. None of the alternatives currently under consideration are anticipated to have an adverse impact on Indian Treaty rights.

The diversion is operated and maintained by the Board of Control under contract with Reclamation. It is anticipated that this arrangement would continue upon completion of the project.

Groundwater

Groundwater also can constitute an ITA as a water right. Montana regulates and permits groundwater withdrawals. It is not anticipated that this project will affect groundwater resources.

Impacts to Indian Trust Assets

The following discussion addresses the potential impacts of the proposed alternatives on ITAs. The alternatives potentially could affect three different categories of ITAs, if any are identified: 1) trust lands, 2) hunting, fishing, and gathering rights, and 3) Indian water rights. The potential impacts are summarized in table H.3.

Table H.3 – Summary of the Consequences of No Action and Potential Impacts to ITAs by Action Alternatives.

Indian Trust Assets	No Action Alternative	Action Alternatives
Trust Lands – none identified	No consequences	No effect
Hunting, Fishing & Gathering Rights – none identified	The existing Intake Diversion Dam is a partial barrier to some fish species and a total barrier to others, like the pallid sturgeon. Operation of the unscreened intake would continue to entrain fish.	No Affect; all action alternatives would improve pallid sturgeon fisheries in the Yellowstone River to varying degrees.
Indian Water Rights – surface water	No consequences	Undetermined Most tribes within the Missouri River Basin have not quantified these rights; those that have will not receive any water directly from the Lower Yellowstone.
Indian Water Rights - groundwater	No consequences	No effect

Trust Lands

Trust lands are lands set aside for Indians to which the United States holds legal title and the Indians receive the beneficial interest. A review of the Bureau of Indian Affairs land database for the tribes listed in table H.1 indicates that no trust lands are within the area of potential effects for the proposed alternatives.

No Action Alternative There are no trust lands in the area of potential effects.

Relocate Main Channel and Rock Ramp Alternatives Neither of the action alternatives would affect trust lands.

Hunting, Fishing, and Gathering Rights

Many of the treaties with the tribes in the Missouri River basin provided for continued hunting, fishing, and gathering on ceded lands. If future federal court decisions affirm the hunting, fishing, and gathering rights of the tribes, those rights may need to be given consideration.

No Action Alternative The existing Intake Diversion Dam is a partial barrier to some fish species and a total barrier to others, like the pallid sturgeon. Operation of the unscreened intake would continue to entrain fish. Because no fishing rights have been identified in the area of potential effects, there would be no consequences to ITAs.

Relocate Main Channel and Rock Ramp Alternatives Both of the proposed action alternatives would improve pallid sturgeon fisheries in the lower Yellowstone River to varying degrees. These improvements are discussed in the aquatic resources impacts section of chapter four.

Indian Water Rights

The basis for Indian water rights in the western United States stems from the U. S. Supreme Court decision in *Winters v. United States* (1908), commonly known as the Winters Doctrine. According to the Winters Doctrine, the establishment of an Indian reservation implied that sufficient water was reserved to fulfill purposes for which the reservation was created, with the priority date being the date the reservation was established. As such, Indian water rights to both surface water and groundwater constitute an ITA.

No Action Alternative The No Action Alternative would not have consequences for surface water or groundwater rights.

Relocate Main Channel and Rock Ramp Alternatives Surface water rights have been quantified for the two tribes upstream of Intake, Montana. The Northern Cheyenne Water Rights Compact with the State of Montana was ratified by Congress in September 1992. The Crow Water Rights Compact with the State of Montana was ratified by the State in June 1999. A Crow settlement Act has been introduced into Congress; however, it has not yet been passed. All of these water rights have a earlier priority date than the water rights diverted by the Lower Yellowstone Project. The proposed Intake Project would not affect Indian water rights.

Appendix I – Actions to Minimize Effects

Introduction

A key factor in successful construction and operation of this Intake Project would be the implementation of actions to minimize effects and monitoring. If a FONSI is signed, to ensure that Intake Project activities are completed concurrently and in full compliance with all environmental commitments, Reclamation and the Corps will establish the Environmental Review Team to implement management practices to avoid, minimize or mitigate adverse impacts to Intake Project area resources. This team will be comprised of federal, state, and local entities, which will develop the specific actions and monitoring programs and provide input to Reclamation and the Corps. This Team could include technical representatives of the following agencies:

- Bureau of Reclamation
- U.S. Army Corps of Engineers
- Lower Yellowstone Irrigation Project Board of Control
- Montana Department of Environmental Quality
- Montana Department of Natural Resources and Conservation
- Montana Fish, Wildlife & Parks
- U.S. Fish and Wildlife Service
- The Nature Conservancy
- Montana State Historic Preservation Officer
- Other technical entities as deemed important to the process

When construction affects private lands or lands administered by agencies other than those listed above, landowners or specialists representing other agencies will be invited to participate on the team for the components that potentially affect their lands.

The Environmental Review Team will use adaptive management principles and other methods to monitor the effectiveness of actions to minimize effects. The purpose of this team is to ensure that Intake Project activities are completed concurrently and in compliance with all environmental commitments in NEPA documents, such as the Final EA and FONSI decision. This team will also address other relevant state and federal environmental rules and regulations, such as the Clean Water Act and the National Historic Preservation Act.

Environmental Review Team Responsibilities, Goals, and Objectives may include:

- Review and evaluate project construction plans and specifications to assist in identifying, avoiding, minimizing, or mitigating potential impacts to resources. Annually or as needed, the Team will review modifications to the construction plans.

- Conduct field reviews (annually or as needed) prior to construction to identify environmentally sensitive areas where site-specific mitigation may be required.
- Review construction plans to determine if all required field surveys within the appropriate survey periods and whether surveys have been completed prior to Intake Project disturbance.
- Review previous construction activities to determine if required mitigation measures are sufficient and have been accomplished and prepare an annual environmental mitigation/progress report for the Intake Project.

Recognizing that the details of Intake Project impacts cannot be fully identified until the final engineering stage, many of the environmental commitments (identified below) are general in nature. Depending upon the alternative selected in the FONSI, the following commitments will be implemented to avoid adverse impacts to resources. Some of these commitments are not applicable to every alternative. The FONSI will list the environmental commitments applicable to the selected alternative.

Adaptive Management

- Reclamation and the Corps recognize that there is uncertainty in addressing natural resource issues. To manage this uncertainty Reclamation and the Corps will develop an adaptive management plan. The plan will be developed in accordance with the Department of the Interior Policy guidance (Order 3270) and the report *Adaptive Management, The U.S. Department of Interior Technical Guide* (Williams et al. 2007).
- Reclamation and the Corps will follow the Adaptive Management Strategy outlined in appendix J. Prior to completing construction, a specific Adaptive Management Plan for the selected alternative will be completed.
- All constructed features will be monitored for at least 8 years in accordance with an adaptive management plan to ensure that these are operating as designed to improve fish passage and reduce entrainment.

Air Quality

- Dust suppression techniques, such as sprinkling problem sites with water, will be used during construction activities.

Geomorphology

- River morphology will be monitored to assess changes to the stream channel resulting from construction of the selected alternative. The Environmental Review Team will be consulted regarding specific measures to mitigate impacts if substantive changes are determined to have been caused by the Intake Project.

Surface Water Quality

- A water quality monitoring program will be established for ensuring that water quality standards are not violated during construction activities.
- Equipment for handling and conveying materials during construction shall be operated to prevent dumping or spilling the materials into wetlands and waterways.
- Discharges of dredge or fill material into waters of the U.S. will be carried out in compliance with provisions of Section 404 of the Clean Water Act the permit

requirements of the Corps, and requirements contained in the Section 401 water quality certification issued by the Montana Department of Environmental Quality.

- Erosion control measures will be employed where necessary to reduce wind and water erosion. Erosion and sediment controls will be monitored daily during construction for effectiveness, particularly after storm events, and the most effective techniques will be used.
- Silt barriers, fabric mats, or other effective means will be placed on slopes or other eroding areas where necessary to reduce sediment runoff into stream channels and wetlands until vegetation is re-established. This will be accomplished either before or as soon as practical after disturbance activities.
- Contamination of water at construction sites from spills of fuel, lubricants, and chemicals would be prevented by following safe storage and handling procedures in accordance with state laws and regulations.
- Hazardous materials will be handled and disposed of in accordance with a hazardous waste plan.

Aquatic Communities

General

- All work in the river will be performed in a manner to minimize increased suspended solids and turbidity, which may degrade water quality and damage aquatic life outside the immediate area of operation.
- All areas along the bank disturbed by construction will be seeded with native vegetation to minimize erosion.

Fish

- To avoid potential impacts, coffer dam construction and in-stream heavy equipment activity will be coordinated with fishery experts from the Service, FWP, Reclamation and the Corps to avoid and or minimize potential impacts.
- All pumps will have intakes screened with no greater than ¼” mesh when dewatering cofferdam areas in the river channel. Pumping will continue until water levels within the contained areas are suitable for salvage of juvenile or adult fish occupying these areas. Fish will be removed by methods approved by the Service and FWP prior to final dewatering.
- Reclamation will consult with FWP to ensure that flows comparable to environmental baseline are maintained during construction to support the fishery during low-flow periods (late summer/early autumn).

Federally-Listed Species and State Species of Special Concern

Whooping Crane

- Reclamation will monitor the Service's whooping crane sighting reports to ensure that whooping cranes are not in the Intake Project area during construction. If any are sighted within the Intake Project area, Reclamation will consult with the Service regarding appropriate actions.

Interior Least Tern

- Visual surveys will be conducted weekly from May 15 to August 15 at all potential least tern nesting areas (sparsely vegetated sandbars) within line of site of the construction area.
- All surface-disturbing and construction activities will be restricted from May 15 to August 15 within 0.25 mile or the line of site of any active interior least tern nest.

Pallid Sturgeon

- A physical model of the rock ramp will be constructed to provide additional velocity and turbulence data needed for final design of an effective ramp.
- Reclamation and the Corps will consult with the BRT during the design of the selected alternative, including but not limited to reviewing results and making recommendations on the physical model, hydraulic modeling, and final alternative design.
- The construction activities within the wetted perimeter of the active channel will be observed and monitored by a qualified fisheries biologist to avoid direct impacts to adult or juvenile pallid sturgeon. In-stream construction activities will cease if the fisheries monitor determines there is potential for direct harm or harassment of pallid sturgeon, until the potential for direct harm or harassment has passed. This will include coordination with FWP to make sure radio-tagged pallid sturgeon and other monitored native fish continue to be monitored, especially during the construction season.
- Any in-stream construction activity will be conducted during periods most likely to minimize the potential impact to the pallid sturgeon. The months to avoid and/or minimize impacts to pallid sturgeon are June and July.

Species of Special Concern

- Before every construction season, the Environmental Review Team will meet with FWP to determine procedures to minimize impacts to species of special concern. Surveys for species likely to occur in the Intake Project area may be required as some of these species could be potentially harmed by construction activities. Survey requirements will be coordinated with Montana Natural Heritage Program and FWP prior to any construction activities. These species could require surveys: bald eagle, grasshopper sparrow, red-headed woodpecker, Townsend's big-eared bat, nine-anther clover, pale-spiked lobelia, and silky-prairie clover.

Lower Yellowstone Irrigation Project

Modification of the original engineering design to incorporate an additional screen and phasing construction would avoid interruptions in water deliveries to the irrigation districts during the irrigation season.

- If the Relocate Main Channel Alternative is selected, a cofferdam would be used during construction to maintain flow in the existing river channel to allow uninterrupted operation of the Lower Yellowstone Project irrigation facilities during the irrigation season.
- If the Rock Ramp Alternative is selected, construction of the north half of the concrete weir and rock ramp will start after completing the headworks and canal extension to continue diversion of flows for uninterrupted operation of the irrigation districts.
- If either action alternative is selected flows would continue to be diverted into the main canal through the existing headworks while building the new headworks.

Recreation

- In order to minimize impacts to recreationists, the construction contractor will implement dust abatement activities on all dirt or gravel roads within or leading to the construction zone, on both sides of the river.
- To allow access to recreation areas, the construction contractor will grade, on an as needed basis, all dirt or gravel roads within or leading to the construction zone, on both sides of the river, except in areas with historic properties.
- The construction contractor will use “flaggers” during periods of time when large volumes of vehicles cross the entrance road to the campground and picnic/day use area.
- The construction contractor, Reclamation, and the FWP will meet to evaluate and coordinate closures at the FAS and Joe’s Island to recreational use, including closure of construction zones to swimming, fishing, boating, hiking, camping, hunting, etc. within or on both sides of the river.
- The construction contractor, Reclamation, and the FWP will identify a “portage” route around or through the construction zone to allow boaters to hand-carry or drag their boats past the construction zone.
- The construction contractor will clearly post and sign any areas within any designated construction zones. Signs will include warnings limiting or prohibiting certain recreational uses within the zone, such as swimming, fishing, boating, hiking, camping, etc. Signs will be posted upstream and downstream of the Intake Diversion Dam to warn boaters of construction activity.
- The FWP will designate access corridors through the existing Intake FAS campground and picnic/day use area that could be used to access the river by foot or to launch boats under “primitive” conditions.
- To the extent possible, construction activities will cease during the paddlefish season or until the paddlefish season is closed at Intake FAS.

For either action alternative, Reclamation and the FWP will evaluate and the Corps will construct either:

- A new boat ramp at the existing Intake FAS, or
- A new boat ramp immediately adjacent to the existing Intake FAS, or

- A new boat ramp at a site near the existing Intake FAS on the west side of the Yellowstone River and accessible by Highway 16

For the Relocate Main Channel Alternative, Reclamation and the FWP will evaluate and provide for:
- Constructing a road from the campground and picnic/day use area to a location adjacent to the new channel, and a parking area; or
- A new campground and picnic/day use area adjacent to the relocated channel on the Intake FAS or on Joe's Island side of the river

Reclamation and the FWP will develop a public notification plan to include:
- Signs on the road leading to the FAS or Joe's Island advising the public of closures or restrictions
- Signs indicating the location of other recreation sites including campgrounds, picnic/day use areas and boat ramps

Lands and Vegetation
General
- The Environmental Review Team will play a role in oversight of actions to minimize effects for land and vegetation.
- Before every construction season, Reclamation and Corps will meet with the Service and the appropriate state wildlife agencies to determine a procedure to minimize impacts to lands and vegetation. A reconnaissance survey of construction easements will be conducted to identify and verify wetlands, grasslands, woodlands, and riparian areas subject to disturbance and/or destruction in the Intake Project area during construction activities. The Environmental Review Team will be consulted, as necessary, to determine appropriate avoidance and/or protection measures. If adverse impacts cannot be avoided, appropriate procedures and requirements for minimizing or mitigating effects will be discussed with the Environmental Review Team.
- Disturbance of vegetation will be minimized through construction site management (e.g., using previously disturbed areas and existing easements when feasible and designating limited equipment/materials storage yards and staging areas.) It will be limited to that which is absolutely necessary for construction of the Intake Project.
- All areas disturbed or newly created by the construction activity will be seeded with vegetation indigenous to the area for protection against subsequent erosion and noxious weed establishment.
- All equipment tracks and tires working on Joe's Island or other noxious weed infested areas will be cleaned prior to transportation to an uninfested site.
- An integrated weed plan will be developed and approved by the Environmental Review Team. It will identify best management practices to control the spread or introduction of any noxious weeds or plants. The weed plan will be implemented during and subsequent to construction.
- Erosion control measures will be employed where necessary to reduce wind and water erosion. Erosion and sediment controls will be monitored daily during construction for effectiveness and only effective techniques will be used.

- No permanent or temporary structures will be located in any floodplain, riparian area, wetland or stream that would interfere with floodwater movement, except for those described in chapter two of the Intake Final EA.

Wetlands

- Prior to beginning construction through Conservation Reserve Program lands or program wetlands, the Natural Resource Conservation Service, Consolidated Farm Services Agency, and respective landowners will be consulted to ensure that landowner eligibility in farm subsidy programs (if applicable) will not be jeopardized and that Sodbuster or Swampbuster requirements will not be violated by construction.
- Waste material, topsoil, equipment, debris, excavated material, or other construction related materials will not be disposed of within 50 feet of any wetland, drainage channel, irrigation ditch, stream or other aquatic systems.
- If wetland mitigation is necessary wetland soils would be stockpiled for use when constructing new areas.
- Discharges of fill material associated with unavoidable crossings of wetlands or intermittent streams will be carried out in compliance with provisions of Sections 401 and 404 of the Clean Water Act and the nationwide and/or Intake Project-specific permit requirements of the Corps. The Natural Resource Conservation Service may evaluate isolated, non-navigable wetlands outside the jurisdiction of the Corps for jurisdiction and impacts.
- Rock quarry materials will come from sites with no potential to impact wetlands or other protected resources.
- The Environmental Review Team will play a role in oversight of actions to ensure compliance with Sections 401 and 404 of the Clean Water Act and will suggest actions to minimize effects to wetlands.

Grasslands

- Whenever possible, grasslands affected during Intake Project construction will be restored. Where existing native prairie cannot be re-seeded in its current location, procedures will be reviewed by the Environmental Review Team.
- Disturbed native grassland will be reseeded with native species with the seed mix being determined during final design and reviewed by the Environmental Review Team. Planted grassland will be reseeded with a seed mixture appropriate for the site and watered, if necessary, during establishment. Reseeding may require mulching in order to be successful.
- Areas requiring re-vegetation will be seeded and mulched during the first appropriate season after redistribution of topsoil. If reseeding cannot be accomplished within 10 days of topsoil replacement, erosion control measures will be implemented to limit soil loss. Local native grass species would be used (mixture to be reviewed by the Environmental Review Team).
- Grassland seeding will be completed prior to May 15, where feasible. If spring seeding is not feasible, fall seeding will be performed between August 15 and October 15 prior to ground freezing.
- To reduce erosion, water bars will be installed at specified intervals, depending upon soil type, grade, and terrain on disturbed slopes with grades of 6% or greater.

- Vegetation and soil removal will be accomplished in a manner that will prevent erosion and sedimentation.
- Noxious weeds will be controlled, as specified under state law, within the construction footprint during and following construction. Herbicides will be applied in accordance with labeled instructions and state, federal, and local regulations.
- Grass-seeding plantings will be monitored for at least three years. Where grasses do not become adequately established, areas will be reseeded with appropriate species.

Woodlands and Riparian Areas

- No disposal of waste material, topsoil, equipment, debris, excavated material, or other construction related materials will be done within 50 feet of any riparian area.
- Woodland and riparian areas will be avoided where practical when constructing permanent facilities.
- Whenever possible, woodland and riparian areas impacted by the Intake Project will be restored with native species. Where existing woodland and riparian areas cannot be restored in original locations, then off-site mitigation will be considered by the Environmental Review Team.
- Native trees and shrubs will be replaced with similar native species at a ratio of two trees or shrubs planted for each tree or shrub removed, when shelterbelts, riparian woodlands, or woodland vegetation cannot be avoided. Long-term success of plantings will be reviewed and approved by the Environmental Review Team.
- Weed growth in tree plantings will be controlled, and tree plantings will be monitored for three years. Where plantings do not adequately succeed, they will be replanted with appropriate species.
- Where practicable, replanted riparian areas will be watered to ensure survival of planted vegetation. Long-term success of plantings will be reviewed and approved by the Environmental Review Team.

Wildlife

Mammals and Migratory Birds

- Before each construction season, the Environmental Review Team will meet with FWP to determine procedures for avoiding and minimizing impacts to nesting or migrating birds.
- Areas potentially hazardous to wildlife will be adequately protected (e.g., fenced, netted) to prevent access to wildlife.
- To protect wildlife and their habitats, Intake Project-related travel will be restricted to existing roads and Intake Project easements. No off-road travel will be allowed, except when approved through the Environmental Review Team.
- Wildlife-proof fencing will be used on reclaimed areas, if it is determined that wildlife species and/or livestock are impeding successful vegetation establishment.

Amphibian and Reptiles

- All riverbank disturbance areas will be inventoried for potential turtle nesting habitat. If turtle nesting habitat or evidence of turtle nesting is found in construction areas, construction in these areas will be restricted during June and July, or mitigation measures approved by the Environmental Review Team will be implemented.

Historic Properties

Reclamation proposes to implement the following actions to offset any adverse effects to historic properties:

- Engineering drawings and photographs of affected buildings and structures, if available, will be filed with the State Historic Preservation Office and the National Archives.
- If engineering drawings and photographs are not available, the buildings and structures will be recorded in accordance with the Historic American Buildings Survey and the Historic American Engineering Record, as appropriate.
- If practicable, historic buildings or structures that must be moved for construction will be returned to their original locations after construction of the Intake Project is completed. If that is not feasible, Reclamation will seek a party willing and able to adopt the historic structure or building with appropriate preservation covenants.
- Reclamation will develop and implement a data recovery plan in consultation with the Montana SHPO, Advisory Council on Historic Preservation, and other interested parties, as appropriate, for mitigation of the Headworks Camp (24DW447).
- One or more signs will be installed at or near the Intake FAS to summarize the history of the Lower Yellowstone Irrigation Project.
- A fence will be installed around the Old Cameron and Brailey Sub-Camp (24DW298) to protect it from disturbance by unloading and storage of rock or other construction activities.
- All construction activities will avoid using the road through the late plains archaic campsite (24DW430).
- All gravel, fill, and rock materials will be obtained from a source approved by Reclamation to ensure compliance with Section 106 of the NHPA.
- Reclamation will continue consultation with the Montana State Historic Preservation Office on the preparation of a formal memorandum of agreement stipulating the mitigation and treatment plan.

Indian Trust Assets

- Reclamation will continue to consult with the Bureau of Indian Affairs and tribes to identify potential Indian trust assets and any adverse effects to them.

Appendix J – Adaptive Management Strategy

Introduction

From an operational point of view, adaptive management simply means learning by doing (i.e., learning through management) and adapting what one does based on what is learned (i.e., adjusting management as understanding improves). Learning contributes to management by providing information on which to base management strategies, and management reinforces learning by implementing actions that are useful in investigating the resource system. A sequential application of these component activities should produce both improved understanding of resource dynamics and improved resource management.

> **Adaptive Management Terms**
>
> **Adaptive Management Plan** – Framework explaining how managers, scientists, and other professionals will work together to ensure the successful implementation and operation of the federal action.
>
> **Adaptive Management Work Group** – Team composed of representatives of federal agencies, state agencies, and environmental groups that recommend modifications in operating criteria or changes in resource management actions, policies, or procedures to ensure the successful implementation and operation of the federal action.
>
> **Technical Team** – Team comprised of technical representatives of groups represented by the Adaptive Management Work Group and operates under the direction of the Adaptive Management Work Group.

This strategy will guide the Bureau of Reclamation (Reclamation) and the U.S. Army Corps of Engineers (Corps) in developing an adaptive management plan for the Intake Diversion Dam Modification, Lower Yellowstone Project (Intake Adaptive Management Plan). The goal of this strategy is to clearly outline the basic steps in the process, and how, when, and by whom decisions will be made. Thus, the strategy will serve as a road map for decision making and a how-to guide showing how various entities contribute to the adaptive management process. The strategy will provide the basis for an informed decision making process that allows for successful passage of the endangered pallid sturgeon and other native fish at Intake Diversion Dam, and successful reduction in fish entrainment into the Lower Yellowstone Project's main canal.

The Intake Adaptive Management Plan will also address post-construction commitments from the final decision document on the Intake Diversion Dam Modification, Lower Yellowstone Project Environmental Assessment (Intake EA), the Biological Assessment (see Appendix D), and the subsequent letter of concurrence. Because these documents are still in progress, the Adaptive Management Plan will not be completed before the finalization of the EA.

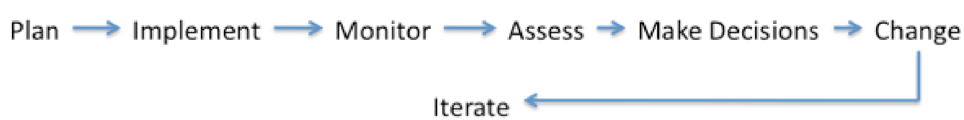
It is anticipated that the Intake Adaptive Management Plan will be long-term (up to 8 years post-construction); however, it is recommended that the Adaptive Management Work Group review the plan at the beginning of every other federal fiscal year. The review process should be completed within 6 months of the beginning of the fiscal year in which the review takes place. If any work group member suggests modifications to the plan, including changes to goals, management objectives, or information needs, these recommendations will be reviewed by the entire Adaptive Management Work Group and incorporated into a revised Lower Yellowstone Adaptive Management Plan, if approved by Reclamation and the Corps.

Adaptive Management Program Organizational Framework

The operational definition used in the *Department of Interior Technical Guide on Adaptive Management* is adopted from the National Research Council, which characterizes adaptive management as an iterative learning process producing improved understanding and improved management over time:

> Adaptive management [is a decision process that] promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders (Williams et al. 2007).

In summary, the framework employs the standard adaptive management flow model as illustrated below:



- *Plan* - the collaborative work conducted by Federal agencies, State agencies, and non-governmental organizations prior to and during the National Environmental Policy (NEPA) Process.
- *Implement*- build structures to pass fish and reduce entrainment (preferred alternative).
- *Monitor*- collect data to evaluate if desired outcomes of implemented actions are being met.
- *Assess*- analyze data to determine if the implemented actions are meeting the predicted outcomes; if unexpected outcomes resulted, determine why.
- *Make decisions* – determine if changes to the Intake Project are needed to pass fish and reduce entrainment
- *Change* – Modify the Intake Project according to the decision
- *Iterate* – Continue to monitor, assess, make decisions, and change as necessary to achieve success.

Intake Diversion Dam Adaptive Management Plan

Due to uncertainty regarding how some resources could be affected by construction and operation of the preferred alternative, the Intake EA stipulates an adaptive management approach. An adaptive approach involves exploring alternative ways to meet management objectives, including predicting outcomes of management actions (the preferred alternative) based on the current state of knowledge, implementing management actions, monitoring effects, and comparing against predictions and objectives. Updated knowledge is used to adjust management actions as necessary to achieve overall program objectives. Adaptive management focuses on learning and adapting through partnerships with managers, scientists, and other professionals who learn together how to create and maintain sustainable resource systems.

Tools for Decision Making

The proposed adaptive management approach to manage construction and subsequent operation effectiveness of the Lower Yellowstone Project is as follows:

- The Adaptive Management Plan will focus on actions and responses identified in the Intake EA for fish screen design and fish passage design.
- Goals and objectives for each action will be identified. Actions include the construction of the fish screen and fish passage features, and may include other requirements of the final Intake EA, and the Lower Yellowstone Construction Biological Assessment and subsequent letter of concurrence.
- Models may be developed to reveal the potential effects of management actions, activities, or practices being considered for implementation.
- Questions will be formulated as testable hypotheses regarding the expected responses or linkages of construction, operations, and other management actions.
- Studies will be conducted to test hypotheses and answer questions.
- Management activities will reveal, through monitoring and evaluation of results, the accuracy or completeness of the earlier predictions.
- New knowledge and information produced through experimentation will be incorporated into management discussions and recommendations to the Reclamation and Corps representatives.

Organizations and Positions in the Adaptive Management Program

With the signing of the FONSI for the Intake Final EA, an Adaptive Management Program will be established to develop and implement an Intake Adaptive Management Plan. The program may include the following positions or organizations:

- Reclamation and Corps representatives
- Adaptive Management Work Group
- Technical Team
- Independent review panels

The roles, functions, and relationships of these positions and organizations are depicted in figure J.1 and are described in detail below.

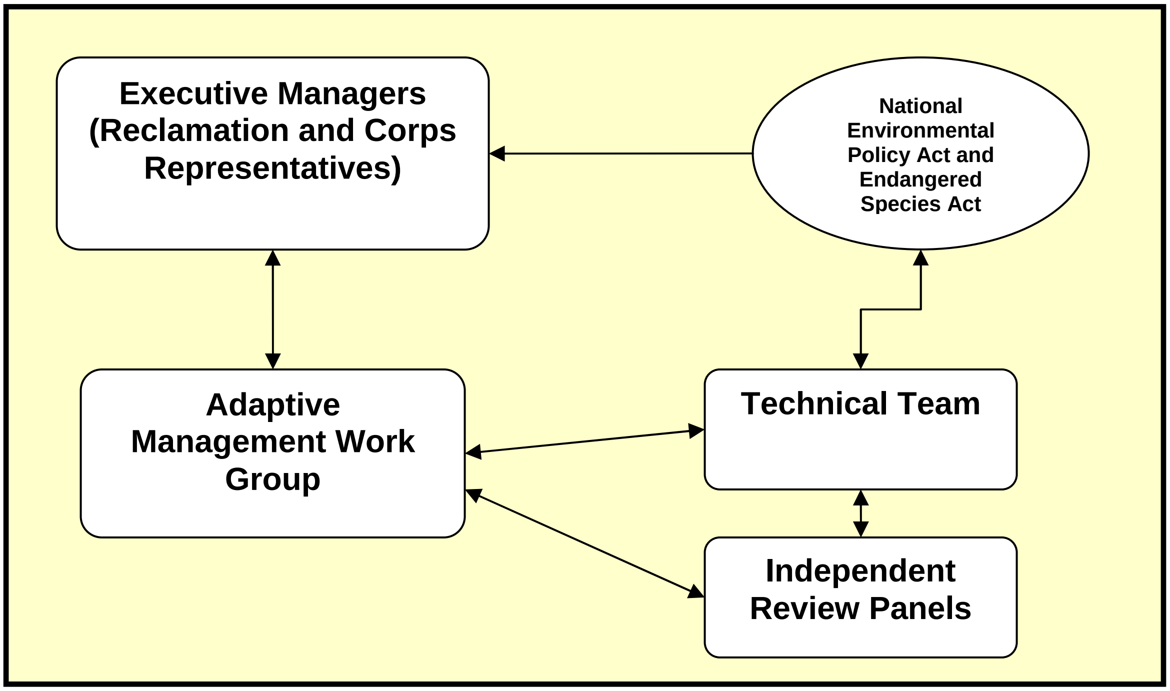


Figure J.1 - Graph of Positions and Organizational Relationships in Lower Yellowstone Adaptive Management Plan.

Reclamation and Corps Representatives

Reclamation and Corps representatives will serve as the principal contacts for the Lower Yellowstone Project Adaptive Management Program and as the focal point for issues and decisions associated with the program. As executive representatives, their responsibilities include:

- Co-Chairing the Adaptive Management Work Group;
- Ensuring that Reclamation complies with its obligations under the Final Intake EA, FONSI, Biological Assessment and letter of concurrence; and
- Reviewing, modifying, accepting, or remanding recommendations from the Adaptive Management Work Group in changing the management actions.

Adaptive Management Work Group

The Adaptive Management Work Group may include but is not limited to representatives from the agencies, organizations, and institutions listed below:

Reclamation's Montana Area Office, Resource Management Division
Corps' Omaha District, Product Delivery Team and Integrated Science Program
Lower Yellowstone Irrigation Project Board of Control
Montana Department of Environmental Quality
Montana Department of Natural Resources and Conservation
Montana Fish, Wildlife & Parks
U.S. Fish and Wildlife Service
The Nature Conservancy

Responsibilities of the Adaptive Management Work Group will include:

- Creating a framework for the Adaptive Management Plan goals, direction, and priorities;
- Providing recommendations to Reclamation and Corps representatives for resource management actions or procedures. These recommendations will be included in an annual report on current and projected year operations;
- Review the framework and Adaptive Management Plan at the beginning of every other federal fiscal year. The review process should be completed within 6 months of the beginning of the fiscal year in which the review takes place;
- Facilitating coordination and input from the Technical Team;
- If any work group member suggests modifications to the plan, including changes to goals, management objectives, or information needs, these recommendations will be reviewed by the Adaptive Management Work Group and incorporated into a revised Lower Yellowstone Adaptive Management Plan, if approved by Reclamation and the Corps;
- Reviewing and submitting annual budget proposals; and
- Ensuring coordination of operating criteria changes in the Annual Operating Plan for the Lower Yellowstone Project and other ongoing activities.

The group will work within the decision of the Intake Final EA, FONSI, Lower Yellowstone Construction Biological Assessment and letter of concurrence, and will develop recommendations through experimentation.

Technical Team

The Technical Team, listed below, will be comprised of technical representatives of groups represented by the Adaptive Management Work Group and other agencies. The Team will operate at the direction of the Adaptive Management Work Group. The following entities will be invited to participate:

Reclamation, Montana Area Office, Resource Management Division
Corps, Omaha District including the Integrated Science Team
Lower Yellowstone Irrigation Project Board of Control
Montana Department of Environmental Quality
Montana Department of Natural Resources and Conservation
Montana Fish, Wildlife & Parks
U.S. Fish and Wildlife Service, Lower Yellowstone River Coordinator/Pallid Sturgeon Recovery
The Nature Conservancy
Other entities as deemed important to the process

The Technical Team's main purpose is to provide technical assistance to the Adaptive Management Work Group. However, this Team will also provide guidance to Reclamation and the Corps to assure that the Project activities are completed concurrently and in full compliance with all environmental commitments described in Intake Final EA and associated Lower Yellowstone Construction Biological Assessment.

Technical Team functions may include:

- Assisting Reclamation and the Corps in development of the Adaptive Management Plan;
- Assist Reclamation and the Corps in implementing the Adaptive Management Plan, including post-construction monitoring identified in final NEPA and ESA documents;
- Providing information as necessary for preparing annual resource reports and other reports, as requested by the Adaptive Management Work Group; and
- Reviewing strategic plans, annual work plans, and other assignments from the Adaptive Management Work Group.

Technical Team Responsibilities, Goals, and Objectives may include:

- Develop criteria and standards for post-construction monitoring programs discussed in Intake Final EA Appendix I and the biological assessment. This includes providing periodic reviews and updates of monitoring and research programs;
- Review and comment on the post-construction monitoring activities and any scientific studies conducted by the adaptive management program;
- Develop recommendations for the adaptive management process based on information learned through studies.

Independent Review Panels

Independent review panels are comprised of qualified individuals not otherwise participating in the monitoring and research studies. Independent review panels will be used at the discretion of the Adaptive Management Workgroup. The panels include peer reviewers, science advisors, and protocol evaluation panels whose primary responsibility is to assess the quality of research, monitoring, or science being conducted by the Adaptive Management Program and to make recommendations to improve it.

The Review Panels may:

- Review Intake Diversion Dam Modification, Lower Yellowstone Project Adaptive Management Program post-construction monitoring and research programs and protocols;
- Provide reports based on their review to the Technical Team and Adaptive Management Work Group;
- Make recommendations and provide advice to the Technical Team and Adaptive Management Work Group; and
- Assess proposed research plans and programs, technical reports and publications, and other program accomplishments.

Adaptive Management Plan Objectives

The Plan will be based on objectives that meet post-construction monitoring needs and the Corp's success criteria. It will incorporate commitments from the Final EA and FONSI as well as those in the Lower Yellowstone Construction Biological Assessment and subsequent letter of concurrence. The Adaptive Management Plan objectives will be developed by the Adaptive

SMART Model
Specific
Measureable
Achievable
Realistic/Relevant
Time bounded

Management Work Group and the Technical Team. The primary focus of these objectives is to evaluate whether or not the Intake Project is successful (e.g., allows effective passage of pallid sturgeon and other native fish and achieves entrainment protection). It is likely that these objectives will include or be similar to those outlined in table J.1. The SMART model will be used in developing objectives.

Table J.1 - Potential Adaptive Management Objectives for the Intake Diversion Dam Modification, Lower Yellowstone Project.

Pallid Sturgeon Passage Objectives
Develop post-construction monitoring activities to determine if the Intake Diversion Dam Rock Ramp (preferred alternative) provides effective passage for the pallid sturgeon (adult and juvenile).
Fish Screening Objectives
Develop post-construction monitoring activities to determine if the Intake headworks and fish screen provide effective entrainment protection of pallid sturgeon and other native fish.
Mitigation and Monitoring Objectives
Develop protocol to evaluate and ensure the monitoring and mitigation measures identified in the Intake Final EA, Biological Assessment, and letter of concurrence are implemented.

For any objective eventually selected, all reasonable and implementable measures within the boundaries discussed below will be considered in developing study designs for testing hypotheses and management actions and programs for this Plan.

The components of each objective analysis include:

- A hypothesis
- A monitoring and data assessment approach
- A timeline
- Trigger events
- Response(s)
- Response limits
- A response evaluation
- End point(s)
- Reporting results
- Responsibilities and funding

A generalized flow chart identifies the steps and components of evaluating the Adaptive Management Plan's objectives (figure J.2). For each objective, the Adaptive Management process will test hypotheses to determine if an objective is being met. The methods used to test hypotheses are shown as the "Monitoring and Data Assessment Approach" box in figure J.2. These methods likely will use existing lower Yellowstone River surveys and data analyses (e.g. pallid sturgeon surveys being conducted by Montana Fish, Wildlife & Parks).

Adaptive Management Plan Boundaries

It is important that specific authorities are understood so that adaptive management does not exceed agency authorities. The primary goal of the NEPA is to ensure that agency decision makers and the public recognize and account for environmental and other related impacts of proposed agency actions. The Intake Final EA and its associated Biological Assessment acknowledge the uncertainty that is present in certain resource areas. Adaptive management allows for managing the uncertainty and providing flexible and appropriate decision making necessary to meet the Intake Project objectives.

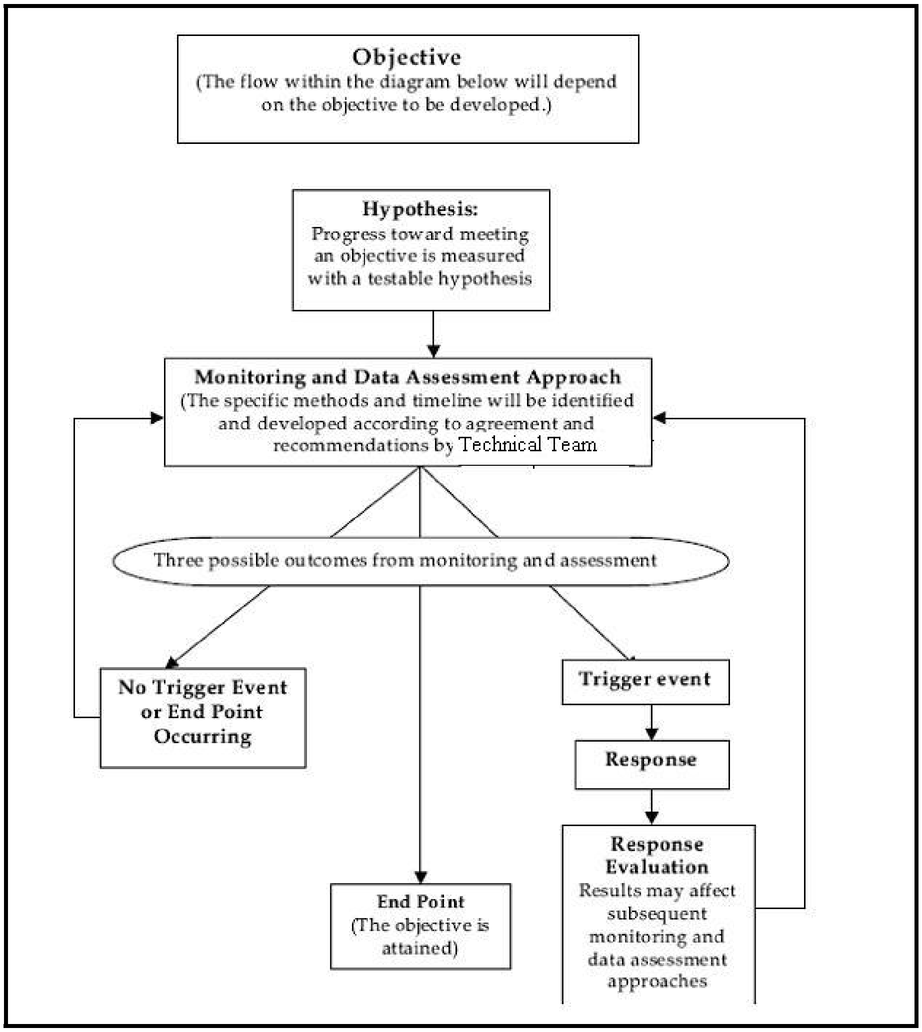


Figure J.2 - Flow Chart of the Components of Adaptive Management Objectives and Their Relationships.

The Intake Diversion Dam Modification, Lower Yellowstone Project Adaptive Management Program will be developed and designed to provide an organization and process for a collaborative, science-based integration of action, monitoring and research information necessary to ensure success. Recommendations from the Adaptive Management Work Group and the Technical Team will recognize the environmental commitments of the Intake Diversion Dam Modification, Lower Yellowstone Project NEPA and ESA documents.

Responsibility for Adaptive Management Plan

The development of the Adaptive Management Plan will be a Corps and Reclamation collaborative effort using the Adaptive Management Workgroup and the Technical Team. The Plan will follow the intent of this strategy.

Development of the Intake Diversion Dam Modification, Lower Yellowstone Project Adaptive Management Program

Initiation of the Adaptive Management Program would commence upon issuance of the Intake Final EA and FONSI and Lower Yellowstone Construction Biological Assessment, and funding for project construction. The first step in initiating adaptive management is to engage the appropriate work group members in assessing the resource issues and reaching agreement on the scope, objective, and potential management actions.

Work Group Involvement

Potential members have been identified in the Adaptive Management Work Group and in the Technical Team, as noted above. In order to move the member identification process forward, the Executive Managers will identify and initiate the Adaptive Management Work Group and the Technical Team. This process will include the following steps.

1. Executive Managers meet to review this adaptive management strategy and identify potential participants.

2. Executive Managers send letters inviting potential members to participate, explaining the Adaptive Management Program, and requesting confirmation. The managers also identify an initial meeting schedule for implementation of the program.

3. Hold an initial meeting of the Adaptive Management Work Group to:
    a. Engage members in the Adaptive Management Program process
    b. Establish agreement with members on specific resource areas to be addressed by the Adaptive Management Program.

Establishing Group Objectives

The Adaptive Management Work Group will identify clear, measurable management objectives to guide decision making and evaluate management effectiveness over time. The term "objective" is used here to mean some desired outcome or performance measure (post-construction assessment) that can be used to guide decision making and measure success. Objectives typically are expressed in terms of management performance over the timeframe of a project (see table J.1). These objectives should be specific, measurable, achievable, results-oriented, and time fixed ($\leq$ 8 years). Objectives should also incorporate the social, economic and/or ecological values of work group members, and reflect the value of learning over time.

Management Actions

Both the Adaptive Management Work Group and the Technical Team will work together to identify a set of potential management actions for successful Intake Project implementation.

Like any iterative decision process, decision making in adaptive management involves selection of an appropriate management action at each point in time, given the status of the resources being managed at that time. The Adaptive Management Work Group, working with the Technical Team and other invited expert scientists, have the responsibility of identifying the set of potential actions from which this selection is made.

These management actions will also use where necessary:

1. **Models**
   Identify models that characterize different ideas (hypotheses) about how the system works. Models play an important role in virtually all applications of structured decision making, whether adaptive or otherwise. In order to make smart decisions, it always is important to compare and contrast management alternatives in terms of their costs, benefits, and resource consequences. Models typically express benefits and costs as outputs of management through time. More importantly, they allow one to forecast the impacts of management.

   The term "model" as used here means a plausible representation of a dynamic natural resource system. Models can be as informal as a verbal description of system dynamics, or as formal as a detailed mathematical expression of change. Models in adaptive management should characterize system behaviors and responses to management actions. Models should incorporate different ideas (hypotheses) about how the resource system works and how it responds to management. The suite of models should capture key uncertainties (or disagreements) about resource processes and management effects. Models must be compatible with, and calibrated to, available data and knowledge.

2. **Monitoring Plans**
   It is important to design and implement a monitoring plan to track resource status and other key resource attributes. Specifically, monitoring programs should be designed to focus on the information needed to make management decisions and evaluate their effects. The value of monitoring in adaptive management is derived from its contribution to adaptive decision making, and monitoring efforts should be designed with that goal in mind.

3. **Assessment**
   The information produced by monitoring should be used for assessments of decision making and learning. More specifically;
   - Assessment/analysis includes parameter estimation, comparative assessments, and prioritization of management alternatives.
   - Comparison of predicted and actual responses is used to update understanding of management impacts.
   - Comparison and ranking of projected outcomes for management alternatives is used in selection of management actions.
   - Comparison of desired and actual outcomes is used to evaluate management effectiveness.

Iterative Management Actions

Once management actions have been identified and implemented, the monitoring begins and analysis and assessment occur (see figure J.3). As understanding is gained through the assessment process, there is need for specific decision making. This decision making could culminate in a final action, or from the assessment and decision making result in new or additional management action. The management strategy can continually adjust based on what is learned. At some point in time it is possible that the uncertainty is removed and management decisions can be dormant, but this is unlikely in a learning-based adaptive approach.

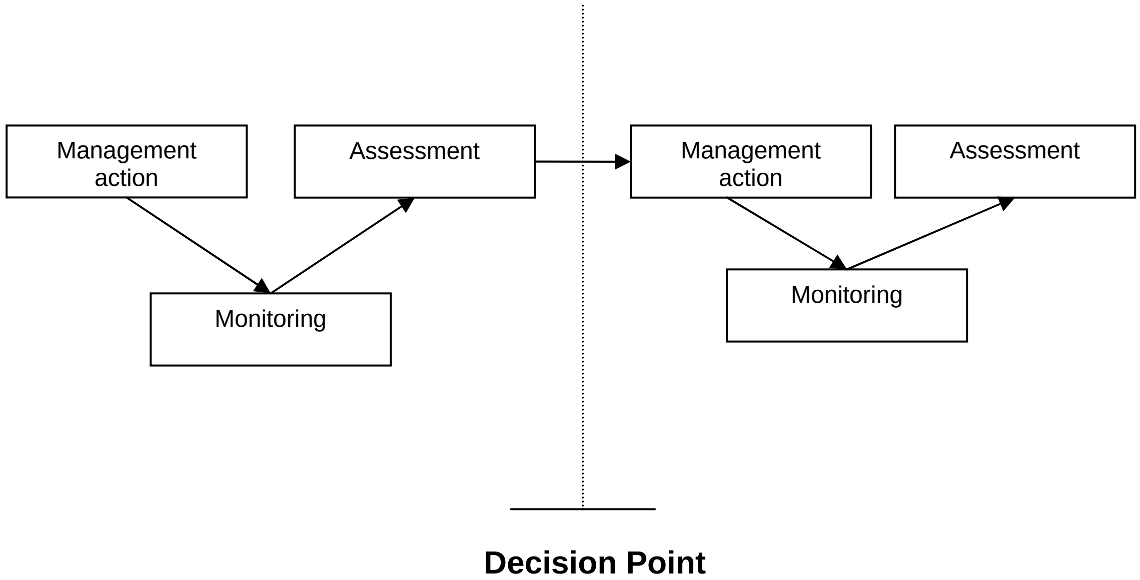


Figure J.3 – Iterative Cycle of Adaptive Management.

Literature Cited

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2007. *Adaptive Management: The U.S. Department of the Interior Technical Guide.* Washington, DC: Adaptive Management Working Group, U.S. Department of the Interior.

Appendix K – Surface Water Quality Tables

Introduction

This appendix contains summary tables from the Corps 2009 report, *Results of Elutriate Sampling Conducted Along the Yellowstone River at Intake Dam, Montana on April 29-30, 2009,* that are cited in surface water quality section of the Intake EA.

Table K.1 - Nutrients and General Water Quality Characteristics of Collected Receiving Water and Prepared Sediment Samples.

Parameter	Detection Limit	Receiving Water	Prepared sediment Samples								
		YR-W1	YR-S1	YR-S2	YR-S3	YR-S3 (split)	YR-S4	YR-S5	YR-D1	YR-D2	YR-D3
Alkalinity, Total (mg/l)	4	139	138	183	139	139	144	140	140	140	164
Ammonia Nitrogen, Total(mg/l)(1)	0.02	n.d.	0.17	n.d.	n.d	n.d.	n.d	n.d	n.d	n.d	3.84
Carbon, Total Organic (mg/l)	0.2	2.9	3.4	6.5	3.5	5.0	4.0	3.7	3.3	3.6	4.9
Carbonaceous Biochemical Oxygen Demand – CBOD (mg/l)	2	n.d.	n.d.	4	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	4
Chemical Oxygen Demand – COD (mg/l)	3	38	14	35	14	16	47	17	15	13	26
Ammonia plus Organic Nitrogen (mg/l)	0.2	n.d	1.1	1.2	0.7	n.d.	1.1	0.9	0.8	0.9	4.9
Nitrate-Nitrite Nitrogen (mg/l)	0.02	0.50	0.40	0.40	0.40	0.40	0.40	0.50	0.50	0.40	0.30
Oxidation Reduction Potential (mV)	-----	-13	-50	-48	-38	1	1	1	-41	-38	-64
pH (standard units)(2)	0.1	8.3	8.1	7.9	8.1	8.1	8.0	8.1	8.1	8.1	7.4
Phosphorus, Total (mg/l)	0.02	0.36	0.13	0.23	0.13	0.24	0.35	0.21	0.15	0.10	0.22
Suspended Solids, Total (mg/l)	4	875	-----	-----	-----	-----	-----	-----	-----	-----	-----
Turbidity	1	86	149	219	148	82	418	268	131	117	292

(1) Montana's water quality criteria for total ammonia are pH and temperature dependent. Acute and chronic criteria (salmonid fish not present) for a pH of 8.3 and a temperature of 20°C are, respectively, 4.7 and 1.0 mg/l.
(2) Montana's water quality criteria for pH are ≥ 6.5 and ≤ 9.0.

Table K.2 - Metal Concentrations in Collected Water and Prepared Sediment Samples.

Parameter	Detection Limit	Water	Elutriate Samples									Montana WQS Criteria[1]
		YR-W1	YR-S1	YR-S2	YR-S3	YR-S3 (split)	YR-S4	YR-S5	YR-D1	YR-D2	YR-D3	
Calcium, Total (mg/l)	1	49.2	49.9	65.9	49.1	48.8	63.6	51.2	55.1	49.4	44.5	-----
Magnesium, Total (mg/l)	1	19.5	19.1	28.9	19.3	19.2	19.4	19.1	17.2	18.0	21.4	-----
Hardness, Total (mg/l)	1	203	203	284	202	201	239	207	208	197	199	-----
Aluminum, Total (ug/l)	25	4,600	4,997	7,731	6,109	3,989	11,731	9,425	5,100	4,402	10,100	See Note 1
Antimony, Total (ug/l)	0.5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	5.6[5]
Arsenic, Total (ug/l)	1	6	11	3	4	3	6	5	4	3	11	340[2], 150[3], 10[4]
Beryllium, Total (ug/l)	2	2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	4[4]
Cadmium, Total (ug/l)	0.2	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	4.4[2], 0.46[3], 5[4]
Chromium, Total (ug/l)	1	n.d.	n.d.	n.d.	n.d.	10	18	10	n.d.	n.d.	10	3,220[2], 154[3], 100[4]
Copper, Total (ug/l)	1	20	n.d.	11	n.d.	10	17	10	n.d.	n.d.	10	27[2], 17[3], 1,300[4]
Cyanide, Total (ug/)	8	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	22[2], 5.2[3], 140[4]
Iron, Total (ug/l)	7	4,300	3,395	5,949	4,961	2,872	11,731	7,763	4,540	3,268	6,900	1,000[3], 300[5]
Lead, Total (ug/l)	0.5	n.d.	3	5	3	2	8	5	3	2	8	201[2], 7.8[3], 15[4]
Manganese, Total (ug/l)	2	46	227	81	43	28	199	97	92	92	530	50[5]
Mercury, Total (ug/l)	0.02	n.d.	n.d.	n.d.	n.d.	n.d.	0.02	n.d.	n.d.	n.d.	n.d.	1.7[2], 0.91[3], 0.05[4]
Nickel, Total (ug/l)	10	n.d.	n.d.	n.d.	n.d.	n.d.	16	10	n.d.	n.d.	10	854[2], 95[3], 100[4]
Selenium, Total (ug/l)	1	n.d.	3	3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	3	20[2], 5[3], 50[4]
Silver, Total (ug/l)	3	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	14[2], 100[4]
Thallium, Total (ug/l)	0.5	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.24[4]
Zinc, Total (ug/l)	10	21	16	25	21	13	36	34	16	16	30	218[2,3], 2,000[4]

[1] Montana's water quality criteria for Cadmium, Chromium, Copper, Lead, Nickel, Silver, and Zinc are based or hardness. Criteria given are for a hardness of 203 mg/l. [2] Acute criterion for protection of warmwater aquatic life. [3] Chronic criterion for protection of warmwater aquatic life. [4] Human health criterion for surface waters. [5] Secondary maximum contaminant level based on aesthetic properties. Note 1: Montana's water quality criteria for Aluminum are based on dissolved concentrations and not directly comparable to the measured total concentrations. The acute and chronic criteria for dissolved aluminum are, respectively, 750 and 87 ug/l. Historic monitoring of total and dissolved aluminum levels in the Missouri River at Williston, North Dakota, indicates that ambient total aluminum levels are much higher than dissolved levels (i.e., > 1,000 times).

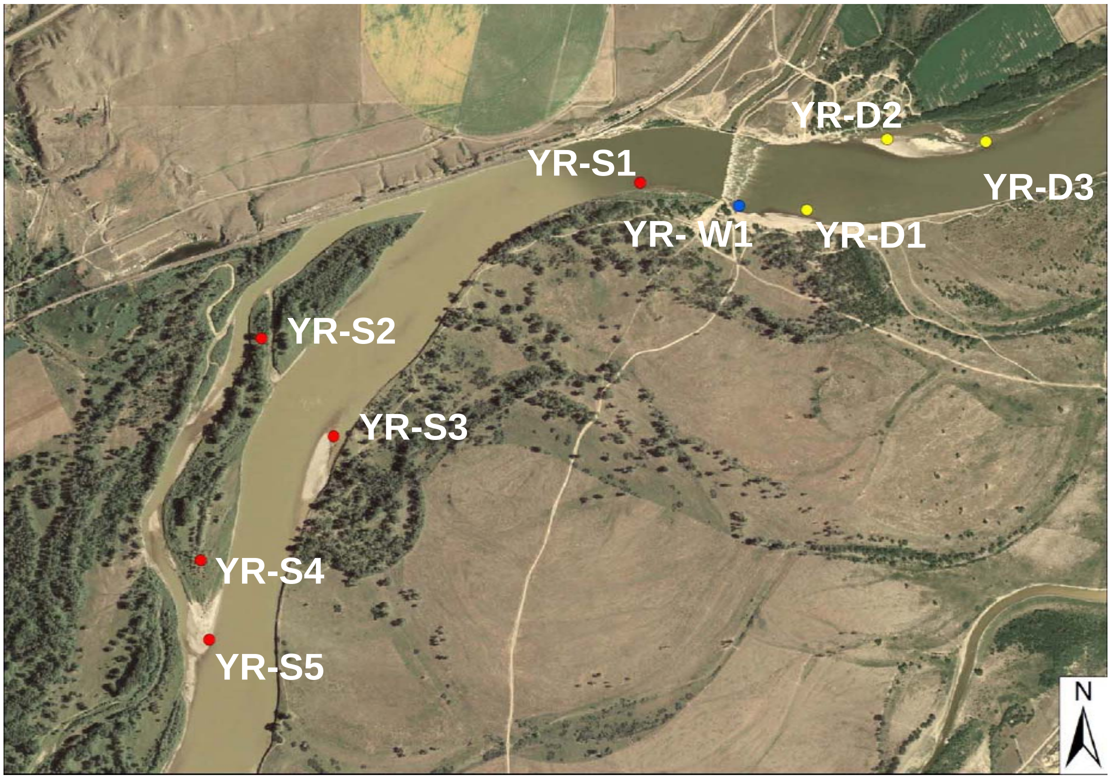


Figure K.1 – Sediment and Water Sample Sites.

Appendix L - Missouri River Recovery Implementation Committee Questions and Answers

Introduction

The Missouri River Recovery Implementation Committee (MRRIC), authorized by Congress in Section 5018 of the 2007 Water Resources Development Act, offers guidance to the Corps with respect to the Missouri River Recovery and Mitigation Plan. MRRIC includes representatives from federal agencies, tribes, states, local governments and non-governmental stakeholders in the Missouri River basin. MRRIC also provides guidance to the Corps and any affected federal agency, state agency, or Indian tribe on an ongoing study of the Missouri River and its tributaries. The study is known as the Missouri River Ecosystem Recovery Plan.

Recently MRRIC invited the Corps and Reclamation to summarize the proposed Intake Diversion Dam Modification, Lower Yellowstone Project at its July 2009 meeting. As a result of that presentation, MRRIC sent the agencies a series of questions about the project and requested an independent science review. The Corps and Reclamation agreed to convene a panel of sturgeon species experts to review Reclamation's and the Corps' responses to MRRIC questions and to determine whether such responses, and the need for fish passage and screens, are supported by the best available scientific information.

This appendix contains MRRIC questions and the agencies answers to those questions. The results of the panel review are in Appendix M.

A. Larval Drift

A. 1 Question: Where above Intake on the Yellowstone River does spawning substrate exist? What is the likelihood of the pallid using the newly opened area for spawning? And if they use it, is adequate drift distance/time provided for larvae survival?

A.1 Answer: **Spawning Substrate Location** Specific spawning substrate has not been identified in the upper Missouri River Basin including the Yellowstone River; however, there are data supporting the existence of spawning substrates above Intake.

Pallid sturgeon spawning currently occurs in the Yellowstone River downstream of Intake Diversion Dam (Fuller et al. 2008). Intensive relocation and spatial analysis of telemetered pallid sturgeon of known gender and sex stage suggest that fish spawn in bluff pool habitats in the Yellowstone River. In 2007 seven male and one gravid female pallid sturgeon aggregated in a bluff pool for about three days and subsequent recapture of the female pallid sturgeon indicated that spawning had occurred (Fuller et al. 2008).

Similar aggregations in this bluff pool were observed by Bramblett and White (2001) who speculated that spawning occurred downstream of Intake. This observation is supported by telemetry data from the middle and lower Missouri River where female pallid sturgeon in spawning condition are believed to have spawned over or adjacent to hard, coarse substrates in relatively deep water on outside bends where flows converge (Aaron DeLonay, U.S.Geological Survey (USGS), personal communication).

Bluff pool habitats occur when the outside bend of the channel scours against bedrock at the valley margin. These habitats are generally longer, have lower average and bottom velocities, higher maximum and average depths, and a higher percentage of coarse, hard boulder and bedrock substrates than other habitats in the valley bottom (Jaeger et al. 2008). Terrace pool habitats are similar in their attraction to pallid sturgeon but are found adjacent to alluvial terraces (Jaeger et al 2005a). There are over 4,000 acres of bluff and terrace pool habitats between Intake and Cartersville Diversions (Matthew Jaeger, FWP, personal communication) and substrates throughout this reach are predominately hard gravel and cobble (Bramblett and White 2001).

In general, other sturgeon species spawn over hard substrates which supports the conclusion that pallid sturgeon most likely spawn over hard substrates. Other sturgeon spawning substrates are as follows:

- Short nose sturgeon (*Acipenser brevirostrum*) spawn over rubble (Taubert 1980);
- Lake sturgeon (*A. fulvescens*) spawn over coarse gravel and rounded cobble (Manny and Kennedy 2002) and where substrates were predominantly cobble (Chiotti et al. 2008);
- White sturgeon (*A. transmontanus*) spawn over a diversity of substrates, including boulder, bedrock, cobble, and sand (Parsley et al. 1993; Perrin et al. 2003); and
- Gulf sturgeon (*A. oxyrinchus*) spawning areas consist of hard substrates and gravel (Heise et al. 2004).

Given the association of pallid sturgeon spawning with hard substrates and bluff pool habitats and the abundance of hard substrates and high habitat diversity, including bluff pools, upstream of Intake Dam it is reasonable to infer that suitable spawning substrate for the species exists upstream of Intake Dam.

Pallid Sturgeon Using the Newly Opened Area for Spawning The likelihood of pallid sturgeon using a newly opened area for spawning is uncertain, as with most restoration actions for endangered species. However, like most sturgeon species, pallid sturgeon generally move upstream to spawn, and spawning is believed to occur at or near the apex of this movement (Aaron DeLonay, USGS, Personal Communication). Telemetry data indicate that almost all remaining pallid sturgeon in RPMA 2 move into the Yellowstone River in the spring and that each year some move upstream to Intake Diversion Dam but not above (Bramblett and White 2001; Fuller et al. 2008).

Work specifically studying fish in known spawning condition documented at least one gravid female and several male pallid sturgeon moving up to Intake Diversion Dam, staging immediately below the dam for several days, and then moving back downstream (Fuller et al. 2008; M. Jaeger, personal communication). Intensive netting studies have also documented relatively high numbers of pallid sturgeon immediately below Intake Diversion Dam (Backes et al. 1994), and historic accounts documented pallid sturgeon upstream of Intake Diversion Dam during the putative spawning period (Brown 1955).

It is reasonable to conclude that if Intake Diversion Dam was not a barrier to movement, pallid sturgeon would continue to move above this point to satisfy various life history needs, including spawning.

Adequate Drift Distance/Time Natural variability in water temperature and velocity will result in a wide range of drift distances for pallid sturgeon larvae produced upstream of Intake Diversion Dam in the Yellowstone River. The free-drifting phase of pallid sturgeon larvae is a developmental stage that occurs between hatching and yolk sac absorption. The duration of this developmental stage is influenced by water temperature. At 16^{o}C the time between hatching and yolk sac absorption is 13 to 15 days, but at 24^{o}C it is reduced to 7 to 9 days (Kevin Kappenman, U.S. Fish and Wildlife Service (Service), personal communication). Temperatures on the lower Yellowstone River when larvae are expected to hatch and enter the free drifting phase typically range between 20^{o}C and 25^{o}C, which result in an expected drift time of 7 to 10 days.

While total drift time is dictated by water temperature, both laboratory and field trials indicate that drift rates of larval pallid sturgeon are related to water velocity. Thus, cumulative drift distance is related to both drift time and drift rate. Simply put, at a given temperature larvae drift farther at higher velocities (Kynard et al. 2007; Braaten et al. 2008), but in reality it is much more complex.

Larval drift rates decrease from average water velocities as habitat complexity increases due to entrainment of drifting larvae in areas of reduced velocity, such as eddies (Kynard et al. 2007; Braaten et al. 2008). Continuous exposure to eddies and channel complexity during the entire larval drift period will likely reduce cumulative distance drifted by larvae, as suggested by Braaten et al. (2008) and observed during 2007 when larval pallid sturgeon were allowed to free drift throughout a 112 mile reach of the mainstem Missouri River (Braaten et al., in preparation).

For example, Bratten et al. (2008) observed a three-fold increase in the average durations for all observed 1 to 9 day old larvae to drift 4,265 feet compared to 328 feet. Similarly, the deviation from water traveling at average velocity for the entire observed distributions of 1 to 9 day old larvae was 3 times greater at 4,265 feet than at 328 feet (Braaten et al. 2008). The further larvae drift through complex habitat, the greater the range of time it will take all larvae to drift a given distance. Based on the observations of Braaten et al. (2008), it is expected that the entire distribution of drifting larvae would require an additional 4 days of travel time to cover the same distance as a drop of water traveling at average column velocity over a distance of 317 miles, which is the cumulative amount of riverine habitat between Cartersville Diversion and the present headwaters of Sakakawea Reservoir.

Higher habitat complexity in the Yellowstone River as compared to previous studies suggests that drifting larvae will be more frequently exposed to and resultantly entrained in lower velocity habitats, such as eddies, secondary channels, and boundary layers associated with coarser substrates. This will likely reduce drift rates and cumulative drift distance relative to average water velocity more than previously reported.

Previous larval drift studies were conducted in smooth-bottomed tanks with limited rock material (Kynard et al. 2007) or over sand and silt substrates (Braaten et al. 2008), whereas Yellowstone River substrate above Intake Diversion Dam is predominately gravel and cobble (Bramblett and White 2001). Increased roughness associated with gravel and cobble substrates results in a thicker, low-velocity boundary layer on the stream bottom. In other words, the water traveling along the river bed substrate interface moves more slowly over coarse substrates than it does over sand or silt substrates (Gordon et al. 1992). Because larval pallid sturgeon drift at or near the stream bottom (Kynard et al. 2007; Braaten et al. 2008), entrainment in low-velocity boundary layers or interstitial spaces within the substrate could reduce drift rates and distances from those predicted based on average column velocity alone.

Laboratory studies incorporating limited rock cover provide somewhat contradictory results. Pallid sturgeon did not attempt to use rock cover at low velocities (Kynard et al. 2002) but did try to hold position behind rocks at higher velocities (Kynard et al. 2007). Larval drift rates associated with gravel substrates are lower than those associated with sand substrates for other sturgeon species (Nechako White Sturgeon Recovery Initiative 2007).

There are approximately 176 miles of seasonal and perennial secondary channels accompanying 236 miles of mainstem channel below Cartersville Dam on the Yellowstone River (Jaeger 2004). Average and bottom velocities of secondary channel habitats are significantly lower than those of mainstem habitats ($P < 0.001$; Jaeger et al. 2008). These lower velocities effectively reduce drift rates of fish entering these habitats.

The Yellowstone River has 35% - 50% more area of slow current velocity habitat patches than the Missouri River during periods when larval drift occurs (Bowen et al. 2003). This likely reduces larval drift rates on the lower Yellowstone River relative to average water velocity than modeled in the Missouri River. Accordingly, increased habitat complexity in the Yellowstone River may make direct extrapolation of larval drift distances modeled under lower habitat complexity or considering only average water velocity inappropriate.

In summary, it is anticipated that the average larvae will drift faster in the Yellowstone River than described in laboratory (Kynard et al. 2007) or field investigations (Braaten et al. 2008) because of higher velocities. A combination of other physical factors, i.e. temperature, habitat complexity, etc., will shorten total drift time and thus drift distances for some larvae relative to those predicted by water velocities alone. Based on the amount of variation in temperature and drift rate, it is expected that a wide range of larval drift distances will occur within and among years.

It is expected that the fastest drifting larvae traveling at approximately the same rate as the average water column velocity at relatively cool temperatures and resultantly long drift times (10 days) will require over 497 miles of drift distance on the Yellowstone River. However, it is also expected that the slowest drifting larvae, which will deviate by several days from drift times predicted by water traveling at average velocity, at relatively warm temperatures and resultantly short drift times (7 days) will requires less than 217 miles of drift distance. Thus, we anticipate that adequate larval drift distance will be available for a portion of any naturally produced larvae spawned in currently inaccessible reaches upstream of Intake Diversion Dam during most years.

Summary The potential for natural recruitment and enhancement by providing passage at Intake Diversion Dam has been a position long held by pallid sturgeon biologists (Service 2000a; Service 2003). This was confirmed more recently by the Upper Missouri Basin Pallid Sturgeon Workgroup (Workgroup). The Workgroup was asked by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and the U.S. Army Corps of Engineers (Corps) to address habitat availability and larval drift issues for pallid sturgeon in the Yellowstone River. The Workgroup (2009) concurred that additional ecosystem and connectivity restoration efforts could further increase the amount of habitat available for larval drift in the Yellowstone River. Furthermore, the Workgroup agreed that if pallid sturgeon passage at Intake Diversion Dam results in spawning at upstream locations, then it is possible that adequate larval drift distances exist for natural recruitment to occur. Details of the Workgroup's assessment are summarized in their report (Workgroup 2009).

A.2 Question: What is the current speed during the high water period on the Yellowstone May 15--to July 15, at Cartersville and below and what velocity rate (or range of rates) is appropriate to calculate larval drifts?

A.2 Answer: In regard to spawning and larval drift, Question A.2 proposes too broad a time period. Spawning does not occur until about mid-June through early July (Fuller et al. 2008). Larvae hatch and begin drifting about 3 to 5 days following egg fertilization and drift for 7 to 10 days at temperatures common for the Yellowstone River (K. Kappenman, personal communication). This answer, therefore, focuses on the period when larvae are drifting, which is typically during the descending hydrograph from mid- to late-June through mid-July.

Determining "what velocity rate (or range of rates) is appropriate to calculate larval drifts" on the Yellowstone River is difficult because of the range of physical factors. These factors include velocities and temperatures during the time of larval drift and the complexity and diversity of habitats in the river. However, information collected by biologists over time can give us a picture of what is appropriate to calculate larval drift. Assuming a fish is drifting in the main channel in late June to early July, it is reasonable to use 2.9 feet per second.

Velocity will vary among years in relation to discharge and within years at a given discharge. This will occur at different locations in the Yellowstone River. River velocities generally increase as discharge increases (Leopold et al. 1964). At average discharges of 4,400 cubic foot per second (cfs) average velocities between Cartersville Diversion and the confluence with the Missouri River are 2.77 feet per second (f/s) (M. Jaeger, personal communication). By comparison, at flood stage (i.e. discharges of over 100,000 cfs) average velocity measurements at a single station with an artificially confined channel at Sidney Bridge are about 10 f/s (Leopold et al. 1964).

Average discharge on the Yellowstone River over the past 20 years from mid-June to early July is about 25,000 cfs near Sidney, Montana. Although river-wide average velocities have not been measured at this specific discharge, it is expected that average velocities during periods of larval drift may exceed 3.28 f/s (Workgroup 2009) but will be less than 6.56 f/s. For example, Bramblett (1996) measured velocity at points associated with sturgeon locations at discharges ranging from about 2,000 cfs to 50,000 cfs and the maximum average velocity recorded was 5.93 f/s while mean average velocity was 3.34 f/s.

However, it is also expected that velocity will vary considerably in the Yellowstone River at a given discharge. Jaeger et al. (2008) reported significant differences in average velocities among different habitat types in the Yellowstone River. Measurement of velocity at 4,400 randomly selected points indicated that average velocities ranged from 11.05 f/s to 0.00 f/s (M. Jaeger personal communication). Additionally, larval pallid sturgeon drift at or near the stream bottom (Kynard et al. 2007; Braaten et al. 2008) where velocities can be significantly lower than average velocities. Bottom and average velocities are substantially different on the Yellowstone River ($P < 0.001$); bottom velocities are about 21% lower than average velocities (M. Jaeger, personal communication).

As discussed above, increased habitat complexity in the Yellowstone River may make direct extrapolation of larval drift distances based only on average water velocity inappropriate. It is anticipated that the average larvae will drift faster in the Yellowstone River than described in laboratory (Kynard et al. 2007) or field investigations (Braaten et al. 2008) because of higher velocities. However, a combination of other physical factors, i.e. temperature, habitat complexity, etc., will shorten total drift distances for some larvae relative to those predicted by water velocities alone.

Based on the amount of variation in temperature and drift rate, it is expected that a wide range of larval drift distances will occur within and among years. Yellowstone River temperatures during periods of larval drift indicate that larvae will likely drift for 7 to 10 days. Distributions of larval drift rate and distance relative to water traveling at average velocity in the Missouri River suggests that some larvae will lag up to 4 days behind water traveling at average velocity over distances comparable to providing passage at Intake Diversion (317 miles). Additionally, given the higher complexity of the Yellowstone River, it is expected that the deviation of the entire distribution of drifting larvae from water traveling at average velocity would be greater on the Yellowstone River than described above on the Missouri River.

It is expected that the fastest drifting larvae traveling near the velocity of average water at relatively cool temperatures and resultantly long drift times (10 days) will require over 497 miles of drift distance on the Yellowstone River. However, it is also expected that the slowest drifting larvae at relatively warm temperatures and resultantly short drift times (7 days) will require less than 217 miles of drift distance. Thus, we anticipate larval drift distance would be adequate for some larvae spawned upstream of Intake Diversion Dam during most years.

Reclamation asked the Upper Basin Pallid Sturgeon Recovery Workgroup to provide their best biological judgment about drift issues. This paper (Workgroup 2009) is appended.

A.3 Question: What data is available to support the conclusion that any larvae would actually survive without ending up in the head waters of Lake Sakakawea where they would die?

A.3 Answer: Hatchery-reared larvae released when 5 to 17 days old have been recaptured months or years later in the Yellowstone River and Missouri River below the confluence. This indicates that habitat in these river reaches is suitable for survival of pallid sturgeon larvae (M. Jaeger, personal communication). However, these findings are based on fish that have artificially reduced drift rates because a portion of their drift phase was spent in a hatchery environment. By increasing drift distance, it is anticipated that naturally-produced larval pallid sturgeon would settle in the same areas capable of supporting these hatchery-reared study fish.

The Workgroup (2009) reports:

> "The near-natural hydrograph and associated temperature and sediment regimes characteristic of the unimpounded Yellowstone River (White and Bramblett 1993) combine to provide one of the best habitat templates and opportunities to support pallid sturgeon recovery in the upper Missouri River basin. Current habitat conditions include intact migration and spawning cues and habitats; most extant adult pallid sturgeon in [Recovery-Priority Management Area] RPMA 2 migrate into the lower Yellowstone River each spring (Bramblett and White 2001) and subsequent spawning has been documented (Fuller et al. 2008). However, inadequate larval drift distances (~150 kilometers) [93 miles] between known spawning reaches and the present headwaters of Sakakawea Reservoir may not exist. Accordingly, inadequate larval drift distances are one of the leading hypotheses to explain recruitment failure in RPMA 2."

While there is no way to guarantee survival of larval pallid sturgeon that may result following implementation of passage and entrainment protection at Intake Diversion Dam, the data provided above suggest that habitat diversity in the Yellowstone River may make larval drift rate data from other studies (i.e. Kynard et al. 2002; Kynard et al. 2007; Braaten et al. 2008) difficult to directly extrapolate to the Yellowstone River. However, data available from these studies suggest that not all pallid larvae drift at the same rate (Braaten et al. 2008), and development of larvae influences drift (Kynard et al. 2007). The Workgroup paper (2009) also addresses larval drift distances.

Furthermore, water temperature influences larval development rates; larvae develop faster in warm water. Temperature profiles for the Yellowstone River indicate that larval development rates (based on degree days) are higher than the Missouri River downstream from Fort Peck Dam. Therefore, we anticipate that while some larvae will drift into Lake Sakakawea, a portion of the slowest drifters likely will not.

A.4 Question: What are the anticipated drift rate and distance required for larval pallid sturgeon in the relevant reaches? What is the required water level in Lake Sakakawea to attain this distance? How often should these conditions exist? What is the level of uncertainty in the drift rate and distance calculations? How was this data considered when planning the Intake project?

A.4 Answer: Not all larvae drift at the same rate – some drift faster than mean velocity, some drift at about mean velocity, and some drift slower than mean velocity. Although there are uncertainties relative to larval drift speed and distance in relation to high velocities and coarse substrates in the Yellowstone River, it is likely that at least a portion of the larvae hatched upstream of Intake Diversion Dam would survive (note previous discussions above).

If pallid sturgeon passage at Intake Diversion Dam results in spawning at upstream locations, then it is possible that larval drift distances would be adequate for some natural recruitment to occur (Workgroup 2009). Construction of a fish passage alternative at Intake Diversion Dam would provide between 253 and 317 miles of natural free-flowing river between Cartersville Dam, which is the next upstream barrier on the Yellowstone River and Lake Sakakawea.

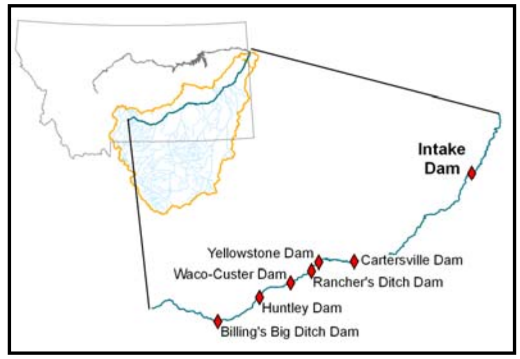
While the range of available habitat is related to pool elevations of Lake Sakakawea, any requirements for specific pool elevations have not been determined, because the current focus is on providing passage to as much upstream habitat as possible. This additional increase in the length of free-flowing riverine habitat likely would provide adequate drift distance for at least a portion of the larvae (Workgroup 2009). Further discussion of drift rates and distance calculations can be found in the Workgroup's (2009) white paper and above. Specific calculations on drift distances can also be found in the recent Montana Fish, Wildlife & Parks (FWP) presentation to MRRIC (Jaeger 2009).

Any specific recommendations for pool elevation manipulations may be discussed through the adaptive management process as pallid spawning and recruitment success is monitored. It is not known how often this species needs to accomplish a successful spawn/recruitment year class, but the spawning periodicity of adult females is every two to three years. With the long-lived nature of pallid sturgeon, it is likely they do not need to successfully spawn every year in order to accommodate a wild population of naturally reproducing fish, as evidenced by the natural fluctuations in historic flow regimes.

In planning the Intake Diversion Dam Modification, Lower Yellowstone Project (Intake Project), the best available scientific data were considered. This is documented in the draft environmental assessment (EA) prepared for the Intake Project. The Service's Biological Review Team, as well as researchers from Reclamation's Denver Technical Service Center, the Workgroup, the Pallid Sturgeon Recovery Coordinator, and other Reclamation staff, Corps, Service, USGS, and state biologists have all participated in planning the Intake Project.

A.5 Question: Is there a need to modify other upstream dams to allow enough drift distance for larvae? What progress/plans have been made on modifying upstream structures?

A.5 Answer: There are six low-head diversion dams on the Yellowstone River downstream from Billings, Montana (see Intake EA, page 3-6). Huntley Dam and Intake are federally-owned, while the middle four (Waco-Custer, Rancher's Ditch, Yellowstone, and Cartersville) are privately-owned and managed by the local irrigation districts. These structures present some degree of impediment to fish passage; however, the extent of fish blockage at these dams seems to depend on river stage and the swimming ability of the various species trying to negotiate the dams (see Helfrich et al. 1999).



Diversion Dams Along the Yellowstone River (adapted from Jenkins 2007).

At present, three of these diversion structures fall within what is generally considered to be the historical range of pallid sturgeon. In addition to Intake, fish passage needs at the Cartersville Dam near Forsyth, Montana, are under discussion. The Cartersville Dam is privately owned but FWP, the Service, the Corps, and the Nature Conservancy are working together to find a solution. To date, a value engineering study has identified a suite of potential options for passage of native species, including sturgeon (FWP and Enlien Consultants 2009). FWP has hired an engineering and consulting firm to analyze these potential passage options, prepare an environmental assessment, and identify a preferred alternative.

Dams on tributaries to the Yellowstone have also been modified to address fish passage issues including the T&Y Dam and the Mobley Dam on the Tongue River. These new fish passage projects open additional miles of pallid sturgeon habitat on the Tongue River.

A.6 Question: Can/should a study be conducted on the Yellowstone River to provide drift information specific to this reach?

A.6 Answer: The best available scientific information, many biologists, and researchers concur that larval drift distance on this reach would be adequate for a portion of pallid sturgeon larvae most of the time once the passage issue at Intake has been resolved. A study could be conducted, but there are several complicating factors involved with such a study on the Yellowstone, such as:

- Are there sufficient numbers of pallid sturgeon larvae available for study? Adult female pallid sturgeon typically produce between 0 to 243,450 larvae, although average production is about 100,000 larvae (Rob Holm, Service, personal communication). Previous mainstem drift tests required about 428,285 larvae at a discharge of about 6,400 cfs (R. Holm, personal communication). At discharges expected in the Yellowstone River during times of larval drift (25,000 cfs) about 1,672,988 larvae would be required for a comparable drift test to account for dilution associated with increased discharges.

Because the slowest drifting portion of larvae are of most interest, it would be essential to release adequate numbers of larvae to accurately describe the entire distribution of drift times and distances in the Yellowstone River for the study to be worthwhile. About 17 gravid adult female pallid sturgeon would be needed to produce the required number of larvae. It is estimated that there are currently 40 female pallid sturgeon remaining in RPMA 2 (Gillian Hadley, personal communication), about half of which will spawn in any given year (Fuller et al. 2008). The highest number of gravid female pallid sturgeon ever captured in a year was 16 in 2007. In 2009 one of the lengthiest broodstock collection efforts to date resulted in capture of only seven gravid female pallid sturgeon. Accordingly, it is unlikely that an adequate number of gravid female pallid sturgeon could be captured to provide the number of larvae necessary to accurately characterize the full distribution of drift times and distances on the Yellowstone River.

- Would these larvae be better used for a different recovery project or study? Although applied research remains a high priority for pallid sturgeon recovery efforts within the Upper Missouri River Basin, preventing extinction of the species through a conservation stocking program is the highest priority for hatchery-reared pallid sturgeon (Upper Basin Pallid Sturgeon Workgroup Workshop, Billings, Montana, 2009). As such, the propagation and conservation stocking program will require at least the first seven gravid female pallid sturgeon captured in any year until stocking goals in each RPMA are attained (Upper Basin Pallid Sturgeon Workgroup Workshop, Billings, Montana, 2009). Most larvae allocated to a drift study on the Yellowstone River would need to be produced by gravid female pallid sturgeon captured subsequent to the seven fish required by the propagation program. Accordingly, it is increasingly unlikely that an adequate number of gravid female pallid sturgeon could be captured to provide the number of larvae necessary to accurately characterize the full distribution of drift times and distances on the Yellowstone River.

- The presence of naturally produced shovelnose sturgeon larvae concurrent with the time that pallid sturgeon larvae will be available for a Yellowstone River drift test will require genetic analysis of all captured sturgeon larvae. Gravid shovelnose sturgeon occupy the entire reach of the Yellowstone River between Cartersville Diversion and the confluence with the Missouri River each year (Haddix and Estes 1976; M. Jaeger, personal communication). It is suspected that shovelnose sturgeon spawning occurs throughout this reach (Haddix and Estes 1976; M. Jaeger, personal communication) and naturally produced shovelnose sturgeon larvae are commonly captured (Penkal 1981; Braaten and Fuller 2005). To distinguish pallid sturgeon larvae captured as part of the drift test from naturally produced shovelnose sturgeon genetic analyses of all captured sturgeon larvae likely will be necessary. Analysis costs are about $50 per fish (G. Jordan, personal communication). Braaten et al. (2008) recaptured about 5,800 larvae during a side channel drift test on the Missouri River. Although it is unknown what number of pallid and shovelnose sturgeon larvae would be captured by a comparable Yellowstone River drift test, analysis costs for the number of fish captured during the side channel study would be about $290,000.

- There is little time left before wild pallid sturgeon are extirpated in the Upper Missouri River Basin. While there is some debate over the year that local extirpation will occur (2017 – 2024), maintaining the status quo is not addressing long-term pallid sturgeon recovery goals.

- Conservation of genetic variability within pallid sturgeon is an important component of long-term recovery goals. The upper Missouri River Basin pallid sturgeon are genetically distinct from those in the lower parts of the species' range (Campton et al. 2000; Schrey and Heist 2007; Tranah et al. 2001). The wild pallid sturgeon population is facing extirpation due to several decades of failed spawning and/or recruitment (Service 2007). Furthermore, approximately 136 wild pallid sturgeon remain in RPMA 2 (Service 2007) that would likely benefit from these recovery efforts on the Yellowstone River.

FWP, Reclamation, the Service, and the Corps have been studying pallid sturgeon issues at Intake for 20 years. Unfortunately, the declining population of mostly mature wild pallid sturgeon in the Yellowstone River and Missouri River between Fort Peck Dam and Lake Sakakawea is expected to be locally extirpated in the near future if reproduction and survival of the young fish does not improve. Given the limited time to resolve the problem, it was decided that priority should be given to resolving passage and entrainment issues at Intake instead of continuing to study the problem.

B. Fish Passage

B.1 Question: Will the project allow passage of pallid sturgeon for spawning and will it allow larval pallid sturgeon passage downstream and lead to their survival?

B.1 Answer: The Corps and Reclamation are using the best available science to design a fish passage structure for pallid sturgeon at Intake, Montana, and will use adaptive management to make sure that it works. Although there are no fish passage projects in existence specifically built for pallid sturgeon, successful fish passage projects for other sturgeon species have been constructed in the western United States.

An example is the Glen Colusa Irrigation District gradient facility built by the Corps on the Sacramento River for salmonids. This facility is similar to the Rock Ramp Alternative proposed for the Intake Project. The Glen Colusa passage successfully provides passage for other sturgeon species, specifically the green and white sturgeon. Other successful projects for sturgeon species include:

- Red Bluff Diversion Dam in the Sacramento River,
- Through Delta Project facility in California,

- Heiberg Dam and a dozen other passage projects for lake sturgeon on the Red River Basin in North Dakota/Minnesota.

The Corps and Reclamation, in consultation with the Service and FWP, are working cooperatively to ensure that the best available science and fish passage technology is used in the design of the preferred alternative. Therefore, we are reasonably certain that this design will work to pass pallid sturgeon. Any problems would be corrected through adaptive management.

Once pallid sturgeon can pass over or around the Intake Diversion Dam, they will have access to an additional 165 miles of river for spawning. They will also have access to the tributaries within this reach, including the Powder and Tongue Rivers.

The available options at this time to increase larval drift distances in the upper Missouri River basin are:

1) removal of Fort Peck Dam,
2) removal of Garrison Dam,
3) maintaining Lake Sakakawea at lower reservoir pool elevations to increase riverine habitats upstream of this reservoir, and
4) providing access to habitats further up the Yellowstone river via implementation of fish passage and entrainment protection measures.

When these options are compared, the Intake Project provides one of the best opportunities to achieve natural pallid sturgeon recruitment in the upper Missouri River Basin with the lowest ancillary costs, i.e. no adverse effects to hydropower generation, water intakes, flood control, navigation, irrigation, etc.

B.2 Question: Will the rock ramp design allow passage of pallid sturgeon?

B.2 Answer: There is an opportunity for pallid sturgeon passage with a rock ramp design (also known as a gradient facility), which is similar to other dams that have been modified in the western United States to allow passage of other sturgeon species (see answer to question B.1). Performance tests to quantify the swimming capabilities of pallid sturgeon and identify physiological and behavioral parameters were completed prior to design of the Intake Project alternatives (White and Medford 2002). The results were used in the design specifications.

Several Yellowstone River riffles and rapids of relatively high gradient that adult and juvenile pallid sturgeon are known to pass at a variety of discharges were extensively surveyed to provide further design criteria. A physical model is currently being built at Reclamation's Denver Technical Research Center to refine the rock ramp design and ensure its effectiveness for pallid sturgeon. In addition, an adaptive management plan would be implemented to fine-tune the selected alternative after construction.

B.3 Question: What data is available to support the thesis the majority of the fish even would go up to Cartersville if there was a fish passage?

B.3 Answer: Although we have not suggested that the majority of fish would go up to Cartersville with fish passage at Intake, pallid sturgeon have been documented at least 112 miles upstream of Intake, Montana, which is about 267 miles above the present headwaters of Lake Sakakawea (Brown 1955; Brown 1971). They were observed at this location consistent with times of the year when spawning is known to occur in the Yellowstone River (Fuller et al. 2008). Watson and Stewart (1991) captured a pallid sturgeon near Fallon, Montana, in 1991 in conjunction with studies associated with the Tongue River Project. There are other reports from the 1920s and 1930s that document pallid sturgeon above Intake Diversion Dam and in the vicinity of the Tongue River (Service 2000b).

Furthermore, if we generalize based on what is known about pallid and other sturgeon species spawning habitats in combination with the historical record, then suitable spawning substrate exists above Intake. Telemetry data indicates that almost all remaining pallid sturgeon in RPMA 2 move into the Yellowstone River in the spring and that each year some move upstream to Intake Diversion Dam but not above (Bramblett and White 2001; Fuller et al. 2008). Work specifically studying fish in known spawning condition documented at least one gravid female and several male pallid sturgeon moving up to Intake Diversion Dam, staging immediately below the dam for several days, and then moving back downstream (Fuller et al. 2008; M. Jaeger, personal communication).

Intensive netting studies have also documented relatively high numbers of pallid sturgeon immediately below Intake Diversion Dam (Backes et al. 1994) and historic accounts documented pallid sturgeon upstream of Intake Diversion Dam during the putative spawning period (Brown 1955). It is reasonable to conclude that if Intake Diversion Dam was not a barrier to movement pallid sturgeon would continue to move above this point to satisfy various life history needs including spawning. Additionally, telemetered juvenile pallid sturgeon have traveled up to the Intake Diversion Dam, were unavailable to pass, and turned to swim back downstream (Jaeger et al. 2008). Initial study results indicate that spawning habitats upstream of the Intake Diversion Dam are suitable for pallid sturgeon restoration efforts (Jaeger et. al 2008).

B.4 Question: Is the project design the best available technology for migration and protection of the pallid sturgeon population?

B.4 Answer: Yes, the collective opinion of fisheries biologists working on this Project, including those from FWP, the Service, the Corps, and Reclamation, agree that it is the best available technology. The action alternatives evaluated in the Intake EA were formulated through an iterative and collaborative process initiated during informal Endangered Species Act (ESA) consultations with the Service in 1997. The following documents were developed to help formulate and evaluate alternatives:

- Lower Yellowstone River Fish Passage and Protection Study (Reclamation and FWP 1997)

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

After careful consideration of more than 110 alternatives, two were further evaluated in the Intake Project EA – the Rock Ramp Alternative and the Relocate Main Channel Alternative.

B.5 Question: Is the screening system the best design for the pallid sturgeon?

B.5 Answer: Yes, the collective opinion of fisheries biologists working on this Project, including those from Montana FWP, the Service, the Corps, and Reclamation, agree that it is. The screen design uses the best available technology, including the smallest effective screen size and velocities recommended by the Service's Biological Review Team. This screen system is designed to meet Yellowstone River conditions, Lower Yellowstone Irrigation Project needs, and provide the best protection for pallid sturgeon and other native fish at Intake, Montana. The screen size is the smallest that can be used effectively, in accordance with the National Oceanic and Atmospheric Administration (NOAA) juvenile salmonid criteria.

A laboratory study evaluated the best technology available to use to meet the NOAA screening criteria for juvenile and larval pallid sturgeon that are < 3.9 inches long (Mefford and Sutphin 2008). The study evaluated four related topics: 1) swimming endurance, 2) impingement survival, 3) screening effectiveness, and 4) recovery of impinged fish from traveling fish screens. The study was used to identify and design fish screens for the Intake Project. It was conducted at the Reclamation Water Resources Research Laboratory in Denver, Colorado, using hatchery-spawned pallid sturgeon larvae.

Results of the study indicated that larvae <0.8 inches long displayed little swimming ability and easily passed through NOAA criteria fish screen material. Fish larger than about 1.6 inches long were capable of swimming several minutes against a typical fish screen approach velocity of 0.4 feet/second. This study indicates that NOAA criteria effectively protect pallid sturgeon >1.6 inches long. Screen impingement for periods up to 10 minutes (maximum impingement time evaluated) had no effect on fish mortality, when fish were recovered by back-flushing the screen.

B.6 Question: Is the by-pass design the best for pallid sturgeon?

B.6 Answer: Appendix E, Intake EA uses scoring criteria developed by the Biological Review Team (Jordan 2009) and hydraulic modeling (Corps 2009) to score alternatives on relative comparison scales. Although the Corps used pallid sturgeon life history, biology, and ecology to design the Relocate Main Channel Alternative, Intake EA Appendix E found that this alternative scores lower and less favorably for pallid sturgeon than the Rock Ramp Alternative.

B.7 Question: Will the new diversion designs effectively prevent entrainment of pallid sturgeon or other species that impact pallid sturgeon (e.g. chubs that are a food source for pallid sturgeon)?

B.7 Answer: The screen designs evaluated to date are anticipated to prevent entrainment of pallid sturgeon ≥ 1.5 inches long (Mefford and Sutphin 2008) While the success of this screen with other fish species has not been tested, it is reasonable to assume that it will prevent entrainment of other fish species ≥ 1.5 inches long. Monitoring post-Project construction and adaptive management will be implemented to ensure effectiveness.

B.8 Question: (if so what design)? Supporting information?

B.8 Answer: See discussion above in answer B.5. The fish screen is described in chapter two of the Intake EA, pages 2.9 – 2.10.

B.9 Question: Given the location where pallid sturgeon larvae drift, will larvae either be trapped in the pool behind the Intake dam or end up in the diversion?

B.9 Answer: Given what we know from larval drift studies, it would be unlikely that the larvae would be trapped in the pool behind the dam, because the smooth concrete dam design would allow for free flow over the dam. Furthermore, chapter three of the Intake EA documents sedimentation behind the dam. Corps bathymetry data indicate there is not a characteristic wedge of sediment deposited directly upstream of the dam structure, as often occurs with such structures (figure 3.6, page 3-11). Therefore larvae would likely flow over the dam along with sediments and flow. However, it is possible that upstream larvae could flow toward the Intake headworks main canal screens. Entrainment would be monitored post-construction. If significant issues affecting the survival of pallid sturgeon larvae are identified, adaptive management would be used to resolve this survival issue.

B.10 Question: If pallid sturgeon did go up to Cartersville what data is available regarding predation in that location, that would convince anyone the eggs or larvae would survive?

B.10 Answer: Not all fish eggs and larvae survive in natural settings. However, fish species have evolved mechanisms to mitigate for natural mortality rates associated with things like predation. One mechanism relies on the amount of progeny produced annually. Individual female pallid sturgeon in the upper Missouri River basin release as many as 150,000 – 170,000 eggs when spawning (Rob Holm, personal communication). Not all of these eggs need to hatch nor do all hatching fry need to survive to perpetuate the species. In a self sustaining population, the life history goal is to achieve natural recruitment into the adult population at a level comparable to natural adult mortality. Recruitment is the number of fish hatched in a given year that survive to a specified age.

The physical traits of pallid sturgeon, i.e. small eyes, sensory barbels, etc, suggest this species evolved in low-visibility environments. In rivers suspended particles, often referred to as turbidity, and other materials reduce the amount of available light, which in turn reduces visibility, thus affording some level of concealment from sight-feeding predators, like walleye, goldeye, and sauger. Thus, the occupied environment of the species and conditions during and post-spawning can serve as natural mechanisms to offset predation.

Turbidity is quantified with nephelometric turbidity units (NTU); a measure of how much light can pass through a water sample. On the NTU scale, low values equate to clear water. Relative to the range of pallid sturgeon, Jordan et al. (2006) reported turbidity levels < 12 NTU downstream of Fort Randall Dam, South Dakota. The smallest level reported was 5 NTU. In Lake Sharpe, South Dakota, measured turbidity levels were 80-100 NTU (Erickson 1992). Conversely in a more natural system like the Yellowstone River, turbidity levels seasonally exceed 1,000 NTU (Braaten and Fuller 2002; Braaten and Fuller 2003; Matt Jaeger, personal communication, 2008). To put these reported Yellowstone River values in perspective, the U.S. Environmental Protection Agency’s national primary drinking water regulations (http://www.epa.gov/safewater/contaminants/index.html#primary) turbidity may never exceed 1 NTU and must not exceed 0.3 NTU in 95% of daily samples in any month. With high turbidity on the Yellowstone River, predation of pallid sturgeon larvae on the Yellowstone River is not likely a significant issue.

Additionally, there are studies that document predation on other sturgeon species eggs and juveniles (Miller and Beckman 1996; Gadomski and Parsley 2005a). Most of these studies explore predation rates in altered environments downstream of dams or in laboratory settings in tanks with low turbidity levels, e.g. Gadomski and Parsley (2005a) report study with turbidity levels < 1 NTU. Outside of the laboratory, these studies are downstream of structures similar to the mainstem Missouri River dams that trap sediment and result in clear water downstream.

In many of these studies, predation rates are high and often because of altered conditions below dams (Gadomski and Parsley 2005b). However, none of the irrigation diversion structures on the Yellowstone River (i.e. Cartersville or Intake Diversion dams) significantly trap sediment and alter the resultant seasonally high turbidity levels on the Yellowstone River. Given the relatively high fecundity of pallid sturgeon, the high turbidity levels in the Yellowstone River during and post spawning, and the diversity of habitats in this river, it is reasonable to assume that predation can and will occur, though not at a level exceeding those with which this species evolved.

The most convincing data available regarding larval survival comes from recaptures of hatchery-reared pallid sturgeon initially stocked as larvae. As described above, it is expected that larvae originating from reconnecting reaches upstream of Intake Dam would be distributed throughout the lower Yellowstone River and Missouri River below the confluence. Pallid sturgeon larvae stocked from 5 to 17 days old have been recaptured in subsequent months and years in the Yellowstone River and Missouri River below the confluence, indicating that habitats and biotic conditions (i.e. the presence of predatory fishes) in these reaches of river allow for survival of pallid sturgeon larvae and juveniles (M. Jaeger, personal communication).

C. Impacts on Pallid Populations

***C.1 Question*:** What level of certainty would you attach to this proposal and its claimed positive effect on Pallid sturgeon?

C.1 Answer: When dealing with an endangered species like the pallid sturgeon, there will always be some level of uncertainty. In planning the Intake Project, the best available scientific data were considered. This is documented in the draft Intake EA prepared for the Intake Project. The Service's Biological Review Team, as well as researchers from Reclamation's Denver Technical Service Center, the Workgroup, the Pallid Sturgeon Recovery Coordinator, and other Reclamation staff, the Corps, the Service, the USGS, and state biologists have all participated in planning the Intake Project. The best available science suggests that conditions on the Yellowstone River are suitable for pallid sturgeon restoration, including intact migration and spawning clues, suitable spawning habitats, adequate larval drift distances, and suitable rearing habitats.

The Corps and Reclamation, in consultation with the Service and FWP, are continuing to work cooperatively to ensure that the best available science and fish passage technology are used in the final design of the preferred alternative. Therefore, we are reasonably certain that this design will work to pass pallid sturgeon. Of the available options despite a moderate level of uncertainty with regard to the level of benefit to the species and the native fish community, this one is technically feasible, comparatively cost-effective, acceptable and amenable to most users. It is justifiable given the immediate risk of extirpation and the potential benefit to species recovery in the foreseeable future.

As with passage and entrainment projects across the west, including those successful ones mentioned above in response B.1, there will be benefits, but it is difficult to precisely quantify them prior to implementation. We are reasonably certain the proposed Intake Project will pass native fish, including pallid sturgeon, and will reduce entrainment of hundreds of thousands of native fish annually. It could ultimately create an opportunity for the recovery of the pallid sturgeon. This Project would also allow the Lower Yellowstone irrigation districts to continue to operation in compliance with the ESA.

C.2 Question: How much will this project improve the pallid's survivability?

C.2 Answer: The Service's 5-year species review (Service 2007) states that without artificial supplementation in areas like the Yellowstone River, pallid sturgeon could face extirpation. The Service's Pallid Sturgeon Recovery Plan (1993 and most recent agency review draft pallid sturgeon recovery plan) also supports the Intake Project.

Current recruitment of pallid sturgeon in the Upper Missouri River Basin is zero. While adult fish have been found in spawning condition, there has been no documented recruitment in this aging pallid sturgeon population. If just one juvenile is recruited into the population, then the implementation of passage and entrainment protection will benefit pallid sturgeon. Even if 1-5% of the larvae make it to recruitment, it would be significantly greater than current conditions.

Available data indicate that today sturgeon are entrained into the lower Yellowstone Project (Hiebert et al. 2000) and that specifically, pallid sturgeon can be lost to this system (Jaeger et al. 2005b). This project will significantly reduce the likelihood of entrainment and increase survivability of hatchery and wild fish. Substantial loss of sturgeon chub and other minnow species have also been documented at Intake (Hiebert et al. 2000). These minnow species are believed to be a primary food source for pallid sturgeon (Gerrity et al. 2006). Thus, entrainment protection will help conserve adult pallid sturgeon food resources and may increase adult pallid sturgeon capacity in this system.

Benefits of upstream passage will increase available habitats on the Yellowstone River by 165 miles and will allow stocked fish to disperse into suitable habitats. This would also increase the accessibility of fish to major tributaries like the Tongue River with 106 miles of riverine habitats and the Powder River with 217 of additional potential habitat. Overall, the agencies working on this Project generally agree this is the best opportunity available to facilitate pallid sturgeon toward recovery in the upper Missouri River Basin.

C.3 Question: Will the project as proposed provide meaningful benefit to the pallid sturgeon population given the hydrological and biological information available to date?

a. Drift rate and survival
b. Velocities
c. Reservoir survival
d. Sturgeon migration

C.3 Answer: Yes, see all of the information in above answers.

***C.4 Question*:** What happens to the pallid sturgeon populations in the Recovery Priority Management Area 2 if they do nothing on Yellowstone at intake?

***C.4 Answer*:** The pallid sturgeon could likely be extirpated in the Recovery Priority Management Area 2 (Service 2007). Wild pallid sturgeon in the Yellowstone and Missouri rivers, downstream of Fort Peck Dam and upstream of Lake Sakakawea will continue to exist only as a hatchery-augmented population as older adults die out or are removed for hatchery purposes. The conservation stocking program would be required long-term to artificially maintain the species in this reach.

Conservation stocking does not meet current or future delisting or downlisting requirements of the ESA. Rehabilitation of the reach of the Missouri River below Ft. Peck Dam and above the Yellowstone confluence or dramatically drawing down Lake Sakakawea reservoir levels remain as options to provide for some level of natural recruitment and achieving delisting or downlisting requirements. And at this point in time the options at Ft. Peck and Lake Sakakawea reservoirs are expensive and/or may not be publically acceptable.

Other Important Questions That the Group Anticipates Will Be (And if They Are Not, Should Be) Addressed in the EA

Impacts – Ecological

Ecological 1 Question: What will be the downstream impacts of this project? Bank erosion? Channeling? Widening? Increased turbulence?

Ecological 1 Answer: (Intake EA, Chapter Four, Page 4-12 – 4-18)**:** The only identified hydrologic impact would occur under the No Action Alternative (Continue Present Operation). If Reclamation does not initiate and successfully complete Section 7 ESA consultation with the Service, the impact could be a limitation of water to be diverted into the main canal, which would adversely affect the Lower Yellowstone Project Irrigation Districts. Either action alternative would contribute to ecosystem restoration by reconnecting reaches of the river above and below Intake Diversion Dam.

Regarding geomorphology, the No Action Alternative would have no short-term or long-term effects on channel slope, the channel migration zone, or the number or length of bank stabilizing features. Long-term effects of the Relocate Main Channel Alternative would improve the river channel slope at Intake Diversion Dam. This alternative would permanently affect 597 acres in the channel migration zone and add 54,943 feet of bank stabilization structures to the Intake Project area. Short-term effects would be temporary disturbance of 320 acres within the channel migration zone.

Long-term effects of the Rock Ramp Alternative consist of an improvement in the slope of the channel in the area of the existing Intake Diversion Dam and associated features. This alternative would permanently affect 32 additional acres in the channel migration zone and decrease the amount of bank stabilizing structures by 168 feet when compared to No Action.

Ecological 2 Question: Will the project negatively affect any native fish species?

Ecological 2 Answer: (Intake EA, chapter four, pages 4-16 - 4-20): The No Action Alternative (Continue Present Operation) would continue to cause adverse impacts because of fish passage and entrainment issues. With environmental commitments, impacts to aquatic communities, including fish, mussels, macroinvertebrates and aquatic invasive species, would be minor and temporary for both action alternatives. Both action alternatives could benefit fish and mussels that cannot currently find passage over the current dam and benefit fish populations by preventing entrainment.

Mitigation measures:

- A water quality monitoring program will be established for ensuring that water quality standards are not violated during construction activities.
- Discharges of fill material into waters of the U.S. will be carried out in compliance with provisions of Section 404 of the Clean Water Act and the permit requirements of the Corps.
- All work in the waterway will be performed in such a manner to minimize increases in suspended solids and turbidity, which may degrade water quality and damage aquatic life outside the immediate area of operation.
- Vegetation clearing will be limited to that which is absolutely necessary for construction of the project.
- Silt barriers, fabric mats, or other effective erosion control measures will be placed on slopes or other eroding areas where necessary to reduce sediment runoff into river channel and wetlands until vegetation is re-established.
- All areas along the bank disturbed by construction will be seeded with vegetation indigenous to the area to minimize erosion.
- A physical model of the rock ramp will provide additional velocity and turbulence data needed for final design of an effective ramp.
- All constructed features will be monitored in accordance with an adaptive management plan to ensure that these are operating as designed to improve fish passage and reduce entrainment.

Ecological 3 Question: How do the entrainment numbers account for the fish that successfully return to the river through the irrigation channel?

Ecological 3 Answer: (see summary of this information in Intake EA chapter one, page 1-5 and chapter four, page 4-24): About 576,629 fish of 36 species are annually entrained at Intake Diversion, of which as many as 8% are sturgeon (Hiebert et al. 2000). All radio-monitored sauger and pallid sturgeon that have entered the canal system died somewhere in the system

(Jaeger et al. 2005b). Studies conducted by Hiebert et al. (2000) indicated that some fish (mostly stonecats) tagged in the canal survived and were recaptured in the river. Jaeger et al. (2005a) estimated the probability of a T-bar tagged sauger being caught in the Yellowstone River to be 0.308, and the probability of being reported following capture to be 0.385; therefore, the probability of being caught and reported is 0.119. Between 1999 and 2001, FWP T-bar tagged 343 sauger in Intake Ditch. Of these 8 were later captured and returned by anglers fishing in the Yellowstone River.

The probability of a fish entrained in Intake Canal surviving, returning to the Yellowstone River, and being caught and reported by an angler is 0.023. Dividing by the estimated angler tag return rate (0.385) yields a 0.061 probability of surviving, retuning to the river, and being captured. Based on parameter estimates in Jaeger et al. (2005a), the calculated probability of survival of a sauger entrained in Intake Canal is 0.138, which equates to annual mortality of about 58,000 sauger in the canal system per year based on entrainment estimates provided by Hiebert et al. (2000). By comparison, estimated probability of annual survival of a sauger in the Yellowstone River is 0.704 (Jaeger et al. 2005a). Therefore, we can infer that about 86% of the sauger that are entrained in Intake Ditch die each year compared to only 31% of sauger that are not entrained.

Ecological 4 Question: How will modification of the Intake diversion affect the amount of water downstream of the diversion?

Ecological 4 Answer: (see Intake EA, chapter four, pages 4-10 – 4-11): Neither of the action alternatives propose altering the river in ways that would regulate or impound the river. The proposed Intake Project would not affect the amount of water flowing downstream.

Impacts – Economics

Economics 1 Question: How will the project impact the Paddlefish fishing and roe industry (i.e., Yellowstone Caviar) at Intake, MT?

Economics 1 Answer: (Intake EA, chapter four, pages 4-42 through 4-43)**:** During Project construction, snagging for paddlefish could be impacted. Project construction activities may alter paddlefish concentrations at the dam site discouraging paddlefish from lingering below the dam. This may reduce the number of paddlefish snagged at the Intake Fishing Access Site. However, this could increase overall snagging opportunities if more paddlefish migrate up river. Historically, the paddlefish season at Intake is closed when a designated number of paddlefish are snagged. This often occurs before the season's established closing date. Without the high numbers of paddlefish snagged at Intake, the yearly quota might not be filled as quickly, and the season might stay open longer affording angler more days to snag paddlefish until the quota is either met or the season officially ends.

Once either action alternative is completed, paddlefish would be less inclined to congregate or linger at the Intake Fishing Access Site. This should reduce snagging opportunities at the Intake Fishing Access Site but should also increase snagging opportunities further up river. Paddlefish may benefit from additional spawning areas up river, which could improve reproduction and increase populations.

As a byproduct of the recreational paddlefish fishery on the lower Yellowstone River, the Glendive Chamber of Commerce and Agriculture (Chamber of Commerce) administers the Yellowstone Caviar program. Before and after Project construction anglers would be able to donate roe from paddlefish snagged between Glendive and the Montana/North Dakota State line to the Chamber of Commerce; and, the Chamber of Commerce would be able to accept and process the donated paddlefish roe into caviar (i.e., no commercial fishing or "roe industry" exists on the lower Yellowstone River). Project construction should not reduce the number of paddlefish in the Yellowstone River or the quota for the number of paddlefish to be taken.

However, during and after Project construction the Yellowstone Caviar program could be impacted by a number of factors. Most of the donated roe comes from paddlefish that are currently snagged below the Intake Diversion Dam. Impacts from restricted angler access to the river or reduced numbers of paddlefish snagged at the FAS could result in less paddlefish roe donated to the program, unless the Chamber of Commerce maximizes its authorized opportunities to collect paddlefish snagged between Glendive and the North Dakota-Montana state line. Reduced donations would lower income for the Chamber of Commerce.

To mitigate the temporary effects of construction:

- To the extent possible, construction activities will cease during the paddlefish season or until the paddlefish season is closed at Intake FAS.

Other Important Questions the Group Believes Agency Representatives on the MRRIC Should Answer for the Rest of the MRRIC

Agency Representatives 1 Question: How will "fish credits" be distributed for pallid sturgeon recovery?

Agency Representatives 1 Answer: First, there are no "fish credits". There are two aspects to adjusting the 2003 Amended Biological Opinion related to the Intake Project on the Yellowstone River. First, is related to funding for the construction of the fish passage and screen. It appears that Congress may "require" the Corps to spend $18,000,000 of their Missouri River Recovery Program funding specifically on the Intake Project. That will leave less funding for other activities further down the Missouri River. Much of that funding will come from activities directly related to "shallow-water habitat." Therefore, during the period when the Corps is spending money on Intake, we will move the Biological Opinion shallow water-habitat targets for a similar period. For example, if they are spending a significant amount of "recovery" dollars during the next three years, then their targets would be moved out for three years. In no way does it change the amount of habitat construction required by the Biological Opinion. Secondly, our goal for the upper piece of the river basin is to have a viable pallid sturgeon population. We feel the best chance of achieving that goal lies with construction of the Intake Project on the Yellowstone River. This changes what the Corps will be required to do under the Biological

Opinion. Specially, substituting the current Fort Peck requirements for new requirements related to the Intake Project.

Agency Representatives 2 Question: [2a] What is the value of the Yellowstone River to the Pallid Sturgeon Recovery Plan? [2b] How does it compare to other rivers available for pallid sturgeon projects? [2c] Where does the Intake project fit into the Recovery Plan and how is it prioritized?

Agency Representatives 2 Answer: [2a]: The Pallid Sturgeon Recovery Plan (Service 1993) and the current draft revision of this plan both identify the Yellowstone River as historically occupied and also important for recovery. Within the upper Missouri River basin and much of the species' range, the Yellowstone River is a rare exception in that it retains one of the most natural hydrographs, temperature profiles, and sediment transport process. As such, it is one of the most natural riverine systems within which recovery activities are implemented.

When one considers the Yellowstone River in the context of the 1993 Recovery Plan, many of the outlined recovery tasks are easily implementable or not applicable due, in part to the nearly natural state of this system. However, the few obvious perturbations in the Yellowstone River are related to anthropogenic alterations that, like the Missouri River mainstem dams, block access to historically occupied habitats.

For these reasons, the Yellowstone River is still viewed as an important component of the upper Missouri River ecosystem the Great Plains Management Unit (Service draft recovery plan revision). Thus preservation and providing access to existing habitat is a priority.

[2b]: Under contemporary conditions and relative to other rivers that pallid sturgeon occupy, the Yellowstone River provides some of the best natural habitat, due in part to the natural hydrographs, temperature profiles, and sediment transport process which form the habitats the species evolved with. Available data indicate the river, downstream of Intake Dam is readily used by adults and experimental hatchery releases indicate that juvenile fish will also utilize this system (Bramblett and White 2001; Jaeger et al. 2004 and 2005b).

[2c]: In the current recovery plan (Service 1993) and the draft revision to the pallid sturgeon recovery plan, the first identified tasks are to "Protect and restore pallid sturgeon populations, individuals, and their habitats" and "Conserve and restore pallid sturgeon Habitats, individuals and populations" respectively. While each plan uses slightly different language, they both can be interpreted as identifying the need to address fish passage and entrainment issues as specific recovery tasks. The current plan (Service 1993:19) states "Ensure water intakes and diversions are not adversely affecting pallid sturgeon populations." The revised version identifies the following global recovery task "Restore habitat connectivity where barriers to fish movement occur" and specifically states "Restore fish passage at Intake Diversion Dam, Yellowstone River."

Additionally, similar to the above tasks identified to protect and conserve individuals, the revised plan specifically identifies a need to "Assess potential for entrainment losses at industrial, municipal, and agricultural water intakes, pumping facilities, and other diversion structures." and then to "Implement strategies to prevent/minimize entrainment." While little entrainment data were available when the original plan was written, data within the revised plan do document that Intake Diversion Dam can entrain both shovelnose sturgeon (Heibert et al. 2000) and pallid sturgeon (Jaeger et al. 2004).

Agency Representatives 3 Question: [3a] What does the project financing look like? [3b] Who is responsible for O&M of intake structures and the rock ramp?

Agency Representatives 3 Answer: [3a]: The Corps is providing funding in accordance with Section 3109 of the 2007 Water Resources Development Act. Under that Congressional authorization, the Corps is using funding from the Missouri River Recovery and Mitigation Program to assist Reclamation with compliance with federal laws, design, and construction of modifications to the Lower Yellowstone Project for the purpose of ecosystem restoration. To date the majority of funding needed for planning and environmental compliance activities (such as NEPA, Endangered Species Act, Clean Water Act and National Historic Preservation Act), design and design data collection, and other design and review activities has been provided by the Corps. Funding for future construction, if a decision is made to proceed with the preferred alternative, would be provided by the Corps subject to Congressional appropriation.

[3b]: As is the case for most authorized Reclamation projects, the long-term operation and maintenance of project facilities, such as the intake structures and rock ramp, would be the responsibility of the Lower Yellowstone Project water users. Reclamation would retain ownership of the Lower Yellowstone Project facilities such as the fish screen and rock ramp, but the facilities are operated and maintained by the Board of Control of the Lower Yellowstone Project under contract with Reclamation. The terms of that contract would likely need to be revisited to accommodate the operation/maintenance needs and requirements for the modified intake and diversion structures (i.e. fish screen and rock ramp).

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Appendix M - Intake Diversion Dam Modification, Lower Yellowstone Project Science Review Report

Introduction

A few members of the Missouri River Recovery Implementation Committee (MRRIC) requested an independent review of the science for the Intake project. Further strengthening the quality of the Intake project, the Department of Interior contracted with PBS&J to convene an independent panel to review the science used as the basis for the Intake project as well as the likelihood that the preferred alternative for passage would work for pallid sturgeon. This appendix contains their final report, although an addendum is in progress and will be included in the Final Intake EA. In summary, the panel concluded that the best science available was used in the development of the draft EA, BA, appendix L (MRRIC Questions and Answers), and supporting documentation. This review concluded that the information effectively supports hypotheses that:

1. The project will provide passage and enhance upstream migration for adult pallid sturgeon.

2. Suitable spawning habitat exists upstream of the project.

3. Conditions at the potential upstream spawning sites are suitable for the development and survival of pallid sturgeon eggs.

4. There is sufficient downstream drift distance for larval development for at least a portion of the larvae in some years for some level of natural recruitment might occur.

5. Proposed fish screens will effectively decrease entrainment of adult, juvenile, larval, and embryonic pallid sturgeon and other fish species.

6. Conditions in the Yellowstone and connected sections of the Missouri River are suitable conditions to support completion of the pallid sturgeon life cycle.

The panel concluded that additional analysis or research might marginally reduce uncertainties regarding the probability of success but is not likely to lead to fundamentally different conclusions. The true test and quantification of project benefits can only be made by project implementation and subsequent monitoring of the response. This action clearly represents a reasonably realistic alternative for restoration of natural recruitment for this distinct and evolutionarily significant population of pallid sturgeon.”

Intake Diversion Dam Modification, Lower Yellowstone Project

Science Review Report

Final

November 30, 2009

Prepared for:
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Summary

At the request of the Bureau of Reclamation (Reclamation) a Science Review Panel (Panel) was convened to provide a critical evaluation of the science surrounding the Lower Yellowstone Diversion Dam Project. The objective of the project is to provide both fish passage and a fish screen at the Lower Yellowstone Diversion in the Yellowstone River near Intake, Montana.

This review specifically considered whether the information provided in the Draft Environmental Assessment (DEA), Biological Assessment (BA), and responses to Missouri River Restoration Implementation Committee (MRRIC) Questions use the best available science and support a conclusion that the Intake Project is a viable alternative with benefits for recovery of pallid sturgeon in the Great Plains Management Unit. Questions of whether the project is the best choice from the range of possible management actions within the Management Unit are outside the scope of the review.

The science review process was facilitated by scientists from PBS&J and conducted by a panel of five scientists with specific, in-depth knowledge of pallid sturgeon life history, Upper Missouri sturgeon issues, lower Missouri and Mississippi river sturgeon issues, and life history of other sturgeon species. The review was organized by pallid sturgeon life stages (egg/embryo, larvae, juvenile, and adult). Given the importance of achieving adequate larval drift distance to the success of this project, the Panel also conducted a quantitative analysis of the range of expected drift distances associated with historical discharge on the Yellowstone River.

It is the consensus view of the Panel that the best science available was used in the development of the DEA, BA, MRRIC Question and Answers, and supporting documentation. This review concluded that the information effectively supports hypotheses that:

1. The project will provide passage and enhance upstream migration for adult pallid sturgeon.
2. Suitable spawning habitat exists upstream of the project.
3. Conditions at the potential upstream spawning sites are suitable for the development and survival of pallid sturgeon eggs.
4. There is sufficient downstream drift distance for larval development for at least a portion of the larvae in some years for some level of natural recruitment might occur.
5. Proposed fish screens will effectively decrease entrainment of adult, juvenile, larval, and embryonic pallid sturgeon and other fish species.
6. Conditions in the Yellowstone and connected sections of the Missouri River are suitable conditions to support completion of the pallid sturgeon life cycle.

The panel concluded that additional analysis or research might marginally reduce uncertainties regarding the probability of success but is not likely to lead to fundamentally different conclusions. The true test and quantification of project benefits can only be made by project implementation and subsequent monitoring of the response. This action clearly represents a reasonably realistic alternative for restoration of natural recruitment for this distinct and evolutionarily significant population of pallid sturgeon. The project will also be an essential step in identifying the need to consider additional actions throughout RPMA 2 that might be required.

Introduction

At the request of the Bureau of Reclamation (Reclamation) a Science Review Panel (Panel) has been convened. The task before the Panel was to provide a critical evaluation of the science surrounding the Lower Yellowstone Diversion Dam Project (hereinafter referred to as the Intake Project). This report presents the results of this evaluation. The review reflects input from all Panel members. In general, consensus was reached on all items.

The objectives of the Intake Project are to provide: 1) fish passage in the mainstem Yellowstone River , and 2) a fish screen to prevent entrainment into a currently unscreened irrigation diversion canal at the Lower Yellowstone Diversion in the Yellowstone River near Intake, Montana. The primary purpose of the project is to benefit pallid sturgeon a federally endangered species that historically reproduced in this area. Both the ability for adults to move upstream of the dam to spawn and the survival of drifting larvae and juveniles are believed to be hindered at Intake. Several alternatives for meeting the project objective have been evaluated and presented by Reclamation in its Draft Environmental Assessment (DEA).

Panel Description and Review Process

Panel Selection

In order to ensure that the selection of panelists for this effort was not biased in any way, Reclamation contracted with a third-party consultant, PBS&J. It was PBS&J's responsibility to manage the process in which panelists were screened and selected, to facilitate the panel deliberations, and to assist with the compilation of their conclusions into this report. Through internet searches, and word-of-mouth networking, PBS&J identified a pool of 22 potential panelists. Prior to commencing the screening process, PBS&J had no working relationship, nor direct knowledge of the panelists' expertise or professional alliances.

Attempts were made to contact 9 of the 22 potential candidates. The nine were chosen by PBS&J with the general goal to provide a balanced panel with a mix of areas of expertise. The goal was to have a well-rounded panel with specific, in-depth knowledge of the following:

- Pallid sturgeon life history
- Upper Missouri sturgeon issues
- Lower basin (Missouri and Mississippi) sturgeon issues
- Life history of sturgeon species other than pallid sturgeon

Two additional criteria that were essential for any panelist to meet were:

- Ability to meet the tight timeframe for this review process
- Ability to provide a review that would be widely regarded as both credible and independent.

The effort to reach out to nine of the candidates yielded the following results:

- One (Sue Ireland with Kootenai Tribe of Idaho) was on vacation at the time of initial contact and was dropped from further consideration because of time constraints

- Two (Ken Lepla with Idaho Power and Boyd Kynard with University of Massachusetts) were not able to meet the schedule for this review and were dropped from further consideration
- One (Dennis Scarnecchia with University of Idaho) was determined to have a conflict of interest and was dropped from further consideration
- Five (Anders, Beamesderfer, Garvey, Parham, and Peters) were selected to be on the Panel

Brief biographies for each of these individuals are as follows (full resumes have been provided previously to Reclamation and are included in Appendix 1):

- Dr. Paul Anders is a Fishery Scientist with Cramer Fish Sciences Inc., and serves as Affiliate Faculty in the Department of Fish and Wildlife Resources at the University of Idaho in Moscow. Paul has 23 years experience in the fisheries profession, with 20 years in the Columbia River Basin, U.S. and Canada. Pertinent to the issues surrounding the Lower Yellowstone Project, Dr. Anders brings expertise to this project from over two decades of experience involving altered large river ecology and effects on biology, ecology, management, and recovery of sturgeon populations.
- Ray Beamesderfer, M.S., is a Fishery Scientist with Cramer Fish Sciences Inc. and previously worked for the Oregon Department of Fish and Wildlife. He has over 20 years of experience with status and biological assessment, research, management, conservation, and recovery planning for sturgeon throughout the western U.S. and Canada, and has published extensively in this arena.
- Dr. Jim Garvey is an Associate Professor in the Department of Zoology and Director of the Fisheries and Illinois Aquaculture Center at Southern Illinois University. He conducts research on the population dynamics of shovelnose and pallid sturgeon in the Mississippi River and has published extensively in this arena.
- Dr. James Parham is the President of Parham & Associates Environmental Consulting LLC in Tennessee, and serves as a research hydrologist and aquatic biologist for Bishop Museum, Hawaii. He has worked on a range of sturgeon life history issues with a primary research focus on the seasonal movement and habitat use of pallid and shovelnose sturgeon with respect to hydrogeomorphic conditions.
- Dr. Edward Peters is Professor-Emeritus of Natural Resources at the University of Nebraska-Lincoln where he conducted research in natural resources and fisheries. For over 20 years his research emphasis focused on the development of habitat suitability models for Platte River fishes, which included pallid and shovelnose sturgeon.

The opinions presented in this report reflect those of the Panelists and not the views of their respective employers, affiliations, or organizations.

Review Process

PBS&J was provided the Notice to Proceed from Reclamation on this review process on September 30, 2009. At that time, project staff began assembling a pool of potential candidates. The final Panel was selected and notified on October 9, 2009. The Panel members then reviewed relevant documents and convened for an in-person meeting in Missoula, Montana on October 19 and 20, 2009.

At this meeting, the Panel was provided a revised set of responses (dated October 6, 2009) to Missouri River Restoration Implementation Committee's (MRRIC) questions (Appendix 2). This revised set of responses was utilized by the Panel in their review. A revised Draft Environmental Assessment (DEA) (dated October 1, 2009) was provided to PBS&J on October 15, 2009, however, PBS&J was informed by Reclamation that the earlier version of the DEA had not be substantially modified. Therefore, the earlier version (dated September 11, 2009) was utilized by the Panel in their review (Appendix 2).

During the Missoula meeting, each panelist took responsibility for specific sections of this report and provided a draft of their text to the other Panel members. PBS&J staff facilitated the meeting but provided no substantive technical input. By the completion of the meeting, an initial draft of all sections of the Draft Scientific Review Report had been reviewed by each Panel member. Following the meeting the panelists continued drafting and refining various sections. The separate elements were sent to PBS&J where they were assembled into a draft report that was posted for final review by each panelist.

This report was edited by PBS&J staff and distributed for review to Panel members on October 22, 2009. Comments and edits were accepted by PBS&J and a final report completed and submitted to Reclamation on October 30, 2009. Comments were returned to PBS&J by Reclamation on November 13. These were provided to the Panel and a conference call held to discuss the comments and potential revisions to the report. The Panel split the responses to comments and report revisions amongst the Panel. Edited versions were returned to PBS&J for compilation and formatting before being submitted to Reclamation as this final report on November 30, 2009.

The review is grouped into two major levels of comments. Tier 1 comments are those made in response to the MRRIC questions and other major issues related to the DEA. Tier 2 comments are more minor comments related to the structure of the DEA or material presentation. Tier 2 comments do not relate specifically to the science supporting the responses to the MRRIC questions, DEA, or draft Biological Assessment (BA). However, the Panel felt that Tier 2 comments were useful in the broader context of pallid sturgeon recovery.

Directive and Limits of Review

The formal Scope of Work (dated September 16, 2009) from Reclamation states the following in its entirety:

> *"The Scope of Work for this Task Order includes convening a panel of pallid sturgeon and/or other riverine sturgeon species experts to review Reclamation's and the Corps' [Corps of Engineers] responses to questions submitted by the Missouri River Recovery Implementation Committee (MRRIC), to determine whether such responses are supported by the best available scientific information, and provide any uncertainties in that science."*

There were eight tasks in the Scope of Work. The first two related to project management and panel recruitment and do not directly apply to this review. The following tasks provided specific direction to the Panel on the scope of their review:

Task #3. Review relevant section of the DEA and draft BA [for Intake Project].
Task #4. Review the set of questions submitted by the MRRIC.
Task #5. Review Reclamation's and U.S. Army Corps of Engineers' (Corps) responses to those questions.
Task #6. Review relevant scientific literature and other information associated with, but not limited to, pallid sturgeon life history and reproductive strategies; pallid sturgeon swimming ability; availability and suitability of pallid sturgeon migration and spawning habitat in the Yellowstone River below Cartersville; and other structures that provide passage for sturgeon species.
Task #7. Determine whether any relevant scientific information was not considered and provide an assessment of any, or to what degree there may be, uncertainties in the science.
Task #8. Provide a draft report by October 30, 2009. This report should include the panel's conclusions whether Reclamation's and the Corps responses to MRRIC's questions are supported by the best available science; individual and collective comments of respective panel members; and appropriate citations.

This review specifically considered whether the information presented provides sufficient documentation to determine if the Intake Project is a viable project to enhance pallid sturgeon populations independent of other management actions in the region. If the DEA, BA, and Responses to MRRIC Questions use the best available science then the overall conclusion would be that the Intake Project would positively contribute to the recovery of pallid sturgeon in the Great Plains Management Unit (which contains RPMA 2).

It is outside the scope of this review to assess whether this project is the best choice from the range of possible management actions within the Great Plains Management Unit. The Panel did not delve into the regional (range-wide) issues related to pallid sturgeon recovery. For example, no attempt was made to weigh the relative merits of work in the Missouri River or modifications to Fort Peck Dam operations, versus the proposed work in the Yellowstone River.

Life History Model

The Intake Project is intended to aid in the recovery of the endangered pallid sturgeon in the Great Plains Management Unit. To assure that the project has adequately incorporated the best available science, a simplified model of the important life history parameters of pallid sturgeon is presented (Figure 1) in relation to the proposed project (see Wildhaber et al. 2007, for more comprehensive pallid sturgeon life history model). To consider the Intake Project a success, the system must enable pallid sturgeon to move upstream, find suitable spawning habitat, allow larvae to drift downstream, avoid entrainment in the diversion structure, and develop into juveniles and adults. The successful completion of each phase is critical for the ultimate completion of the whole life cycle and the creation of a self-sustaining population in the river. Understanding how the proposed project affects pallid sturgeon at all life stages is fundamental to understanding if the project will result in a positive change in pallid sturgeon populations.

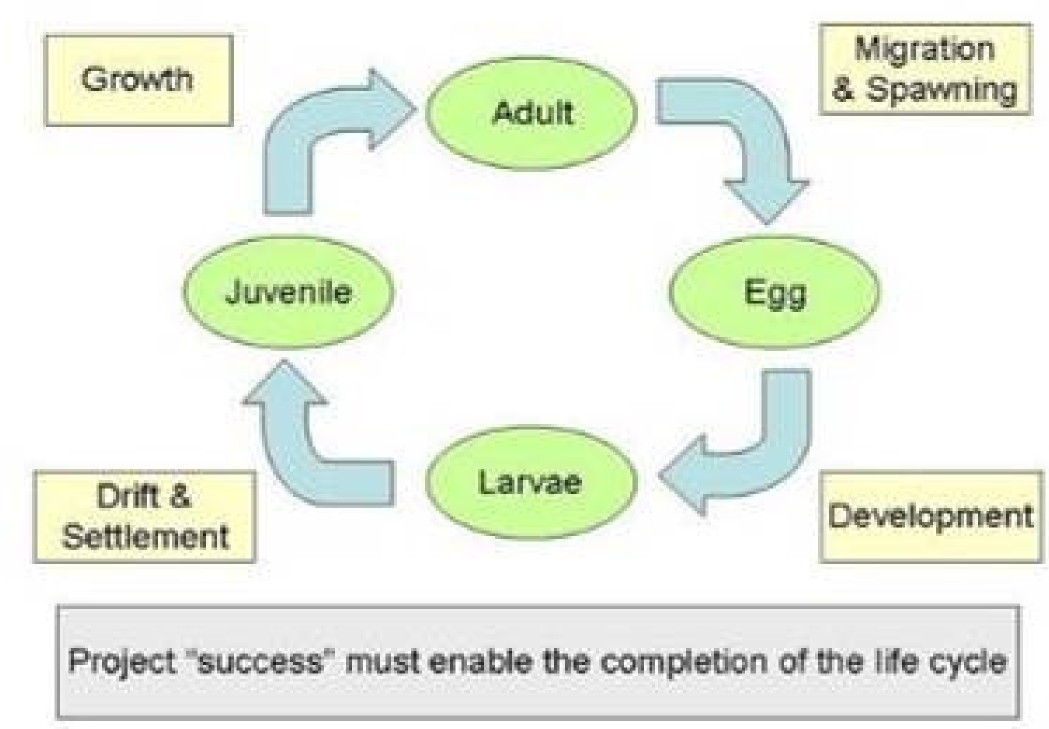

Figure 1. Simplified life history for pallid sturgeon

Pallid Sturgeon Adults (*passage and migration issues*):

Will the Lower Yellowstone Intake Diversion Dam Modification Project provide passage and enhance upstream migration for adult pallid sturgeon? Can and will adult pallid sturgeon pass the diversion structure during the purported spawning season (e.g., May through July) with the proposed modifications?

Pallid Sturgeon Adults (*spawning issues*):

Does suitable spawning habitat exist upstream of the Yellowstone Intake Diversion Dam, and if so, where and how far upstream is it located?

Pallid Sturgeon Eggs (*development and survival issues*): [1]

Are conditions at the potential upstream spawning sites suitable for the development and survival of pallid sturgeon eggs?

Pallid Sturgeon Embryos and Larvae (*downstream drift issues*):

[1] Although there is no specific discussion of pallid sturgeon eggs within the MRRIC questions or responses, DEA, or BA, the Panel felt that some discussion of this topic was appropriate in the life-cycle context of this review.

If pallid sturgeon can access and successfully spawn at upstream locations, is there sufficient downstream drift distance for larval development prior to entering Lake Sakakawea? Are embryo and larval drift distances adequate with respect to the expected range of discharge and water temperature conditions prior to reaching Lake Sakakawea? Does the proposed fish screen decrease entrainment of adult, juvenile, larval, and embryonic pallid sturgeon?

Pallid Sturgeon Juvenile and Adult Life History (*habitat and growth issues*):

If the Intake Project functions as proposed, do conditions in the Yellowstone and connected sections of the Missouri River have suitable conditions to support completion of the pallid sturgeon life cycle? Are conditions suitable for the growth, survival, and maturation of juvenile and adult pallid sturgeon? Will the Intake Project have either neutral or positive effects on the juvenile through pre-reproductive adult stages?

Technical Review Topics

Many of the questions posed by MRRIC apply to multiple life-cycle stages of pallid sturgeon. To facilitate the review of the responses to these questions, the Panel created a table of the specific questions and the applicable life-cycle stage (Table 1). This allowed the Panel to divide the workload of addressing a particular topic while also ensuring that all life stages were evaluated. The following discussion presents the Tier 1 review topics that correspond to the major columns in Table 1.

Because some MRRIC questions contained multiple topics or applied to multiple life-cycle stages they were split into sub-questions (e.g., A1a and A1b). Each MRRIC question that applies to that topic is presented, followed by a summary of the material presented in the response to the MRRIC question, the DEA, and BA. This information is then evaluated to determine if the best available science was used in the analysis of project effects. A discussion of uncertainties and a conclusion complete the evaluation for each major topic.

Table 1. Questions posed by MRRIC and the life-cycle stages of pallid sturgeon to which those questions apply.

	Adult		Free Embryo/Larvae/Juvenile	
MRRIC Question	Migration And Passage	Spawning	Drift and Entrainment	Rearing
A1	X	X	X	
A2			X	
A3			X	
A4			X	
A5			X	
A6			X	
B1	X		X	
B2	X			
B3	X			
B4	X			
B5	X		X	X
B6	X	X	X	X

Table 1. Questions posed by MRRIC and the life-cycle stages of pallid sturgeon to which those questions apply.

MRRIC Question	Adult		Free Embryo/Larvae/Juvenile	
	Migration And Passage	Spawning	Drift and Entrainment	Rearing
B7	X		X	X
B8	X		X	X
B9			X	
B10		X	X	
C1	X	X	X	X
C2	X	X	X	X
C3	X	X	X	X
C4	X	X	X	X

Tier 1 Topics

PASSAGE AND ADULT MIGRATION

The Panel identified five MRRIC questions that are applicable to this topic area. These questions are:

B.1a Question: Will the project allow passage of pallid sturgeon for spawning?

B.2 Question: Will the rock ramp design allow passage of pallid sturgeon?

B.3 Question: What data are available to support the thesis the majority of the fish even would go up to Cartersville if there was a fish passage?

B.4 Question: Does the project design incorporate the best available technology for migration and protection of the pallid sturgeon population?

A.1b. What is the likelihood of pallid sturgeon using the newly opened area for spawning?

What Agencies Said (In Their Responses to MRRIC Questions and in the DEA)

This section provides a summary of what the agencies stated in their responses to MRRIC questions and in the DEA and BA. The authors of the responses to MRRIC's questions and DEA and BA note that no passage of adult pallid sturgeon over the Intake Dam has been documented. Other fish passage projects of similar scope have been used successfully for improving pallid sturgeon migration in other systems; this helps justify the proposed project. If passage is improved at the Intake structure, then adult pallid sturgeon will have access to an additional 165 miles of river in which to forage and spawn. The efficacy of the rock ramp design has been initially tested (White and Mefford 2002) and will allow fish to pass. The slope of the proposed rock ramp (0.5%) may be steeper than that experienced by pallid sturgeon in natural reaches of the Yellowstone River. However, several studies are cited that suggest that this is the best available technology for passage. The BA and DEA support the view that this is the best viable alternative, weighed against the option of altering and moving the river channel as a bypass. The authors cannot say that the majority of pallid sturgeon in RPMA 2 will move upstream of the passage structure, once in place. However, the river upstream of the Intake Dam has at least 4,000 acres of potentially suitable spawning habitat, according to a personal communication by M. Jaeger. Historical information shows that pallid sturgeon adults were present in the reaches above the Intake Dam; thus it is likely that they will revisit this system again, once these areas are open. Fuller et al. (2008), working with telemetered reproductively viable pallid sturgeon, documented that these individuals were apparently staging below the dam as if they were attempting to pass. The authors assume that if these fish were able to pass, they would have done so.

Is This the Best Available Science and If Not What Needs to Be Added

Based on a review of the available information, the Panel concluded that Reclamation's and the Corps' responses to questions submitted by the MRRIC are supported by the best available scientific information.

To the best of our knowledge, information pertaining to adult pallid sturgeon occurrence and movement in the Yellowstone River is fully documented in the responses to the MRRIC questions plus the associated BA and DEA. Conclusions are consistent with a large set of data on pallid sturgeon movement and spawning in other river reaches. This information provides further insight about passage issues associated with the Intake Dam area. These data support the idea that the proposed project will improve fish passage.

Adult pallid sturgeon passage is a pervasive issue throughout the impounded upper Missouri River (i.e., above Gavins Point Dam). Because these systems are typically fixed impoundments with no spill over (e.g., flow and passage are maintained by gates and locks), few opportunities for fish passage exist. An analog to the passage issue being considered at the Intake Dam in the Yellowstone River is the 17-mile Chain of Rocks area of the Middle Mississippi River, near the confluence of the Missouri River. This shallow, shoal area is largely un-navigable and has been bypassed by the construction of a canal plus lock and dam (Lock and Dam 27, Mississippi River). The river upstream of the canal is pooled by a 15 foot low head dam at RM 185.5 of the Middle Mississippi River (Ohio River confluence RM 0 and Lock and Dam 26, Alton, Illinois is RM 200). Catch rates of pallid and shovelnose sturgeon below this location are high relative to other portions of the Middle Mississippi River (Killgore et al. 2007). Also, the proportion of pallid sturgeon captured relative to all sturgeon is greater than other reaches of the Middle Mississippi River (Killgore et al. 2007). The low head may provide habitat conditions that attract pallid sturgeon (e.g., variable flow, scoured substrate) but may also be an impediment to movement. However, research with 87 acoustically tagged adult pallid sturgeon in the Middle Mississippi River and stationary, data-logging receivers demonstrated that pallid sturgeon occasionally did pass over the low head dam and move into the Missouri River (Garvey et al. 2009; http://fishdata.siu.edu/pallid). This movement typically occurred during elevated flow in spring and may have been related to reproduction. Whether passage can occur over this structure during low flow is unknown. Passage through the navigation canal and corresponding lock and dam structure adjacent to the lowhead is unlikely and has not been documented.

Telemetry research with adult pallid sturgeon has shown that those fish that are likely staging to spawn in the Middle Mississippi River are typically found < 500 meters (m) from known gravel or hard-rock (as opposed to sand or silt) beds (Garvey et al. 2009, http://fishdata.siu.edu/pallid). This research supports the idea in the DEA that hard substrates are necessary for spawning.

Research conducted on the habitat use of non-reproductive pallid sturgeon in the Mississippi River suggests that individuals are typically found at the "ecotone" between rapid and slow flow [average 0.9 meters per second (m/s)]. In this reach, these preferred areas are typically associated with wing dikes and adjacent deep scour holes (Garvey et al. 2009). The area below the Intake Dam seems to mimic these areas (see DEA). Similar areas upstream from Intake Dam may provide spawning and non-spawning (e.g., foraging, holding position) opportunities for passing pallid sturgeon.

Considerable information about the behavior and habitat use of spawning pallid sturgeon has been amassed in the lower Missouri River (e.g., DeLonay et al. 2009). These telemetry data not only provide information about the location of spawning but also the depth distribution of the fish. It appears that spawning may occur at a constant depth (given that a variety of depths are used just prior to and following spawning) of about 2 m in revetted outside bends (i.e., areas of clean, scoured substrate plus high flow velocity). Depth contours around the area of the Intake Dam as well as above the dam need to be considered to determine whether they provide depth and flow conditions conducive for spawning.

Pallid sturgeon peak spawning typically occurs at temperatures of 17 degrees centigrade (°C) and depends on complex conditions such as the presence of high spring or early summer discharge; see Delonay et al. 2009; Garvey et al. 2009). Thus, the upstream movements of pallid sturgeon and passage across the proposed structure should be most common prior to and during this time.

Uncertainties

The key uncertainty regarding passage of adult pallid sturgeon upstream from Intake Dam is not if they can pass following dam modification but whether significant numbers will in fact take advantage of the opportunity to seek potential spawning sites upstream.

Density dependent processes affecting adult dispersal throughout the Yellowstone River (and RPMA 2 in general) should be considered. Restoration of passage may not provide significant benefits in the near term when low numbers of adult spawners are available. However, future benefits could become significant as the population density of reproductively viable adults grows in response to the considerable stocking program (Numbers of hatchery-reared pallid sturgeon stocked in RPMA 2 are reported in Appendix D, page 20 of the DEA). This should increase the chance of some pallid sturgeon moving upstream into novel areas. A 1969 population abundance estimate for adult pallid sturgeon in RPMA 2 was 968 fish (Braaten et al. 2009). Recent densities of juvenile pallid sturgeon in the RPMA 2 appear to be growing (5 Year Pallid Sturgeon Recovery Review, Jordan 2007) and may be greater than this level. Thus, it is likely that the opportunities for passage by pallid sturgeon across the intake structure will increase in coming years.

Obviously, more comprehensive pallid sturgeon movement data, relative to hydrology conditions at the Intake Dam would be helpful. Often, upstream movements by pallid sturgeon are short in duration; individuals then drift back downstream (Garvey et al. 2009; Delonay et al. 2009). Upstream forays may be missed by manual crews tracking fish.

The area around the Intake Dam is within a reach that has some apparent attractive quality to it. As described by Jaeger et al. (2008), it is expected that the area having an attractive quality is a larger 139 kilometer (km) geomorphic reach (Reach 2), which extends from Fallon to Sidney, Montana. This reach is bisected by the Intake Diversion. Telemetered pallid sturgeon released within this reach below Intake Dam did not disperse long distances downstream but rather remained in this vicinity. Similarly, movement rates of fish released upstream of Intake Dam (e.g., Cartersville) decreased once they dispersed downstream into this reach, the upper extent of which is about 80 km upstream of Intake Diversion. Some of the fish released upstream passed over Intake Dam. Thus, it is expected that it is not Intake Diversion that has an attractive quality but rather the larger reach that it falls within (M. Jaeger, FWP, personal communication).

The attractive quality of the lowhead dam to all mobile life stages of pallid sturgeon at Intake may be enhanced by the proposed rock ramp. The ramp may produce both foraging and spawning opportunities that are desirable to pallid sturgeon (similar to conditions below the lowhead dam in the Middle Mississippi River). If these conditions encourage spawning at this location rather than cause fish to move upstream then desired outcomes for drifting larvae (i.e., enhancing drift distance) may not be achieved because pallid sturgeon would spawn at this location, as they may already do. Design elements of the rock ramp may help to minimize the attractiveness of the rock ramp to pallid sturgeon.

The current hydrology of the Intake Dam area and its implications for passage were not summarized in any of the comments responses nor in the DEA or BA that were available to the Panel at the time of their review. If water levels are sufficiently high above the current dam during high flow (> 1 m; this depth is uncertain), might this allow some pallid sturgeon movement? Could high flow conditions during occasional years be sufficient to facilitate fish passage without building a passage structure? Specific information about monitoring the "success" of passage is not provided. Preferably, a baseline for future comparisons would be helpful for adaptive management.

Conclusion/Summary

The best available information for the Yellowstone River was included. Information from other systems with parallel issues of passage supports the conclusion that some passage across the current Intake Dam may occur, albeit infrequently and only during the highest flow periods. The current level of monitoring is such that sampling power is low for detecting low levels of current passage. Future monitoring to quantify movements at the Intake Dam area could include telemetered fish and automated receivers (or crews continuously tracking fish).

Some concerns about the potential influence of the rock ramp design on pallid sturgeon spawning behavior (i.e., by discouraging upstream movement to other areas) have arisen. A similar issue could occur with the hard substrates associated with the bypass channel alternative. However, as adult population densities rise in the Yellowstone River following the successful stocking program, it is likely that some upstream movement will occur and may increase through time as spawning sites downstream become "saturated" with spawners and individuals look for novel spawning opportunities upstream.

Rock ramps similar to the one proposed for this project have been used successfully to enhance fish passage in many systems, suggesting a similar impact in the lower Yellowstone River.

SUITABILITY OF SPAWNING HABITAT

The Panel identified seven of the questions posed by the MRRIC as being relevant to the spawning adult life stage of pallid sturgeon. These include:

A.1a Question: Where above Intake on the Yellowstone River does spawning substrate exist?

B.6 Question: Is the bypass design the best for pallid sturgeon?

B.10 Question: If pallid sturgeon did go up to Cartersville what data is available regarding predation in that location, that would convince anyone the eggs or larvae would survive?

C.1 Question: What level of certainty would you attach to this proposal and its claimed positive effect on Pallid sturgeon?

C.2 Question: How much will this project improve the pallid's survivability?

C.3 Question: Will the project as proposed provide meaningful benefit to the pallid sturgeon population given the hydrological and biological information available to date?

a. Drift rate and survival
b. Velocities
c. Reservoir survival
d. Sturgeon migration

C.4 Question: What happens to the pallid sturgeon populations in the Recovery Priority Management Area 2 if they do nothing on Yellowstone at Intake?

What Agencies Said (In Their Responses to MRRIC Questions and in the DEA)

This section provides a summary of what the agencies have stated in their responses to MRRIC questions and in the DEA and BA. From the perspective of habitats for spawning adult pallid sturgeon the Panel summarized the responses to these questions posed by the MRRIC as follows. Without a long-term stocking program pallid sturgeon would be extirpated from this section of the Missouri River and the Yellowstone River. This does not meet the current or future down-listing requirements of the Endangered Species Act (ESA). Other management alternatives, including water release modifications at Ft. Peck Dam and manipulation of water levels in Lake Sakakawea are more expensive and may not be acceptable to the public at this time. Under current conditions on the Yellowstone River, adult pallid sturgeon can only access the area downstream from the diversion dam at Intake. While occurrences of spawning in this reach have been documented using telemetry, no naturally produced offspring have been recruited to the population for decades. This has led to an aging population of large individuals that are reaching senescence and will likely die out in the foreseeable future. Without access to appropriate spawning areas far enough upstream to allow larvae to develop adequately as they drift (before entering Lake Sakakawea), this population will require perpetual stocking to maintain a population.

Modifications in the diversion dam at Intake on the Yellowstone River has been considered an important component in the recovery of pallid sturgeon in this portion of its range, because it would allow adult fish to access extensive areas of spawning habitat potentially as far upstream as Forsythe, Montana. This would allow for longer drift distances, which would reduce the likelihood of the larvae drifting into Lake Sakakawea, where they may be subjected to high rates of predation by planktivorous fishes and other mortality factors. Among the potential modifications to the diversion dam at Intake that were considered, a suite of scoring criteria determined that a ramp structure was the best option. Protection from entrainment at Intake will significantly reduce the losses of pallid sturgeon and minnow species upon which larger juvenile and adult pallid sturgeon feed. Other management alternatives, including water release modifications at Ft. Peck Dam and manipulation of water levels in Lake Sakakawea are more expensive and may not be acceptable to the public at this time.

Pool habitats in general and bluff pool habitats in particular have been identified as important spawning habitats for several species of riverine fishes in the Yellowstone River. Several studies (Bramblett and White 2001; Fuller et al. 2008) have documented potential spawning sites for pallid sturgeon in the Yellowstone River downstream from Intake. The habitat survey by Jaeger et al. (2005) found pool habitats where sauger spawn between 100 and 300 km upstream from the confluence with the Missouri River. This spans the reach which encompasses the Intake diversion dam. DeLonay et al (2009) have found that pallid and shovelnose sturgeon used patches of deep water with relatively fast turbulent flow on the outside bank of revetted bends in the middle Missouri River. These conditions seem similar to the 4,000 acres of terrace pool and bluff pool habitats that M. Jaeger (FWP, personal communication) has estimated are present in the Yellowstone River between diversion dam at Intake and Cartersville, Montana.

Is This the Best Available Science and If Not What Needs to Be Added

As the DEA, BA, and responses to the questions from the MRRIC point out, there have been numerous conferences, long discussions, and excellent research which have documented the habitat alterations that are impacting the pallid sturgeon population in RPMA 2. It is only the longevity of pallid sturgeon, and effects of stocking that have allowed it to persist as long as it has without successful natural spawning and recruitment to the adult population**.** Under current habitat conditions within the Yellowstone River and the Missouri River reach between Ft. Peck Dam and Lake Sakakawea there seems little chance that pallid sturgeon populations can achieve recovery by natural reproduction. Therefore, the most significant measure of success for this project would be documentation of spawning upstream from the diversion at Intake and identification of naturally reproduced offspring from these events.

DeLonay et al. (2009) hypothesized that: "maturation and readiness to spawn in female sturgeon is cued many months before spawning." Specifically, day length and temperature respectively appear to define the "temporal spawning window" and the proximal cue for spawning. Several telemetry studies along with tag returns from intensive sampling throughout the range of pallid sturgeon have documented long distance movements. Whether the total length of riverine habitat associated with the Yellowstone River along with its tributaries and confluent reaches of the Missouri River meet the needs for pallid sturgeon to complete their life cycle is still a question that needs to be answered. However, it seems very likely that without the expansion of the length of the Yellowstone River facilitated by this project, recovery goals for pallid sturgeon in this area will not be met.

The Panel thinks that the authors of the documents have done a good job of reviewing the literature and data available on spawning and spawning habitat for pallid sturgeon in the Yellowstone River, but the Panel believes that the document could be strengthened by incorporating findings from additional, recently published research. Since DeLonay et al. (2009) have found that shovelnose sturgeon and pallid sturgeon use similar, overlapping areas for spawning, it seems that a survey of shovelnose sturgeon spawning locations in the Yellowstone River could provide useful guidance regarding how far upstream from the Intake Dam pallid sturgeon spawning might occur. In addition, several observations from studies in the Mississippi River (e.g., Hurley et al. 2004; Garvey et al. 2009) and the middle Missouri River (Steffensen and Hamel 2007, 2008) found concentrations of pallid sturgeon at the mouths of tributaries. Applying these observations to the Yellowstone River and its tributaries such as the Powder River and using information from Haddix and Estes (1976) and Penkal (1981) could prove fruitful in the identification of potential pallid sturgeon spawning localities. Confirmation of specific spawning areas would enable valuable empirical studies of drift distance for pallid sturgeon larvae, which would facilitate more accurate estimates of larval survival and recruitment potential.

The Panel agrees that the survey of bluff pool habitats done by Jaeger et al. (2005) provides a baseline of available habitat. Based on the habitat data presented, it would appear that most of the bluff pool habitats expected to provide suitable spawning conditions for pallid sturgeon are downstream of the confluence of Tongue and Yellowstone rivers (Jaeger 2005). This might reduce the benefit of the proposed gain of 165 miles of larval drift distance downstream from the Cartersville Diversion as many of the potential spawning locations were far down river from Cartersville and none were reported near Cartersville. The Panel thinks that a determination of shovelnose sturgeon spawning localities could narrow the focus for finding potential pallid sturgeon spawning sites. However, suitable spawning sites for pallid sturgeon upstream of Intake Dam will be most effectively identified by telemetry monitoring of distribution and movements after the Intake Project is completed.

Uncertainties

Because there have been no recent documented occurrences of wild pallid sturgeon upstream from the diversion dam at Intake in recent times, it is difficult to say whether this area will be used immediately. However, as pallid sturgeon stocked into RPMA 2 grow to maturity, it seems likely that they will "explore" and use the habitats made available by the proposed modifications because long distance upstream forays are common in pallid sturgeon juveniles and adults (Garvey et al. 2009).

Another concern for any species with populations as small as this pallid sturgeon population is whether sufficient numbers will be ready to spawn at the same time in one place (i.e., the Allee effect) (Delonay et al. 2009). Therefore, continued stocking may be needed to augment the population until a sufficient number of adults are present to carry on the species.

There is some question about whether the substrate composition in the ramp will act as an impediment to pallid sturgeon using the whole reach from Intake Dam to Cartersville. If the ramp provides habitat that is perceived by the pallid sturgeon as suitable for spawning, they may congregate at Intake Dam and not proceed to suitable upstream spawning sites. Therefore, the ultimate design criteria for the ramp or indeed any bypass at Intake Dam needs to consider how pallid sturgeon will respond to the microhabitat conditions within the modified area so that they will indeed pass the diversion dam at Intake.

Conclusion/Summary

Without the resumption of natural spawning there is no real possibility that the naturally produced (i.e., non-stocked) pallid sturgeon population in RPMA 2 will recover from its endangered status and therefore without stocking it will become extirpated. The Intake Project, as described in the materials the Panel reviewed, has the potential to open a path for pallid sturgeon spawning that has been blocked for nearly a century. In addition, modifications to prevent loss of fish into the canal will also reduce losses of sturgeon and other species as they move downstream.

Although there may be other issues outside of the Yellowstone River proper, this project seems, in the Panel's judgment, to have good potential to contribute to the re-development of a naturally reproducing population of pallid sturgeon in RPMA 2

LARVAL DRIFT

The Panel identified eleven of the questions posed by the MRRIC as being relevant to the larval drift of pallid sturgeon. Entrainment issues are also included in this set of questions. These questions are:

A.1c Question: [If upstream spawning habitat is used] And if they use it, is adequate drift distance/time provided for larvae survival?

A.2 Question: What is the current speed during the high water period on the Yellowstone May 15--to July 15, at Cartersville and below and what velocity rate (or range of rates) is appropriate to calculate larval drifts?

A.3 Question: What data is available to support the conclusion that any larvae would actually survive without ending up in the head waters of Lake Sakakawea where they would die?

A.4a Question: What are the anticipated drift rate and distance required for larval pallid sturgeon in the relevant reaches? A.4b What is the required water level in Lake Sakakawea to attain this distance? How often should these conditions exist? What is the level of uncertainty in the drift rate and distance calculations? How was this data considered when planning the Intake project?

A.5 Question: Is there a need to modify other upstream dams to allow enough drift distance for larvae? What progress/plans have been made on modifying upstream structures?

A.6 Question: Can/should a study be conducted on the Yellowstone River to provide drift information specific to this reach?

B.1b Question: Will it allow larval pallid sturgeon passage downstream and will it lead to their survival?

What Agencies Said (In Their Responses to MRRIC Questions and in the DEA)

This section provides a summary of what the agencies have stated in their responses to MRRIC questions and in the DEA and BA. A central hypothesis in the project justification is that restoration of adult passage will restore sufficient distance of free-flowing river such that larval sturgeon can complete the extended drift phase of their early life history before encountering unfavorable reservoir habitats. Pallid sturgeon in this area are at risk because natural recruitment has failed. Drift distance limitation is the leading hypothesis for this failure. This project may be able to restore some amount of natural recruitment in this management area if the distance between spawning areas upstream from Intake Dam and Lake Sakakawea is long enough to provide adequate in-river larval development before fish enter Lake Sakakawea.

Depending on Lake Sakakawea surface elevation, estimated 84-141 miles of drift distance is currently available in the Yellowstone and Missouri Rivers between Intake Dam and the upstream end of Lake Sakakawea (Table 2). The location of the headwaters of Lake Sakakawea varies and has been estimated to be between 13 and 70 miles from the mouth of the Yellowstone River based on the information provided (10/27/09 email from G. Davis, USBR to P. Callahan, PBS&J). Restoration of effective adult upstream passage at Intake Dam was estimated to provide access additional 165 miles of river for a total of 248-305 miles. If Cartersville Dam were subsequently modified, an additional 56 miles would be available for a total of 304-361 miles.

A distance of 217-497 miles was projected to be needed for completion of the larval drift phase of the life cycle. The range reflected seasonal differences in drift duration related to temperature and uncertainty in estimates of drift rate related to water velocity. The estimated 319 miles available with passage at Intake Dam exceeds the low end of the needed range. This led the Federal agencies to conclude that restoration of passage will provide adequate drift distance for a portion of any naturally-produced larvae spawned upstream of Intake during many or most years.

Estimates of drift distance requirements were based on a synthesis of the available information on the duration of the larval drift phase and the rate of drift (Table 3). Information was primarily derived from a series of articles published in peer-reviewed scientific journals and also included unpublished results of more recent studies. Descriptions of larval pallid sturgeon drift behavior and duration were based on a series of laboratory studies conducted at the USGS Conte Anadromous Fish Research Center in Massachusetts (Kynard et al. 2002, 2007). Drift

Table 2. River distances involved in the proposed project.

Location	River(a)		Above Intake		Above Lk Sakakawea	
	miles	**km**	**miles**	**km**	**miles**	**km**
Lake Sakakawea headwaters (low pool) (b)	[1512]	[2434]	--	--	0	0
Lake Sakakawea headwaters (high pool) (b)	[1569]	[2526]	--	--	0	0
Yellowstone River	[1582]	[2547]	--	--	13-70	21-113
Intake Dam	71	114	0	0	84-141	135-227
Documented occurrence (historical)	183	295	112	180	196-253	315-407
Cartersville Dam	235	378	164	264	248-305	399-491
Yellowstone Dam (passage exists)	276	445	206	331	289-346	466-558
Rancher's Ditch Dam	291	468	220	354	304-361	489-581
Fort Peck Dam	[1709]	[2751]	--	--	140-197	225-317

Notes: (a) Missouri River distances are in brackets [ ]
(b) River mile locations and distances to headwaters are inconsistently reported in the DEA and related material.

behavior in a natural environment and drift rates relative to water velocity were estimated based on experimental field studies by Braaten et al. (2008) and Braaten et al. (in preparation). Braaten et al. (2008) used this information to simulate cumulative distance drifted in the upper Missouri River during ontogenic development. Simulation results were validated by subsequent capture of juveniles released as larvae which confirmed that significant survival could result when sufficient drift distance was available for larvae to complete development prior to reaching Lake Sakakawea. The simulation was subsequently adapted for evaluation of Intake Dam passage benefits on drift distance of larvae originating in the Yellowstone River by Horton (2009).

Table 3. Re-creation of estimates and assumptions in projections of drift distance needed for completion of the larval drift phase of pallid sturgeon.

	Units	Min	Max	Comment
Larval development period	--	--	--	Mid June to Mid July
Temperature	°C	25	20	Average for period
Larval phase duration	Days	7	10	Fastest development at avg. temperate
Stream flow	ft^3/sec	25,000	25,000	20 year average @ Sidney
Water velocity	ft/sec	2.9	2.9	Assumed based on field measurements
Relative drift rate	--	0.62	1.00	Reflects 4 day lag in observed distribution
Drift velocity	ft/sec	1.8	2.9	Water velocity x relative drift rate
	mi/day	30.2	47.5	
Distance traveled	mi	211[a]	475[a]	Phase duration x drift velocity

Note:
a. The Panel's recreation of estimates differs slightly from the reported 217-497 miles (likely due to rounding errors).

Reservoir habitats are thought to be unfavorable to larvae because of unsuitable conditions or habitat in headwater depositional areas or predation by the reservoir fish community. This conclusion was consistent with the general timing of recruitment failure concurrent with the development of impoundments. Observations of significant numbers of mature adults, spawning migrations, spawning habitat, and spawning behavior indicate that recruitment failure is not due to the failure to spawn. Significant rates of survival of hatchery-origin juveniles released at post-larval sizes indicate that the recruitment bottleneck occurs in the early life history stage. Survival of hatchery-origin larvae that were provided the opportunity to complete development in a riverine habitat (as indicated by recapture months or years later) further narrows the bottleneck to the larval stage.

The drift distance limitation hypothesis and projected benefits of the modification of Intake Dam hypothesis is supported by information on the sympatric shovelnose sturgeon and pallid sturgeon populations in other areas. A large shovelnose sturgeon population occurs in the area which is consistent with the shorter duration of the larval drift phase for this species. Drift distance is adequate for completion of the shorter larval drift phase. Similarly, significant recruitment is observed for pallid sturgeon in other areas downstream where adequate drift distance is available.

Is This the Best Available Science and If Not What Needs to Be Added

Based on a review of the available information, the Panel concluded that Reclamation's and the Corps' responses to questions submitted by the MRRIC are supported by the best available scientific information.

We note that a stronger case could be made for estimates of drift requirements and project benefits with a more structured, quantitative modeling analysis that might include:

- Daily flow and temperature profiles
- Representation of both Yellowstone & Missouri conditions
- Seasonal spawning and incubation patterns
- Annual variation in stream discharge and the location of Lake Sakakawea headwaters
- Annual variability in temperature patterns in relation to discharge
- Variable developmental periods based on temperature patterns
- Annual and daily variation in average stream velocity in relation to discharge
- Individual variance in larval drift rate reflecting the effects of channel complexity
- Explicit estimates of the benefit probabilities

While a more comprehensive modeling approach would facilitate consideration of the effects of alternative hypotheses and quantification of the effects of uncertainties, it is not likely to lead to fundamentally different conclusions. However, it would provide a more explicit and descriptive organization of the existing information. This work would involve development of a model from existing information but this model is not currently available. Hence, the analysis and descriptions provided in the existing documents continues to represent the best science currently available.

Given the importance of the larval drift distance to the ultimate success of the Intake Project, the Panel chose to conduct their own independent (coarse-level) analysis using river discharge data to evaluate the occurrence of larval drift distances in the Yellowstone River in relation to annual variability stream discharge based on some simplifying assumptions. The results of this analysis supported the possibility that adequate drift distances for pallid sturgeon larvae could exist in some years. This analysis illustrates how additional modeling of existing information can be instructive but represents just a portion of the more comprehensive physical and biological modeling approach outlined above. A complete analysis of the data is outside the scope of this review.

The methods for this example analysis were as follows:

1. The daily average discharge for the U.S. Geological Survey (USGS) gage at Sidney, MT was downloaded from the USGS website for the period of record (1910 – 2009). The years of 1910 and 1933 were dropped from the analysis because they had long periods of missing data.
2. Next, only data from the time period from May 15 to July 15 were considered because this was given as the likely range of pallid sturgeon spawning in the Yellowstone River. Pallid sturgeon peak spawning typically occurs at temperatures of 17°C and also depends on complex conditions (probably the presence of high spring or early summer discharge; see Delonay et al. 2009 and Garvey et al. 2009). This is cooler than the 20-25°C range suggested in the responses to the questions from the MRRIC, thus the longer time period selected.
3. The average daily discharge for each time period (May 15 – May 31, June 1 – June 30, July 1 – July 15) was calculated.
4. The minimum of the three time periods for each year was used as a potential window for successful larval drift.
5. To estimate average river velocity from discharge, the Panel used the standard relationship of $v = K * Q^a$, where v = mean velocity, K is a constant, Q = discharge, and a = 0.34 (see Jobson 1996). The average velocity was calculated for each year for the minimum time period discharge. K was determined from transect data on the lower Platte River, NE (Peters and Parham 2008) and compared with the estimate of 25,000 cubic feet per second (cfs) having a 3.23 feet per second (ft/sec) average velocity (Responses to the questions from the MRRIC, 2009).
6. The average velocity was also decreased by 40% to estimate the slowing of overall drift with the increased complexity of the Yellowstone River in comparison to the Missouri River as discussed by Jaeger et al. (2008).
7. The 1%, 10%, and 25% minimum drift lengths was calculated for the average velocity and slower 60% of average velocity using Braaten et al. (2008) equations for pallid sturgeon larval drift of the slowest drifters.
8. The number and percent of years that drift distance was less than the 253 miles (estimated minimum distance below Cartersville) and 312 mile (estimated minimum distance including Cartersville passage) were determined.
9. The average, maximum, and minimum drift distances were also reported.

The data tables for steps 3 through 7 are presented in Appendix 3 and Appendix 4 to this report. This analysis should be considered preliminary and a more detailed analysis of discharge to velocity measured on the Yellowstone River associated with the USGS gage sites and seasonal temperature variability would greatly improve the reliability of this estimate. Assessing the viability of this project was complicated by inconsistent mileage data for physical landmarks and associated distances to Lake Sakakawea. Distances from landmark locations to the headwaters of Lake Sakakawea are likely minimum estimates. The location of the headwaters of Lake Sakakawea varies and has been estimated to be between 15 and 55 miles downstream from the confluence of the Yellowstone River and the Missouri River (Scarnecchia et al., 1996). Results of the Panel's larval drift distance analysis for pallid sturgeon in the Yellowstone River suggest that improving passage will provide the possibility of adequate drift distances for pallid sturgeon larvae in some years (Table 4 and Figure 2). Given that pallid sturgeon larvae drift near the river bottom, and that the Yellowstone River has more complex channel structure than the Missouri River, drifting larvae could be expected to travel downstream at rates lower than average river velocity, and at rates lower than those recorded in the Missouri River. This is crucial because calculations using average velocity estimates based on discharge records indicate that few years would provide suitable drift distances (Table 4). If the Cartersville fish passage project is completed then the probability of suitable drift distances increases substantially (Table 5).

Table 4. Number and percent of years that suitable drift distances were available for the slowest 1, 10, and 25% of pallid sturgeon larvae during the 97 year period of record for the Sidney, MT USGS gage on the Yellowstone River. (Average velocity based on the velocity to discharge relationship and reduced velocity is 60% of average velocity. A successful year was considered to have an estimated drift distance less than 253 miles or the estimated distance from Cartersville Diversion to Lake Sakakawea.)

	Percentage of Slowest Drifters					
	At Average Velocity			At Reduced Velocity		
	1%	10%	25%	1%	10%	25%
Number of years out of 97	2	0	0	71	50	33
Percent of years	2%	0%	0%	73%	52%	34%

Table 5. Number and percent of years that suitable drift distances were available for the slowest 1, 10, and 25% of pallid sturgeon larvae during the 97 year period of record for the Sidney, MT USGS gage on the Yellowstone River with passage of Cartersville Diversion included. (Average velocity based on the velocity to discharge relationship and reduced velocity is 60% of average velocity. A successful year was considered to have an estimated drift distance less than 312 miles or the estimated distance with fish passage at Cartersville Diversion included and then downstream to Lake Sakakawea.)

	Percentage of Slowest Drifters					
	At Average Velocity			At Reduced Velocity		
	1%	10%	25%	1%	10%	25%
Number of years out of 97	13	8	2	95	85	73
Percent of years	13%	8%	2%	98%	88%	75%

These estimates (Tables 4 and 5) assume that pallid sturgeon will migrate upstream nearly to the base of the next upstream diversion and find suitable habitat in that area. The probability of this happening is unknown and is likely influenced by many factors, including the quality of spawning habitat in the area and the population size of the pallid sturgeon. It appears that the minimum successful drift distance for 1% of the drifting larvae in the Yellowstone River at the reduced velocity estimate is about 102 miles or 234 miles at the average velocity estimate (Table 6). This suggests that the current distance of 88 miles from the Intake to Lake Sakakawea is insufficient for even the most optimistic estimates. This minimum drift distance also suggests that in some years suitable spawning habitat far downstream of Cartersville Diversion may have the potential for a small fraction of the larvae to survive (Figure 4). These years would be very low discharge years and may not provide adequate passage upstream (see Peters and Parham 2008 for a discussion of the lack of connectivity of river habitats for migrating pallid sturgeon at low flows).

Table 6. Average, maximum, and minimum drift distances for pallid sturgeon larvae in the Yellowstone River.

	Percentage of Slowest Drifters					
	At Average Velocity			At Reduced Velocity		
	1%	10%	25%	1%	10%	25%
Avg drift distance (miles)	429	460	480	220	251	271
Max drift distance (miles)	611	642	662	329	360	380
Min drift distance (miles)	234	265	285	102	133	154

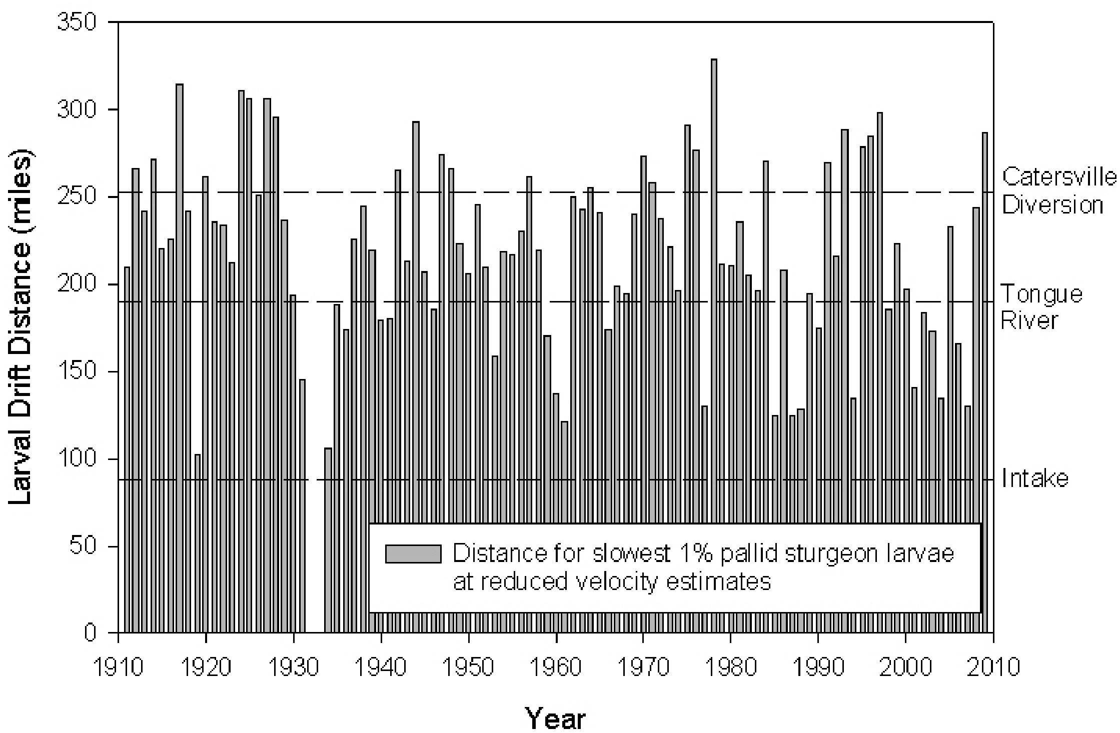

Figure 2. Annual variation of potential minimum larval drift distances for the slowest 1% of pallid sturgeon larvae based on the reduced velocity estimates. (Reference distances of interest are provided.)

This analysis only considers discharge in its prediction of larval drift distance. We used a wide time period of May 15 to July 15 in our model of minimum annual larval drift distances for the Yellowstone River to cover a range of possible spawning temperatures. While exact spawning temperatures and dates in the Yellowstone River are not known, some ranges for recent years have been determined. Estimated ranges for spawning in 2007 included May 24th to June 26th with a water temperature between 15 to 25°C. (Fuller et al. 2008) and in 2008 spawning may have occurred between June 19th and July 8th with water temperatures between 18 to 22°C. (M. Jaeger, FWP, personal communication). The inclusion of water temperature estimates would improve these predictions of the time of spawning and distance traveled by the larvae. Distance traveled is a function of discharge (controls water speed) and temperature (controls development time). The distance traveled curve will differ during spawning seasons and among years. In general, a warm year results in warmer water and therefore shorter development times than a cool year. A wet year will result in higher water flows and therefore faster transport rates than a dry year (Table 7). The combination of conditions will control the parameters of the distance traveled curve.

Table 7. The relationship between seasonal temperature and seasonal discharge. (The relationship is temperature/discharge. The plus (+) denotes shorter larval drift distances and the minus (-) denotes longer larval drift distances.)

	wet	dry
Warm	+/-	+/+
Cool	-/-	-/+

The estimates provided in the section above were inferred from the information provided in the answers to MRRIC, the BA, and the DEA. The Panel attempted to provide an explicit set of predictions of the effect of variable annual stream discharge on larval drift if the proposed project is implemented. This framework would be enhanced with a summary of historical discharge and temperature estimates for the period of record. This would provide an estimate of the proportion of years that may provide suitable drift distances for pallid sturgeon larvae. If this was coupled with a map of all the suitable spawning areas in the Yellowstone River and its tributaries and associated drift distances, then the number of years that suitable upstream spawning sites were available with suitable drift distances would be clearly shown. This would provide clear evidence of the potential for success of this project and provide an estimate of a portion of the uncertainty associated with this effort. The analysis could be further extended to explicitly evaluate the effect of other uncertainties related to seasonal and individual variation in temperature, developmental period, and drift rate in relation to water velocity.

Uncertainties

Estimates of the Intake Project benefits are subject to a number of significant uncertainties which were acknowledged by the authors. These include:

Effect significance – The available information suggests that drift distance may be adequate for some larvae originating upstream from Intake Dam. However, the significance of this effect, in terms of contribution to recruitment, is unknown. The portion of the larvae produced that might be expected to survive, the number of fish represented and the resulting viability of the wild population cannot be determined with the existing information.

Drift distance requirements – A range of estimates is presented based on uncertainty in water velocity of the Yellowstone and upper Missouri systems, larval drift rate in relation to water velocity, effects of larval age and condition on drift rate, and individual variance in drift rates, which determines the affected portion of the larval population.

Annual flow and temperature effects – Estimates of drift distance requirements generally represent average annual conditions but substantial annual and seasonal variability in benefits will result from normal variability in flow and temperature patterns. The incidence of conditions under which drift distance is adequate remains unclear.

Benefits of upstream dam removal – It is unknown whether additional benefits will result from removal of additional dams upstream such as Cartersville. The additional drift distance could enhance the benefits of Intake modification, but benefits would obviously depend on whether adult pallid sturgeon take advantage of passage opportunities at each dam and find suitable upstream spawning locations (see previous sections).

Conclusion/Summary

This review concluded that the qualitative treatment of the available data supports the hypothesis that adequate drift distances would exist for natural recruitment to occur if adult pallid sturgeon passage at Intake Dam results in spawning at upstream locations. The best available science supports a conclusion that larval drift distance would likely be adequate for at least a portion of the larvae in some years.

While additional analysis or research could marginally reduce uncertainties regarding the probability of success, it is not likely to provide a more definitive conclusion. Additional analysis in a more comprehensive modeling framework (described above) is not likely to lead to fundamentally different conclusions. Nor is additional research on related questions such as larval drift rates relative to water velocity likely to result in fundamentally different assessments. The true test and quantification of project benefits can only be made by project implementation and subsequent monitoring of the response.

ENTRAINMENT

The Panel identified several questions from MRRIC related to entrainment topics. These include:

B.5 Question: Is the screening system the best design for the pallid sturgeon?

B.7 Question: Will the new diversion designs effectively prevent entrainment of pallid sturgeon or other species that impact pallid sturgeon (e.g. chubs that are a food source for pallid sturgeon)?

B.8 Question: (if so what design [in reference to the answer to B.7])? Supporting information?

B.9 Question: Given the location where pallid sturgeon larvae drift, will larvae either be trapped in the pool behind the Intake Dam or end up in the diversion?

What Agencies Said (In Their Responses to MRRIC Questions and in the DEA)

This section provides a summary of what the agencies stated in their responses to MRRIC questions and in the DEA and BA. Fisheries biologists working on this project (including those from Montana Fish Wildlife and Parks, the U.S. Fish and Wildlife Service (Service), the Corps, and Reclamation) agreed that the screening system represented satisfactory design for pallid sturgeon and other native fishes at Intake. The screen design used the best available technology, including the smallest effective screen size and velocities recommended by the Service's Biological Review Team. The proposed screen size was the smallest that could be used effectively, in accordance with the National Oceanic and Atmospheric Administration (NOAA) juvenile salmonid criteria (maximum screen size of 1.75 millimeters (mm) profile bar (2.38 mm woven wire; Page 2-9 in DEA). The proposed screen design was deemed effective at avoiding entrainment of pallid sturgeon and other fishes over 1.6 inches total length (TL).

A supporting lab study evaluated the best technology available to meet the NOAA screening criteria for juvenile and larval pallid sturgeon < 3.9 inches [9.9 centimeters (cm)] long (Mefford and Sutphin 2008). This study was used to identify and design fish screens for the Intake Project, and evaluated four related topics: 1) swimming endurance, 2) impingement survival, 3) screening effectiveness, and 4) recovery of impinged fish from traveling fish screens. Fish larger than about 1.6 inches (~ 4 cm) were capable of swimming several minutes against a typical fish screen approach velocity of 0.4 ft/s (12.2. cm/s).

This study also indicated that NOAA criteria effectively protect pallid sturgeon >1.6 inches long. Screen impingement for periods up to 10 minutes (maximum impingement time evaluated) had no effect on fish mortality, when fish were recovered by back-flushing the screen.

Is This the Best Available Science and If Not What Needs to Be Added

Based on a review of the available information, the Panel concluded that Reclamation's and the Corps' responses to questions submitted by the MRRIC are supported by the best available scientific information.

However, several studies have been published involving swimming speed and behaviors of juvenile pallid sturgeon that did not appear to be included in the DEA or the MRRIC question and answer document. These studies provided useful empirical information for characterizing entrainment risk for juvenile pallid sturgeon at the proposed Intake screens (Adams et al. 1999, 2003; ERDC 2005). Since the juvenile life stage of pallid sturgeon lasts for more than 8 or 10 years and fish can move great distances during this time, they may be exposed to risk of entrainment throughout this period. However, screen criteria in the proposed design are expected to protect all pallid sturgeon of post-larval and juvenile sizes.

Adams et al. (2003) reported juvenile pallid sturgeon swimming speeds > 15 cm/s, exceeding the 12 cm/s escape velocity needed to avoid entrainment at the proposed diversion intake screens. Adams et al. (1999) reported burst speed swimming of 55-70 cm/s and 40-70 cm/s for groups of large [17.0-20.5 cm fork length (FL)] and small (13.0-16.8 cm FL) juvenile pallid sturgeon. In all cases, escape velocities or swimming speeds demonstrated by juvenile pallid sturgeon (40-70 cm/s) greatly exceeding the 12 cm/s escape velocity required at the proposed diversion intake screens.

The Corps' Engineer Research and Development Center study (ERDC 2005) provided additional useful information to assess juvenile pallid sturgeon entrainment risk at the proposed diversion intake screens. Maximum swimming speeds were documented for groups of large (> 11.5 cm) and small (< 11.5 cm) pallid sturgeon, including 35 cm/s and 20 cm/s for these groups respectively. In both cases, documented escape velocities (20-25 cm/s) greatly exceeded required escape velocities at the proposed diversion intake screens of 12 cm/s.

Uncertainties

Estimates of project benefits are subject to uncertainties, including: the amount of time spent in area immediately in front of new screens at diversion works of both action alternatives by pallid sturgeon < 1.6 inches TL (deemed to be subject to entrainment), and entrainment efficiency of juvenile pallid sturgeon < 1.6 inch TL with proposed screens.

Conclusion/Summary

Completion of the juvenile life stage for pallid sturgeon is a critical prerequisite for mature, reproducing adults. The diversion currently entrains large numbers of fish produced upstream from Intake Dam but entrainment impacts on pallid sturgeon are limited because pallid sturgeon do not occur in significant numbers upstream from the dam. With the restoration of passage, larval and juvenile pallid sturgeon may then become vulnerable to entrainment at the diversion. However, screening of the diversion is likely to substantially reduce the impact of entrainment on vulnerable life stages. Proposed screening technology associated with both action alternatives appears to resolve any concerns about entrainment of larval or juvenile pallid sturgeon > 1.6 inches TL. However, entrainment might be an issue for larval pallid sturgeon between 1 and 1.5 inches TL should they spend considerable time in the immediate area of the diversion screens associated with either of the action alternatives. Current lack of behavioral and habitat use information for pallid sturgeon at this small size precludes any quantitative conclusions regarding their entrainment risk. Larger juvenile pallid sturgeon do not appear to be at risk of entraining based on several studies that tested and documented escape velocities that exceeded or greatly exceeded entrainment velocities (Adams et al. 1999, 2003; ERDC 2005). The Panel concluded that the net benefit of passage and spawning upstream from Intake Dam is likely to be significant even if a portion of the production is then subject to entrainment losses as long as associated diversion fractions are not excessive.

JUVENILE REARING

The Panel identified eight of the questions posed by the MRRIC as having relevance to the juvenile rearing life stage of pallid sturgeon. These questions are:

B.5 Question: Is the screening system the best design for the pallid sturgeon?

B.6 Question: Is the bypass design the best for pallid sturgeon?

B.7 Question: Will the new diversion designs effectively prevent entrainment of pallid sturgeon or other species that impact pallid sturgeon (e.g. chubs that are a food source for pallid sturgeon)?

B.8 Question: (if so what design [in reference to the answer to B.7])? Supporting information?

C.1 Question: What level of certainty would you attach to this proposal and its claimed positive effect on Pallid sturgeon?

C.2 Question: How much will this project improve the pallid's survivability?

C.3 Question: Will the project as proposed provide meaningful benefit to the pallid sturgeon population given the hydrological and biological information available to date?

a. Drift rate and survival
b. Velocities
c. Reservoir survival
d. Sturgeon migration

C.4 Question: What happens to the pallid sturgeon populations in the Recovery Priority Management Area 2 if they do nothing on Yellowstone at Intake?

Questions B.1-B.6 have been generally addressed in the previous discussion relating to entrainment and are not discussed in more detail in this area. In general, the screened diversion should protect juvenile sturgeon (see previous discussion). Project operations could alter available habitat, but the affects of project operations are to be addressed in a separate consultation process and were therefore not considered by the Panel.

What Agencies Said (In Their Responses to MRRIC Questions and in the DEA)

This section provides a summary of what the agencies have stated in their responses to MRRIC questions and in the DEA and BA. The following questions were summarized from MRRIC Questions C.1 through C.4. Although none of these questions were specifically addressed by the MRRIC questions and responses document for juvenile pallid sturgeon, the Panel has provided the following relevant questions and responses for juveniles.

Will the proposal provide meaningful benefit to [juvenile] pallid sturgeon? What level of certainty would you attach to this proposal and its claimed positive effect on [juvenile] pallid sturgeon?

The proposed Intake Project would provide meaningful benefit to juvenile sturgeon, in terms of reduced loss (mortality) from currently unscreened irrigation diversion, and in the form of increased availability of suitable habitat. Telemetered juvenile pallid sturgeon have traveled upstream to the Intake Diversion Dam, did not pass, and turned to swim back downstream (Jaeger et al. 2008). Post-release growth and condition indicate that releases will provide benefits to the population (Jaeger et al. 2005, 2006, 2007). Of all juvenile pallid sturgeon tagged with transmitters and released at up to three sites in the fall, many moved downriver but not past the first downstream dam encountered (Cartersville and Intake; Jaeger 2005, 2006, 2007).

Therefore, based on pallid sturgeon studies over several years in the lower Yellowstone that provided relevant post-release movement and growth data, it is reasonable to expect that removal of the passage barrier for juveniles at Intake will help expand the geographic range and the amount of suitable juvenile habitat available. This could contribute positively to production of mature adults in the population as required for recovery.

What happens [to juvenile sturgeon] if nothing is done at Intake?

In terms of natural production of pallid sturgeon, unless adequate numbers of remnant adults migrate upstream past Intake following project implementation and produce adequate numbers of juveniles for a sustainable year class, this population will go extinct. Given this scenario, in the absence of hatchery input, the population is also expected to go extinct. However, this conclusion does not specifically depend on any current or predicted future limitation(s) of juvenile pallid sturgeon in the study area. Rather, it depends on production and life cycle completion, two things that are currently limited by the passage barrier at Intake Dam.

Is This the Best Available Science and If Not What Needs to Be Added

Information is provided in the preceding discussion supporting the conclusion that the MRRIC responses, DEA, and BA include best available science.

Uncertainties

For juvenile pallid sturgeon relevant uncertainties that might affect success of the proposed project include specific juvenile pallid sturgeon habitat use and requirements.

Conclusion/Summary

Summary and conclusion information can be found in the responses above.

Tier 2 Topics

Tier 2 comments are more minor comments related to the structure of the DEA or material presentation. Tier 2 comments do not relate to the science supporting the responses to the MRRIC questions, DEA, or BA).

Environmental Assessment Organization

The Panel would recommend considering the following clarifications to the DEA:

- Clarify river miles (and consistently use either English or metric units) between major features relevant to the project
- Include figure of river mile locations
- Are all MRRIC responses to be incorporated somewhere into the DEA/BA?

Conservation Genetics

The DEA and BA consider the project effects in terms of the extant population of aging pallid sturgeon. They seldom (if ever) note that a conservation stocking program is currently in place that has stocked a large number of juveniles into RPMA 2 that are assumed to mature in coming years. To what extent genetic diversity in the remnant population and maintained by stocking translates to phenotypic characteristics such as spawning habitat use, migration capability, and larval drift distance is unknown. This has important implications for the population to remain resilient to environmental changes and varying management decisions. The following elements may warrant consideration:

- Selection for slow drifting larvae?
- Revise based on flow/temperature analysis
- How well is the program representing allele frequencies from the remnant population?
- At what point does stocking stop?

Conclusions

In the life history model section, a series of questions were asked that if answered affirmatively would support the supposition that the proposed project would positively affect pallid sturgeon populations in the Great Plains Management Unit. The following section summarizes the results of the scientific review of question by life stage.

1. Pallid Sturgeon Adults (*passage and migration issues*):

Will the Lower Yellowstone Intake Diversion Dam Modification Project provide passage and enhance upstream migration for adult pallid sturgeon? Can and will adult pallid sturgeon pass the diversion structure during the purported spawning season (e.g., May through July) with the proposed modifications?

1a. The documentation of the proposed project provides evidence that the rock ramp alternative will improve passage for adult pallid sturgeon and with passage available adult pallid sturgeon may use habitats upstream of the Intake diversion.

1b. The documentation of the proposed project provides evidence that entrainment of adult pallid sturgeon will be minimized (and potentially eliminated) by the use of the fish screens on the headwater intakes.

1c. The proposed project does not substantially alter the habitat, hydrology, or sediment transport and thus is unlikely to adversely impact migratory or spawning cues for adult pallid sturgeon.

1d. Because the rock ramp will provide a break in the river gradient, a location with swift current (ramp face) near slower water (downstream scour hole) and extensive hard substrate (the ramp itself), the Panel carefully considered the potential attractiveness of this structure to spawning pallid sturgeon. However, the Panel feels that this is not a major concern for the following reasons:

- The small population size of adult pallid sturgeon in the lower Yellowstone River and connected Missouri River may need to expand to cause individuals to explore further upstream for additional suitable spawning habitats.
- The ability to pass the diversion structure will be improved so pallid sturgeon may not stop at the diversion structure on their upstream migration.
- The selection of the alternative that would relocate the main channel would also provide many of the same attracting characteristics (gradient changes, complex depth and

velocity patterns, and hard substrates from riprap and gradient control structures) as the rock ramp alternative.

1e. The current hydrology of the Intake Dam area and its implications for passage were not summarized in any of the answers nor in the DEA or BA. Including information from other systems with parallel issues of passage suggests that some passage across the current Intake Dam may currently occur, albeit infrequently and only during the highest flow periods.

Panel Conclusion: The proposed rock ramp alternative would provide passage and enhance upstream migration for adult pallid sturgeon. The DEA, BA, MRRIC Question and Answers, and supporting documentation used the best available information in the Yellowstone River basin and provided documentation of the assessment of alternatives, feasibility studies, and project design. Inclusion of comparisons of pallid sturgeon movement associated with the low head dam on other rivers would strengthen the report's conclusions.

2. Pallid Sturgeon Adults (*spawning issues*):

Does suitable spawning habitat exist upstream of the Yellowstone Intake Diversion Dam, and if so, where and how far upstream is it located?

2a. Suitable spawning habitat likely exists upstream of the Yellowstone Intake Diversion Dam.

2b. The definition of suitable pallid sturgeon spawning habitat as "terrace or bluff pools" is reasonably supported by recent scientific findings about pallid sturgeon spawning habitats.

2c. An estimated 4,000 acres of terrace pool and bluff pool habitats are present in the Yellowstone River between diversion dam at Intake and Cartersville, Montana (M. Jaeger, FWP, personal communication). The location (or distance upstream from Lake Sakakawea) is critical in determining if the potential habitat has suitable drift distances.

2d. Jaeger (2005) reports delineating all reaches and habitats on the Yellowstone River between the river km 74 and 537. This delineation included terrace and bluff pools. Given the importance of achieving adequate larval drift distance to the success of this project, a more detailed description to the amount and distribution of terrace and bluff pool habitats throughout the Yellowstone River would greatly improve the readers' understanding of potential increases in larval drift distances provided by the passage of the Yellowstone Diversion Intake Dam.

2e. The Panel thought it important to note that even if pallid sturgeon have suitable spawning habitat upstream near the Cartersville Diversion Dam, it may take some time before sturgeon utilize the spawning locations as sturgeon may stop at equally suitable downstream spawning locations. Increases in population size associated with the maturation of stocked pallid sturgeon would likely increase the probability of the use of more spawning locations.

Panel Conclusions: The consensus of the Panel was that suitable habitat exists upstream of the Yellowstone Diversion Intake Dam at suitable distances for pallid sturgeon larval drift in some years. Our analysis of larval drift distances related to discharge suggests that spawning locations far downstream of the Cartersville Diversion may have adequate larval drift distances for a small portion of larvae to develop prior to reaching Lake Sakakawea in some years. In most years there is some chance for pallid sturgeon larvae to complete the drift and settle in suitable habitats if the adults spawn near Cartersville. The DEA, BA, MRRIC Question and Answers, and supporting documentation used the best available information to support their conclusions although the inclusion of maps with locations of terrace and bluff pool habitats would support the conclusions more strongly.

3. Pallid Sturgeon Eggs (*development and survival issues*):

Are conditions at the potential upstream spawning sites suitable for the development and survival of pallid sturgeon eggs?

3a. The Yellowstone River maintains a relatively natural flow with a snowmelt rise in discharge associated with the spawning of pallid sturgeon. The general habitat conditions are likely suitable for egg development and survival. Any abiotic factors such as toxins in the water or substrate that may limit egg and embryo development and survival have yet to be identified and the proposed modification to the Yellowstone Intake Diversion Dam is unlikely to decrease the development or survival of pallid sturgeon eggs, embryos, and free embryos.

3b. Increases in discharge result in an associated increase in turbidity. The highly turbid natural condition of the Yellowstone River during pallid sturgeon spawning likely provides some protection from sight feeding predators on pallid sturgeon eggs.

Panel Conclusion: Conditions at the potential upstream spawning sites are suitable for the development and survival of pallid sturgeon eggs, embryos, and free embryos. The proposed modification to the Yellowstone Intake Diversion Dam is unlikely to decrease the development or survival of pallid sturgeon eggs. The DEA, BA, MRRIC Question and Answers, and supporting documentation used the best available information to support their conclusions.

4. Pallid Sturgeon Larvae (*downstream drift issues*):

If pallid sturgeon access and successfully spawn at upstream locations, do sufficient downstream drift distances exist for larval development? Are embryo and larval drift distances adequate with respect to the expected range of discharge and water temperature conditions prior to reaching Lake Sakakawea? Does the proposed fish screen decrease entrainment of adult, juvenile, larval, and embryonic pallid sturgeon?

4a. It appears that during some years, potential upstream spawning sites will provide adequate larval drift distances with respect to the expected range of discharge and water temperature conditions prior to reaching Lake Sakakawea.

4b. A decrease in entrainment of larval pallid sturgeon is likely given the design parameters of the screens and empirical swimming attributes of young pallid sturgeon. The Panel agrees that complete elimination of larval entrainment or impingement is not feasible. Positioning the intakes at least 1 m above the bottom would likely avoid entrainment of the bottom drifting larvae.

4c. Given the importance of achieving adequate larval drift distance to the success of this project, a clearer description to range of expected drift distances associated with historical discharge on the Yellowstone River would greatly improve the readers understanding of potential increases in larval drift distances provided by improving the passage facilities at the Yellowstone Diversion Intake Dam. Preliminary analysis conducted by the Panel indicates that:

- A basic model of drift distances related to historical discharge between May 15 and July 15 suggests that that improving passage will provide the possibility of adequate drift distances for small portions of pallid sturgeon larvae during most years.
- Including pallid sturgeon passage of the Cartersville Diversion, adequate drift distances for pallid sturgeon larvae increases substantially.

Panel Conclusions: It is the consensus of the Panel that potential upstream spawning sites will provide adequate larval drift distances with respect to the expected range of discharge and water temperature conditions prior to reaching Lake Sakakawea in some years. The DEA, BA, MRRIC Question and Answers, and supporting documentation used the best available information to support their conclusions, although a more structured analysis of the information would greatly improve support for their conclusions. A clear description of larval drift distances would also highlight the importance completing fish passage at the Cartersville Diversion in the recovery of pallid sturgeon in the Yellowstone River.

5. Pallid Sturgeon Juvenile and Adult Life History (*Habitat and growth issues*):

If the Intake Project functions as proposed, do conditions in the Yellowstone and connected sections of the Missouri River have suitable conditions to support completion of the pallid sturgeon life cycle? Are conditions suitable for the growth, survival, and maturation of juvenile and adult pallid sturgeon? Will the Intake Project have either neutral or positive effects on the juvenile through pre-reproductive adult stages?

5a. Juvenile and adult pallid sturgeon already find suitable habitats for growth, survival, and maturation in the Yellowstone and connected sections of the Missouri Rivers.

5b. The proposed project does not substantially alter the habitat, hydrology, or sediment transport from current conditions and thus is unlikely to adversely impact pallid sturgeon growth, survival, or maturation.

5c. The decrease in entrainment of small fishes will likely provide increased food resources for pallid sturgeon and thus improve growth, survival, and maturation.

5d. The proposed project provides evidence that entrainment of juvenile and adult pallid sturgeon will be minimized (and potentially eliminated) by the use of the fish screens on the headwater intakes thus improving survival.

5e. It is unclear if the opening of habitats upstream of the diversion intake will result in large increases in juvenile pallid sturgeon habitat as many pallid sturgeon stocked at upstream sites moved downstream. This is not a problem with the design of the rock ramp or the overall proposed project. Given the small population size of pallid sturgeon in the lower Yellowstone River and connected Missouri River it is unlikely that juvenile or adult pallid sturgeon are currently habitat limited. Thus even if pallid sturgeon do not use the upstream habitats except during spawning seasons, the creation of adequate larval drift distances has the potential to increase population size within the area as a whole.

Panel Conclusions: Conditions in the Yellowstone and connected sections of the Missouri River appear suitable for the growth, survival, and maturation of juvenile and adult pallid sturgeon. The proposed project will not adversely affect and will likely enhance the growth, survival, and maturation of juvenile and adult pallid sturgeon. The DEA, BA, MRRIC Question and Answers, and supporting documentation used quality available information to support their conclusions. Additional information from published studies (Adams et al. 1999, 2003; ERDC 2005) supports the suitability of the screen design to lower entrainment risk for juvenile pallid sturgeon at the proposed intake screens.

Overall Conclusions

It is the consensus view of the Panel that the best available science was used in the development of the DEA, BA, MRRIC Question and Answers, and supporting documentation. Without the resumption of natural spawning there is no real possibility that the naturally produced (i.e., non-stocked) pallid sturgeon population in RPMA 2 will recover from its endangered status; without stocking it will likely be extirpated within a few years. The Intake Project, as described in the materials the Panel reviewed has the potential to provide access to pallid sturgeon spawning and early rearing habitats that have been blocked for nearly a century by the Intake Dam. In addition, modifications to prevent loss of fish into the irrigation canal will reduce losses of sturgeon and other species.

The Panel recognized that the probability of success cannot be determined with complete assurance because of significant uncertainties that inevitably constrain our ability to predict the behavior of complex biological systems. It remains plausible that the action will not achieve the desired effect. However, this action clearly represents a reasonably realistic alternative for restoration of natural recruitment for this distinct and evolutionarily-significant population of pallid sturgeon. Although there may be other issues outside of the Yellowstone River proper, this project seems, in our judgment, to have good potential to contribute to the re-development of a naturally reproducing population of pallid sturgeon in RPMA 2. It will also be an essential step in identifying the need to consider additional actions required throughout RPMA 2 to meet recovery objectives.

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Appendix 1: Panelist CVs

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PROFESSIONAL HISTORY

Dr. Anders is an Associate Consultant and a Fishery Scientist with Cramer Fish Sciences Inc., and serves as Affiliate Faculty in the Department of Fish and Wildlife Resources at the University of Idaho in Moscow. Paul has 23 years experience in the fisheries profession, with 20 years in the Columbia River Basin, US and Canada. Paul is a prolific writer, having published over 100 scientific papers, reports, articles, and abstracts addressing a wide range of fisheries and aquatic ecology topics since 1991. Dr. Anders has contributed to the acquisition of over $25 million in fisheries and aquatic science project funding through authorship and co-authorship of numerous grant proposals since 1988.

EDUCATION

Ph.D. Natural Resources (Conservation Biology of White Sturgeon), University of Idaho, 2002

M.S. Biology (Fisheries), Eastern Washington University, 1991

B.S. Natural Science, Saint Norbert College, 1983

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EMPLOYMENT HISTORY

1. Associate Consultant, Fishery Scientist, Cramer Fish Sciences (Formerly S. P. Cramer and Associates) Moscow, ID. (10/05-Present)
2. Affiliate Faculty, University of Idaho, College of Natural Resources, Fish and Wildlife Department (9/03-present)
3. Senior Fisheries Consultant, S. P. Cramer and Associates, Moscow, ID. (10/02-10/05)
4. Fisheries Scientist (0.5FTE) Columbia River Inter-Tribal Fish Commission, Steelhead kelt reconditioning project (Fall 01 – Fall 02)
5. Research Support Scientist II, University of Idaho, Center for Salmonid and Freshwater Species at Risk Aquaculture Research Institute, Fish Genetics Lab, Moscow, ID. (1/00-10/02)
6. Research Associate, University of Idaho, Center for Salmonid and Freshwater Species at Risk Aquaculture Research Institute, Fish Genetics Lab, Moscow, ID. (1/99-1/00)
7. Independent Fisheries Consultant (1/99-10/02)
8. Doctoral Research Assistant, University of Idaho, Aquaculture Research Institute, Fish Genetics Lab, Moscow, ID. (7/96-12/98)
9. Fisheries Biologist/Administrator, Kootenai Tribe of Idaho, PO. Box 1269, Bonners Ferry, ID. (5/94-7/96)
10. Fisheries Biologist, Kootenai Tribe of Idaho, PO. Box 1269, Bonners Ferry, ID. (2/93-5/94)
11. Fisheries Biologist (GS-9-482), U.S. Fish and Wildlife Service, Columbia River Field Station, Cook WA. (8/90 - 2/93)
12. Graduate Research Assistant, Eastern Washington University, Cheney, WA. (1/89-5/91)
13. Fisheries Technician, white sturgeon research Idaho Department of Fish and Game, Bonners Ferry, ID. (1/89-8/90)
14. Fisheries Technician, anadromous research, Idaho Department of Fish and Game, Lewiston, ID. (12/87-12/89)
15. Research Assistant, altered reservoir ecology, Fish and Wildlife Cooperative Research Unit, South Dakota State University, Brookings (9/84-12/87)
16. Research Assistant, stream fish ecology, University of North Dakota, Grand Forks, and University of Minnesota Biological Research Station, Itasca, MN. (5-9/84)

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Research grant acquisition history from grant proposals authored or coauthored by Paul Anders, including submitted proposals for work through 2009. See the following page for project titles and funding sources.

Project:	1	2	3	4	5	6	7	8 to 16
Year								
1988	$117,653							
1989	$156,104							
1990	$236,430							
1991	$150,000							
1992	$179,723							
1993	$649,573							
1994	$378,553							
1995	$952,387	$175,000						
1996	$67,356	$175,000						
1997	$566,650	$226,600						
1998	$715,000	$250,000		$40,000				
1999	$1,263,692	$245,598		$60,000				
2000	$880,193	$300,000		$146,938				
2001	$1,147,674	$272,410		$136,043				
2002	$1,330,389	$380,539						
2003	$989,751	$710,268						
2004	$1,390,068	$953,377					$70,000	
2005	$1,413,817	$1,643,840	$20,100					
2006	$1,413,817	$1,643,840	$130,500					
2007	$1,970,800	In negotiation	In negotiation	In negotiation				$68, 367
Totals	**$13,998,830**	**$6,976,472**	**$146,300**	**$382,981**			**$70,000**	**$68,367**

Total grant money secured through to date in 2007: $ 21,642,950

Project	Project funding source(s) and Project Titles
1	BPA/KTOI Project 198806400 - Kootenai River Native Fish Restoration and Conservation Aquaculture
2	BPA/KTOI Project 199404900 - Kootenai River Ecosystem Improvements Project
3	BPA/KTOI Project 200201100 - Kootenai River Floodplain Operational Loss Assessment
4	BPA/UI Projects 19860500/19990220 - Assessing Genetic Variation Among Columbia Basin White Sturgeon Populations
5	BPA/KTOI Project 200200200 - Restore Natural Recruitment of Kootenai River White Sturgeon
6	BPA Project 200701330Systemwide distribution of genetic variation within and among populations of the white sturgeon
7	US Army Corps of Engineers - Fisheries Advisor
8	British Columbia Ministry of Water, Land, & Air Protection - Conservation aquaculture program design and review
9	British Columbia Ministry of Water, Land, & Air Protection - White Sturgeon Recovery
10	BPA-Kootenai River and Kootenai/y Lake Burbot demographic and genetic review
11	Mobrand Inc. - Hatchery Review
12	Parametrix: Lake Roosevelt - Whole Lake Assessment
13	NPPC - Artificial Production Review
14	Tetra Tech Inc. Critical Habitat Restoration Project
15	Canadian Columbia River Intertribal Fish Commission - White Sturgeon Stocking review
16	Canadian Columbia River Intertribal Fish Commission - Experimental non-essential population development and review
17	Yakama Indian Nation – Habitat and nutrient restoration research in anadromous salmonid habitats

PROFESSIONAL SOCIETY AND ORGANIZATION INVOLVEMENT

- Member of American Fisheries Society (1985-Present)
- Upper Columbia River White Sturgeon Recovery Team, Genetics Subcommittee, British Columbia (2001-Present)
- Chair of the Coeur d'Alene Tribal Interdisciplinary Hatchery Team (2002-2003)
- Member of Kootenai Tribe of Idaho's Research Review and Design Team (2002-present)
- Member of International Kootenay Ecosystem Restoration Team (IKERT, 1999-Present)
- Co-Chair of Columbia Basin White Sturgeon Genetics Workgroup (1999- Present)
- Member of the Snake River White Sturgeon Technical Advisory Committee (Idaho Power Company, 1999-Present)
- Member of Coeur d'Alene Tribal Interdisciplinary Hatchery Team, and Project Review Team (2001-2003)
- Member of the Society for Conservation Biology (1997-Present)
- Member of American Fisheries Society, Idaho Chapter (1988-1991, 1995-Present), Graduate Student Representative, Palouse Unit of the Idaho Chapter (1997-1998)
- Federally appointed member of U.S. Fish and Wildlife Service Kootenai River White Sturgeon Recovery Team (1994-Present)
- Member of Pacific Fishery Biologists (1992-1996)
- Member of American Fisheries Society, Pacific International Chapter (1991-1994)
- Member Kootenai River Network (1990-Present)
- Associate Member of Sigma Xi Scientific Research Honor Society (1989-Present)
- Member of Gamma Sigma Delta, Academic Honor Society of Agriculture, (1986, 1987)
- President of Lakota Chapter of the National Audubon Society, Brookings, SD. (1/87-12/87)
- Member of Lakota Chapter of the Audubon Society (3/86-3/88)
- Member of South Dakota Chapter of The Nature Conservancy (1986-1987)
- Member of South Dakota Wildlife Federation (1986)
- Chairman of Fisheries Committee, Brookings Wildlife Conservationists (1986)
- Member of American Fisheries Society, Dakota Chapter (1985-1987)

PROFESSIONAL REFERENCES

The following people are available for comment concerning my professional performance and accomplishments:

- Steve Cramer, President and Principal Consultant, Cramer Fish Sciences Inc. 600 NW Fariss Rd. Gresham OR. 97030 (503) 491-9577. SteveC@spcramer.com
- Ray Beamesderfer, Associate Consultant, Fishery Scientist, Cramer Fish Sciences Inc. Inc. 600 NW Fariss Rd. Gresham OR. 97030 (503) 491-9577. beamesderfer@spcramer.com
- Dr. Ken Cain, Associate Professor, Department of Fish and Wildlife resources, University of Idaho, Moscow, ID. 83843. kcain@uidaho.edu
- Susan Ireland, Fishery Biologist/ Program Director, Kootenai Tribe of Idaho, Bonners Ferry, ID. 83805 (208) 267-3620; ireland@kootenai.org.
- Dr. Ken Ashley, British Columbia Ministry of Land Water and Air Protection, University of British Columbia. Ken.Ashley@gvrd.bc.ca (604) 432-6438.
- Harvey Andrusak, President, Redfish Consulting Ltd. Nelson, British Columbia. handrusak@shaw.ca, (250) 825-9365.
- Colin Spence, Rare and Endangered Species Biologist, British Columbia Ministry of Environment, Lands, and Parks, 333 Victoria St., Nelson, BC. (250) 354-6777

CLIENT AND COLLABORATOR TESTIMONIALS

- "Paul is an outstanding scientist that understands practical application of research results. He is a pleasure to work with and has impeccable integrity."
  - Jason Scott, Senior Fisheries Scientist, GeoEngineers, Inc., Spokane Washington.

- "Dear Dr. Anders: Thank you very much for your expert input and assistance on the Kootenai River fertilization experiment. The Kootenai River project is the largest and one of the most complex nutrient enrichment restoration experiments to have ever occurred. It is a perfect complement to the multi-year Kootenay Lake fertilization experiment downstream in British Columbia. It would not have been possible to obtain regulatory approval for this experiment without the sound science and management experience you brought to the process".

  - Ken Ashley, Ph.D., Limnologist and Senior Engineer, Greater Vancouver Regional District, BC.

- "In collaboration with Paul Anders at Cramer Fish Sciences, we were able to develop a truly innovative approach to Subbasin Planning in the Kootenai. Aspects of our plan became a model for other Subbasin Plans across the Columbia River Basin. Paul's contribution, along with his professionalism and hard work, was a big reason for that."

  - David Rockwell, Natural Resource Author and Consultant, Dixon, Montana

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Raymond C. P. Beamesderfer

Senior Fish Scientist

Education and Training

B.S. in Wildlife & Fisheries Biology 1979, University of California, Davis.

M.S. in Fishery Resources 1983, University of Idaho.

Employment History

Cramer Fish Sciences, Senior Fish Scientist, 2000-Present.

Oregon Department of Fish and Wildlife, Fishery Management Biologist, 1997-2000.

ODFW, Staff Biologist/ Analyst, 1994-1997.

ODFW, Fish Research, 1983-1993.

Professional Activities

Certified Fisheries Scientist, American Fisheries Society, 1989.

Associate Editor, North American Journal of Fisheries Management, 1992-1993.

Speaker at numerous regional, national, and international symposiums of fisheries scientists.

Ray has analyzed applied problems of fish biology and management for over 25 years:

- extensive experience with salmon, steelhead, trout, sturgeon, warmwater gamefish, and nongame species;
- work in Oregon, Washington, Alaska, Idaho, California, and British Columbia;
- numerous reports, biological assessments, management plans, and scientific articles on fish population dynamics, fish conservation, fishery management, sampling, and species interactions;
- special expertise in the use of quantitative analysis, statistics, and computer modeling to solve difficult fish questions and in synthesizing and translating scientific analyses for a variety of audiences;
- widely-recognized expertise in sturgeon population dynamics, biological assessment, conservation, and management.

With *Fish Sciences*, Ray has completed a wide variety of fishery management, biological assessment, and conservation or recovery planning projects for State and Federal Agencies, Indian Tribes, Private Industry, and Non-Governmental Organizations. Significant sturgeon-related projects have included conservation and recovery plans for upper Columbia River white sturgeon and Sacramento green sturgeon, status assessments and hatchery evaluations of Kootenai sturgeon, biological assessments of the effects of water project operations, and design of monitoring and evaluation programs. Ray has also provided extensive technical review and input on pallid sturgeon issues.

Previously, he worked for the Oregon Department of Fish and Wildlife as a management biologist for Columbia River salmon and sturgeon fisheries; staff analyst and agency representative for inter-jurisdictional Columbia River salmon, resident fish, and hydropower issues; and program and project leader for research on sturgeon stock assessments, predator control evaluation, warmwater fish management alternatives, adult and juvenile salmon passage at dams and diversions, and design and implementation of a system to facilitate exchange of salmon and steelhead data for the Columbia River basin (*StreamNet*).

Projects

Biological Assessment

Comments on green sturgeon portions of the Oroville Dam Draft Biological Opinion by the National Marine Fisheries Service. 2009. *California State Water Contractors.*

Comments on green sturgeon portions of the Biological Opinion on the Long-term Central Valley Project and State Water Project Operations Criteria and Plan. 2009. *California State Water Contractors.*

Kenai River Habitat Assessment. 2008. *Alaska Department of Fish and Game and the Kenai River Sportfishing Association.*

Status and limiting factors of ESA-listed lower Columbia and Willamette River chum, Chinook, coho, and steelhead in supplemental comprehensive analysis of the federal Columbia River power system and mainstem effects of the upper Snake and other tributary actions. 2007. *National Oceanic and Atmospheric Administration and the Bonneville Power Administration*.

Independent technical review of predation scenarios on juveniles salmonids in the Columbia River. 2007. *Battelle Pacific Northwest Laboratory*.

Independent technical review of evaluation of ladder use at John Day Dam by chinook salmon and steelhead trout. 2006. *Battelle Pacific Northwest Laboratory*.

Oregon Native Salmon and Steelhead Conservation Assessment. 2005. *Oregon Department of Fish and Wildlife*.

Population dynamics and extinction risks of Kootenai River burbot. 2004. *Kootenai Tribe of Idaho and Idaho Department of Fish and Game*.

Historical and current information on green sturgeon occurrence in the Sacramento and San Joaquin Rivers and tributaries. 2004. *California State Water Contractors*.

Stranding of juvenile fall chinook salmon in the Hanford Reach of the Columbia River as a result of hydropower operations. 2003. *Columbia River Intertribal Fish Commission for Alaska Department of Fish and Game*.

Green sturgeon status review. 2002. *Metropolitan Water District of Southern California*.

Indirect effects of water export on juvenile salmon in the Sacramento-San Joaquin Delta: a conceptual Foundation. 2002. *Metropolitan Water District of Southern California*.

Analysis of cutthroat trout population viability in Timothy Lake, Oregon. 2002. *Portland General Electric*.

Evaluation and modeling of steelhead capacity, population dynamics, and reintroduction potential above impoundments in the upper Deschutes River, Oregon. 2001. *Portland General Electric*.

Analysis of salmon rearing, migration, survival, and passage based on PIT tag detections for the Clackamas River. 2001. *Portland General Electric*.

Biological assessment of effects of Sherman Island Levee repairs on listed Delta smelt and Sacramento splittail. 2001. *James C. Hanson Engineers*.

Review of conservation assessment of steelhead populations in Oregon. 2001. *American Forest Resources Council*.

Documentation of existing and historic habitat, and native and introduced fish in the Clackamas basin, Oregon. 2001. *Portland General Electric*.

Relicensing studies of fish populations in the upper Stanislaus River, California. 2001. *Pacific Gas and Electric Company and Tri-dam Project*.

Assessments of biological and habitat effects of Otter Creek and South Fork to Black Bear Creek projects. 2001. *Alaska Power and Telephone*.

Conservation & Recovery Planning

Assessment of adult population objectives and monitoring needs for Pallid Sturgeon. March 23-24, 2009. Pallid Sturgeon Conference and Workshop. Billings MT.

Peer review of critical habitat designation for white sturgeon populations in British Columbia, Canada under the Species At Risk Act. 2009. *Department of Fisheries and Oceans Canada.*

Preparation of background materials for the development of the recovery plan for the southern distinct population segment of North American green sturgeon. 2009. *National Marine Fisheries Service Southwest Region.*

Lower Columbia salmon and steelhead recovery plan. 2009. *Washington Lower Columbia River Fish Recovery Board*.

Research, monitoring and evaluation program for Lower Columbia Salmon and Steelhead. 2008. *Washington Lower Columbia River Fish Recovery Board.*

Estimation of salmon recovery targets for ESA-listed lower Columbia and Willamette river coho, Chinook, Chum, and steelhead using population viability analysis. 2007. *Oregon Department of Fish and Wildlife and Washington Lower Columbia River Fish Recovery Board.*

Lower Columbia salmon and steelhead recovery plan (interim). 2002-2004. *Washington Lower Columbia River Fish Recovery Board*.

Kootenai River Burbot conservation plan. 2004. *Kootenai Tribe of Idaho*.

Upper Columbia River white sturgeon recovery plan. 2002. *Spokane Tribe of Indians, British Columbia Ministry of Water, Land and Air Protection, and BC Hydro Corporation*.

Fishery Management

Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. 2009. *Pacific Fishery Management Council.*

Biometrics and fishery analysis support for the Pacific Fishery Management Council Scientific and Statistical Committee. 2009. *Oregon Department of Fish and Wildlife.*

Risk Analysis of All-H Recovery Strategies for Tule Fall Chinook. 2009. *Washington Lower Columbia River Fish Recovery Board.*

Peer review of Marine Stewardship Council assessment of the sustainability of British Columbia commercial salmon fishery. 2009. *TAVEL Certification.*

Problems and solutions in escapement goal management of upper Cook Inlet salmon fisheries. 2008. *American Fisheries Society Alaska Chapter Meeting.*

Marine Stewardship Council assessment of the sustainability of Russia's JSC Gidrostroy commercial salmon fishery on Iturup Island in the south Kuriles. 2008. *Scientific Certification Systems*.

Upper Cook Inlet salmon fishery model for analyzing harvest, allocation, and escapement effects of alternative management strategies. 2008. *Kenai River Sportfishing Association*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2008. *Kenai River Sportfishing Association*.

Fishery risk assessment for Columbia River coho based on population viability analysis. 2007. *Washington Department of Fish and Wildlife and the Lower Columbia Fish Recovery Board*.

Biological analysis of population and fishery effects of *de minimis* fisheries for Klamath Fall Chinook. 2007. *Pacific Fishery Management Council*.

Marine Stewardship Council assessment of the sustainability of Alaska commercial salmon fisheries. 2007. *Scientific Certification Systems and the Alaska Department of Fish and Game*.

Kasilof sockeye escapement goal analysis. 2007. Kenai River Sportfishing Association.

Analysis of size-selective Kenai King salmon fisheries and regulations. 2007. *Alaska Department of Fish and Game*.

ESA fisheries management and evaluation plan for lower Columbia River coho in Oregon freshwater fisheries of the lower Columbia River. 2005. *Oregon Department of Fish and Wildlife*.

Analysis of the potential effects and alternatives for selective fishing in the lower Columbia River commercial and recreational fisheries. 2005. *Bonneville Power Administration*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2005. *Kenai River Sportfishing Association*.

Review of the Coded Wire Marking Program for Columbia Basin Hatchery Salmon and Steelhead, Phase I. 2004. *Bonneville Power Administration*.

Review of live capture selective harvest methods study for Columbia River spring chinook. 2003. *Salmon for All*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2002. *Kenai River Sportfishing Association*.

Effects of large-mesh gillnet use on steelhead and salmon catch in Columbia River Zone 6 gillnet fisheries. 2001. *Yakama Nation and the Bonneville Power Administration*.

ESA fisheries management and evaluation plan for lower Columbia River chinook in Oregon freshwater fisheries of the lower Columbia River. 2001. *Oregon Department of Fish and Wildlife*.

ESA fisheries management and evaluation plan for upper Willamette Spring chinook in freshwater fisheries of the Willamette basin and lower Columbia River. 2000. *Oregon Department of Fish and Wildlife*.

Conservation risks of mixed stock fisheries for wild spring chinook salmon from Oregon's McKenzie River based on a population viability analysis. 2000. *Oregon Department of Fish and Wildlife.*

Peer review of certification report on sustainability of Alaska salmon fisheries. 2000. *Marine Stewardship Council*.

Hatchery Evaluation

Strategic and Hatchery Master Plans for impounded white sturgeon populations of the lower Columbia and Snake rivers. 2008-2009. Columbia River Inter-tribal Fish Commission.

Sturgeon hatchery planning and evaluation technical assistance. 2009. *Yakama Nation Fisheries.*

Upper Columbia sturgeon hatchery release strategy. 2008. *British Columbia Ministry of Environment and BC Hydropower*.

Kootenai River White Sturgeon Conservation Aquaculture Program Overview, 1990-2007. 2008. *Kootenai Tribe of Idaho*.

Kootenai River sturgeon hatchery and endangered species evaluations. 2001-2009. *Kootenai Tribe of Idaho*.

Hatchery genetic management plans for the Sandy and Clackamas River Hatcheries. 2005. *Oregon Department of Fish and Wildlife*.

Coeur d'Alene Tribe Trout Production Master Plan. 2002. *Coeur d'Alene Tribe*.

Scientific Publications

2009. Evidence of density- and size-dependent mortality in hatchery-reared juvenile white sturgeon in the Kootenai River. Canadian Journal of Fisheries and Aquatic Sciences 66:802-815. *(Justice, Pyper, Beamesderfer, Paragamian, Rust, Neufeld & Ireland).*

2008 Population dynamics and extinction risk of burbot in the Kootenai River, Idaho, USA and British Columbia, Canada. American Fisheries Society Symposium 59:213-234. *(Paragamian, Pyper, Daigneault, Beamesderfer & Ireland).*

2007 Use of life history information in a population model for Sacramento green sturgeon. Environmental Biology of Fishes 79:315-337. *(Beamesderfer, Simpson, & Kopp).*

2005 Status, population dynamics, and future prospects of the endangered Kootenai River white sturgeon population with and without hatchery intervention. Transactions of the American Fisheries Society 134:518-532. *(Paragamian, Beamesderfer & Ireland).*

2004 Dilemma on the Kootenai River - The risk of extinction or when does the hatchery become the best option? American Fisheries Society Symposium 44:377-385. *(Paragamian & Beamesderfer).*

2003 Growth estimates from tagged white sturgeon suggest that ages from fin rays underestimate true age in the Kootenai River, USA and Canada. Transactions of the American Fisheries Society 132:895-903. *(Paragamian & Beamesderfer).*

2002 Success of hatchery-reared juvenile white sturgeon (Acipenser transmontanus) following release in the Kootenai River, Idaho, USA. Journal of Applied Ichthyology 18: 642-650. *(Ireland, Beamesderfer, Paragamian, Wakkinen & Siple)*.

2000 Managing fish predators and competitors: Deciding when interspecific intervention is effective and appropriate. Fisheries 25(6):18-23. *(Beamesderfer).*

1997 Alternatives for the protection and restoration of sturgeons and their habitat. Environmental Biology of Fishes 48:407-417. *(Beamesderfer & Farr).*

1996 Evaluation of the biological basis for a predator control program on northern squawfish (*Ptychocheilus oregonensis*) in the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908. *(Beamesderfer, Ward & Nigro).*

1995 Growth, natural mortality, and predicted response to fishing for largemouth and smallmouth bass populations in North America. North American Journal of Fisheries Management 15:688-704. *(Beamesderfer & North).*

1995 Differences in the dynamics and production of impounded and unimpounded white sturgeon populations in the lower Columbia River. Transactions of the American Fisheries Society 126:857-872. *(Beamesderfer, Rien & Nigro).*

1994 Accuracy and precision in age estimates of white sturgeon using pectoral fin rays. Transactions of the American Fisheries Society 123:255-265. *(Rien & Beamesderfer).*

1994 Retention, recognition, and effects on survival of several tags and marks on white sturgeon. California Fish and Game 80:161-170. *(Rien, Beamesderfer & Foster).*

1993 Distribution and movements of white sturgeon in three lower Columbia River reservoirs. Northwest Science 67:105-111. *(North, Beamesderfer & Rien).*

1993 A standard weight equation for white sturgeon. California Fish and Game 79:63-69. *(Beamesderfer).*

1992 Book review of "Pacific Salmon Life Histories." Fisheries 17:56-58. *(Beamesderfer).*

1992 Reproduction and early life history of northern squawfish (*Ptychocheilus oregonensis*) in Idaho's St. Joe River. Environmental Biology of Fishes 35:231-241. *(Beamesderfer).*

1991 Abundance and distribution of northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:439-447. *(Beamesderfer & Rieman).*

1991 Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458. *(Rieman, Beamesderfer & Poe).*

1990 Management implications of a model of predation by a resident fish on juvenile salmonids migrating through a Columbia River reservoir. North American Journal of Fisheries Management 10:290-304. *(Beamesderfer, Rieman, & Vigg).*

1990 Comparison of efficiency and selectivity of three gears used to sample white sturgeon in a Columbia River reservoir. California Fish and Game 76:174-180. *(Elliott & Beamesderfer).*

1990 Dynamics of a northern squawfish population and the potential to reduce predation on juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 10:228-241. *(Rieman & Beamesderfer).*

1990 White sturgeon in the lower Columbia River: Is the stock overexploited? North American Journal of Fisheries Management 10:388-396. *(Rieman & Beamesderfer).*

1988 Size selectivity and bias in estimates of population statistics of smallmouth bass, walleye, and northern squawfish in a Columbia River reservoir. North American Journal of Fisheries Management 8:505-510. *(Beamesderfer & Rieman).*

Name James E. Garvey

Title Associate Professor, Zoology, College of Science
Director, Fisheries and Illinois Aquaculture Center, Graduate School

Date of Birth 11 July 1968

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Fisheries and Illinois Aquaculture Center (FIAC)
Department of Zoology
1125 Lincoln Drive
Southern Illinois University–Carbondale
jgarvey@siu.edu
http://www.science.siu.edu/zoology/garvey/index.html
http://fisheries.siu.edu
http://fishdata.siu.edu (curator)

Education

1998	Post-Doctoral Fellow, Queens University, Ontario
1997	Ph.D., Zoology, The Ohio State University, Ohio
1992	M.S., Zoology, The Ohio State University, Ohio
1990	B.A., *cum laude*, Zoology, Miami University, Ohio

Professional Experience

2009	Director, Fisheries and Illinois Aquaculture Center, Southern Illinois University
2008-2009	Interim Director, Fisheries and Illinois Aquaculture Center, Southern Illinois University
2005-2008	Associate Director, Fisheries and Illinois Aquaculture Center, Southern Illinois University
2005-	Associate Professor, Department of Zoology, Southern Illinois University
2000-2005	Assistant Professor, Department of Zoology, Southern Illinois University
1998-2000	Assistant Professor, Division of Biology, Kansas State University
1997-1998	Postdoctoral Fellow, Department of Biology, Queens University, Ontario
1997	Research Associate, Department of Zoology, The Ohio State University
1996-1997	Presidential Fellow, Graduate School, The Ohio State University
1990-1996	Graduate Research Associate, Department of Zoology, The Ohio State University
1990-1996	Graduate Teaching Associate, Department of Zoology, The Ohio State University
1988-1990	Research Technician, Department of Zoology, Miami University
1988	Student Researcher, School for Field Studies, St. John, U.S. Virgin Islands

Fields of Research Competence

Aquatic ecology, fish ecology, basic and applied fish biology, limnology, food web dynamics, life history modeling. My current research follows three basic themes:

1. Understanding how bioenergetics and various life history characteristics of fishes and other ectotherms vary along environmental gradients to affect population dynamics

and community interactions in lakes and rivers.

Key citations:

Garvey, J.E. et al. 2003. Energetic adaptations along a broad latitudinal gradient: implications for widely distributed communities. BioScience 53(2):141-150.

Garvey, J.E. et al. 2009. Searching for threshold shifts in spawner recruit relationships. Canadian Journal of Fisheries and Aquatic Sciences 66:312-320.

2. Determining the relative impact of abiotic and biotic characteristics of aquatic systems on the movement and spatial distribution of fishes through effects on physiology and biotic interactions.

Key citations:

Garvey, J.E. et al. 2004. Interactions among allometric scaling, predation and ration affect size-dependent growth and mortality of fish during winter. Ecology 85(10):2860-2871.

Garvey, J.E. et al. 2007. A hierarchical model for oxygen dynamics in streams. Canadian Journal of Fisheries and Aquatic Sciences 64:1816-1827.

3. Exploring the impact of spatial scale on species interactions, with particular relevance to the invasion potential of exotic species.

Key citations:

DeGrandchamp, K.L., **J.E. Garvey**, and L.A. Csoboth. 2007. Linking reproduction of adult Asian carps to their larvae in a large river. Transactions of the American Fisheries Society 136:1327-1334.

Lohmeyer, A.M., and **J.E. Garvey**. 2009. Placing the North American invasion of Asian carp in a spatially explicit context. Biological Invasions 11:905-916.

Administrative Duties at Fisheries and Illinois Aquaculture Center (FIAC)

Plan and implement actions that fulfill the research and graduate training mission of the FIAC–an interdisciplinary research laboratory and training facility with considerable laboratory and office infrastructure and over fifty personnel, including faculty members, graduate assistants, post-doctoral associates, researchers, administrative assistants, and undergraduate technicians.

Courses at Southern Illinois University

Conservation Biology, Zoology 410–(3 hours, Fall 2009)
Limnology, Zoology 415–(3 hours, Fall 2007, 2008; web site: http://fisheries.siuc.edu/water/)
Aquatic Ecosystem Management, Zoology 585C–(3 hours, Summer 2007)
Principles of Ecology, Biology 307- (3 hours, Spring 2006)
Fish Ecology, Zoology 485-2–(3 hours, Spring 2004)

Fisheries Conservation and Management, Zoology 466 - (3 hours; Fall 2000-2007; course web site: http://www.science.siu.edu/zoology/materials/zool466/index.html)
Advanced Fisheries Management, Zoology 569 - (3 hours; Spring 2001)
Fisheries Seminar, Zoology 586 - (1 hour; Fall 2001 [fisheries science sociology], Fall 2005 [review of "A Primer of Ecological Statistics"])
Fish Stock Assessment, Zoology 568 - (2 hours; Spring 2002)
Fish Biology, Zoology 306–(Occasionally lectured, Spring 2003)
Dynamics of Exploited Fish Populations, Zoology 585Z–(3 hours, Spring 2005)

Courses at Kansas State University

Fish Ecology, Biology 697 - (3 hours; 1 year)
Ichthyology, Biology 542 - (3 hours; 1 year)

Courses at Ohio State University

Honors General Biology - Prepared and conducted laboratory sessions (1 year)
Introduction to Ecology - Developed course and occasionally lectured (5 years)

Completed Graduate Students at Southern Illinois University = 18

Post-Doctoral Fellows

Dr. Timothy Spier, 2001-2004. Demographics of Pallid Sturgeon. Assistant Professor, Western Illinois University, Fall 2004.

Current Graduate Students

Quinton Phelps, Ph.D., Recruitment of sturgeons in the Mississippi River corridor. (anticipated graduation: fall 2010)

Dawn Sechler, M.Sc., Feeding ecology of young sturgeon in the Mississippi River. (anticipated graduation: fall 2009)

Heather Calkins, M.Sc., Trophic basis of habitat selection of Asian carps. (anticipated graduation: fall 2009)

Jenny Johnson, M.Sc., Habitat selection of young sturgeon (start: fall 2009)

Bill Hintz, Ph.D., Sturgeon recruitment in the Mississippi River system (start: fall 2009)

Funded Grants (> $2.5 M lifetime); Since 2005

Monitoring Population Status and Movement of Native and Non-native Fishes in the Upper Mississippi River. **Garvey** and Brooks. May 2009–September 2009. U.S. Army Corps of Engineers (includes projects for sturgeon, fish passage, New Madrid Floodway, and Asian carps; Federal)

Status of Aquatic Resources on Sparta National Guard Property. Garvey. Illinois Department of Military Affairs. 2008-2009 (State)

Pallid sturgeon reproduction in the Mississippi River. Garvey, Brooks, Herzog, Hrabik. Spring 2008. U.S. Army Corps of Engineers, Navigation and Ecosystem Sustainability Program (Federal–Cooperative Ecosystem Study Unit Program)

Maintenance of a fish passage monitoring network in the Upper Mississippi River. Garvey and Brooks. Spring 2008. U.S. Army Corps of Engineers, Navigation and Ecosystem Sustainability Program (Federal–Cooperative Ecosystem Study Unit Program)

Development of a hydrological monitoring network at the Mississippi River Wetland Field Station. Whiles, Baer, Battaglia, Hellgren, **Garvey**, Whitledge, Williard. Spring 2007. ORDA Interdisciplinary Grant Program. (University)

Development of a Geographic Information System for Asian carps. September 2006-September 2007. **Garvey**. U.S. Fish and Wildlife Service. (Federal)

Monitoring Population Status and Movement of Native and Non-native Fishes in the Upper Mississippi River. **Garvey** and Brooks. May 2006–September 2007. U.S. Army Corps of Engineers (includes projects for sturgeon, fish passage, and Asian carps; Federal)

Age-Related Demographics of Asian Carp in the Illinois River. ORDA Undergraduate Research Award with Matt Wegener. July 1, 2005 - June 30, 2006. (University)

Larval fish assemblages in the Illinois River. ORDA Undergraduate Research Award with Shea Cox. July 1, 2005 - June 30, 2006. (University; declined by Cox)

Honors and Awards

2008 Illinois Award, Illinois Association of Wastewater Agencies, Evanston, Illinois

2001 Best Oral Presentation, Annual Meeting of the Illinois Chapter of the American Fisheries Society, February 2001

2000 Best Oral Presentation, 2000 Annual Meeting of the Kansas Chapter of the American Fisheries Society, Manhattan, Kansas

1999 Article titled "Competition between larval fishes in reservoirs: the role of relative timing of appearance" (co-author, R.A. Stein) was among 5 nominated by a selection committee for Best Paper in Transactions of the American Fisheries Society (out of ~100 articles)

1999 American Society of Limnology and Oceanography's DIALOG III Symposium, Bermuda, October 1999

1998 Graduate Faculty Status, Kansas State University, November 1998

1996 Best Poster, Annual Meeting of the American Fisheries Society, Dearborn, Michigan, August 1996

1996 University Presidential Fellowship, July 1996

1995 Honorable Mention, Best Oral Presentation, Annual Meeting of the American Fisheries Society, Tampa, Florida, August 1995

Student Awards

2009 Quinton Phelps, Student Mentee Award, American Fisheries Society Annual Meeting, Nashville, TN (national)

2009 Quinton Phelps, Richard E. Blackwelder Student Achievement Award, Department of Zoology (department, one of Zoology's highest honors)

2009 Dawn Sechler, Student Research Grant, Illinois Chapter of the American Fisheries Society, $500 (state)

2009 Quinton Phelps, Student Research Grant, Illinois Chapter of the American Fisheries Society, $480 (state)

2008 Dawn Sechler, Semi-finalist, Janice Lee Fenske Memorial Award, North Central Division, American Fisheries Society (regional)

2008 Quinton Phelps, College of Science, Todd Fink Memorial Conservation Award (college)

2008 Dawn Sechler, Best Poster Award, Illinois Chapter of the American Fisheries Society, Rockford, IL (state)

2006 Rob Colombo, Department of Zoology, Foote and Foote Graduate Teaching Award (department)

2006 Rob Colombo, Best Paper, Mississippi River Research Conference, LaCrosse, Wisconsin (regional)

2005 Rob Colombo, Skinner Travel Award, American Fisheries Society Meeting, Anchorage, Alaska, September 2005 (national)

2005 Laura Csoboth, Student Travel Award, Early Life History Section, American Fisheries Society, Barcelona, Spain, July 2005 (international)

2005 Rob Colombo, Lewis Osborne Best Student Platform Presentation Award, Illinois American Fisheries Society Meeting, Moline, Illinois, March 2005 (Provides travel support to national AFS meeting) (regional)

2005 Rob Colombo, Kelly DeGrandchamp, and Doug Schultz. Student Travel Awards, Illinois American Fisheries Society Meeting, Moline, Illinois, March 2005 (state)

2004 Brian Koch, National Society of Environmental Toxicology and Chemistry, Jeff Black Student Award (national)

2004 Dean Sherman, Honorable Mention, Best Poster Award, Undergraduate Research Forum, Southern Illinois University, Carbondale, March 2004 (university)

2004 Laura Csoboth, Student Travel Award, Illinois American Fisheries Society Meeting, Champaign, Illinois, March 2004 (state)

Professional Service (Since 2005)

2009 Reviewer, Great Lake Fishery Commission proposal

2009 Reviewer, USGS Columbia Environmental Research Center, draft research product (report)

2009 Program Co-Chair, 2009 Midwest Fish and Wildlife Conference Planning Committee, Springfield, IL

2009 Panelist, NSF Graduate Research Fellowship Program, Ecology, February 2009, Arlington, VA

2009 Reviewer, Hudson River Foundation proposal

2008 Past-president, Illinois Chapter of the American Fisheries Society

2008 SIUC Representative, Cooperative Ecosystems Study Unit

2006-present Webmaster, Illinois Chapter of the American Fisheries Society

2007 President, Illinois Chapter of the American Fisheries Society

2007 Site Reviewer, USGS Upper Mississippi Environmental Research Center, LaCrosse, WI, Sept. 10 -14, 2007

2007 Reviewer, USGS Long-term Monitoring Program 10- Year Report, 189 pages

2007 Reviewer, National Science Foundation, Ecology Panel, October 2007

2006 President-elect, Illinois Chapter of the American Fisheries Society

2006-2007 Chair, Farm Bill Advisory Committee, American Fisheries Society

2006 Reviewer, National Science Foundation, Ecology Panel & Biological Oceanography Program (N=2)

2006 Reviewer, National Fish and Wildlife Foundation proposal

2005 Participant, Pallid Sturgeon Recovery Team meeting to decide stocking strategies in the Missouri and Mississippi River basins, Denver, Colorado

2005	Member, Committee to Draft Pallid Sturgeon Conservation Plan for the Middle Mississippi River
2005-2006	Member, Systems Evaluation Team for Environmental Management Program in the Upper Mississippi River, US Fish and Wildlife Service, US Army Corps of Engineers, and US Geological Survey
2005	Secretary-Treasurer, Illinois Chapter of the American Fisheries Society
2005	Reviewer, US Army Corps of Engineers Scope of Work, Barge Entrainment by Larval and Adult Fish
2005	Reviewer, Great Lake Fisheries Commission grant proposal
2005	Reviewer, National Science Foundation proposals, Ecology Panel (2 proposals)
1994-present	Peer Reviewer of journals including *Behaviour, Biological Invasions, Canadian Journal of Zoology, Canadian Journal of Fisheries and Aquatic Sciences, Transactions of the American Fisheries Society, North American Journal of Fisheries Management*, *Ecology*, *Ecological Applications*, *Fisheries, Fisheries Management and Ecology, Great Basin Naturalist*, *American Midland Naturalist, Prairie Naturalist, Journal of Plankton Research, Animal Behaviour, Journal of the North American Benthological Society, Journal of Fish Biology, Environmental Biology of Fishes, Northwest Science, North American Journal of Aquaculture*, *Proceedings of the Royal Academy of Science –Great Britain, Journal of Applied Ichthyology, Journal of Animal Ecology, Hydrobiologia, Limnology and Oceanography* (average 8 reviews per year)

Society Memberships

2003-present	Member, American Institute of Biological Sciences
1990-present	Ecological Society of America
1990-present	American Fisheries Society
1990-present	North American Benthological Society
2001-present	Illinois Chapter of the American Fisheries Society
1999-present	Full Member, Sigma Xi
1999-2000	Kansas Chapter of the American Fisheries Society

University Service (Since 2005)

2009-	Senator, Faculty Senate Representative for College of Science, 3-year term (elected)

2009	Member, Governance Committee, Faculty Senate
2009-	Member, Middle Mississippi River Wetland Field Station Advisory Committee
2009	Chair, Aquaculture Faculty Search Committee, Department of Zoology, SIUC
2009	Member, Todd Fink Memorial Award Selection Committee
2008	SIUC Representative, North Central Regional Aquaculture Center Science Committee
2007	Member, SIUC Department of Zoology, Aquaculture/Fish Physiology Faculty Search Committee, Fall 2007
2007-2009	Touch of Nature Advisory Board, SIUC
2007-2009	Member, Doctoral Fellowship panel, SIUC
2005	Member, SIUC Department of Zoology, Fisheries Faculty Search Committee, Spring 2005
2005-2006	Member, Faculty Seed Grant Committee, Biological Science Panel, ORDA

Invited Presentations (Since 2005)

2009 College of Agricultural Sciences, SIUC, Brazil Agricultural Minister Visit, May 2009

2008 Department of Biology, Saint Louis University, November 2008

2008 Department of Biology, Kent State University, Kent, Ohio, October 2008

2008 Participant, Round-table discussion on Mississippi River research and management; Mississippi River Research Consortium, Davenport, Iowa, April 2008.

2007 Presenter, Bridging the Gap: addressing critical uncertainties in North American sturgeon conservation and recovery. Symposium, American Fisheries Society Meeting, San Francisco, CA, September 2007

2007 Department of Forestry and Natural Resources, Purdue University, March 2007

2006 Ecology, Evolution, and Organismal Biology Seminar Series, The Ohio State University, January 2006

2005 Chicago Sanitary Shipping Canal, Invasive Species Barrier stakeholder meeting, June 2005

2005 Water Resources Program, Utah State University, March 2005

Technical Reports (Selected reports available at http://fishdata.siu.edu)

R.C. Brooks, S.J. Tripp, and **Garvey, J.E.** 2008. Evaluation of a prototype ultrasonic detection system for quantifying fish movement in the Upper Mississippi River. Year 3. Annual Progress Report, US Army Corps of Engineers, St. Louis District and Rock Island District. 90 pages

R.C. Brooks, S.J. Tripp, and **Garvey, J.E.** 2007. Evaluation of a prototype ultrasonic detection system for quantifying fish movement in the Upper Mississippi River. Year 2. Annual Progress Report, US Army Corps of Engineers, St. Louis District and Rock Island District. 56 pages.

Garvey, J.E. 2007. Spatial assessment of Asian carp population dynamics: development of a spatial query tool for predicting relative success of life stages. US Fish and Wildlife Service. 45 pages. Spatial tool at http://fishdata.siu.edu/carptools

Garvey, J.E., and multiple co-authors. 2007. Swan Lake Habitat Rehabilitation and Enhancement Project: Post-Project Monitoring of Water Quality, Sedimentation, Vegetation, Invertebrates, Fish Communities, Fish Movement, and Waterbirds. US Army Corps of Engineers. 608 pages.

Garvey, J.E., E.J. Heist, R.C. Brooks, D.P. Herzog, R.A Hrabik, and K.J. Killgore. 2006. Current status of the Pallid Sturgeon (*Scaphirhynchus albus*) in the Middle Mississippi River: Habitat, Movement, and Demographics. Final Report–St. Louis District, US Army Corps of Engineers. 475 pages. (http://fishdata.siu.edu/pallid)

Garvey, J.E., R.C. Brooks, and S.J. Tripp. 2006. Evaluation of a prototype ultrasonic detection system for quantifying fish movement in the Upper Mississippi River. Annual Progress Report, US Army Corps of Engineers, St. Louis District and Rock Island District. 32 pages.

Garvey, J.E., K.L. DeGrandchamp, C.J. Williamson. 2006. Growth, fecundity, and diets of Asian carps in the Upper Mississippi River system. U.S. Army Corps of Engineers Technical Note, ERDC, Waterways Experimental Station. ERDC/TN ANSRP-06.

Colombo, R., **J.E. Garvey**, and R.C. Heidinger. 2005. Population Demographics of Catfish in Fished and Unfished Reaches of the Wabash River. Final Report to Indiana Department of Natural Resources, Federal Aid in Sport Fish Restoration Program, 128 pages.

Garvey, J.E., R. Brooks, M. Eichholz, J. Chick. 2005. Swan Lake Habitat Rehabilitation and Enhancement Project: Post-Project Monitoring of Fish Movement, Fish Community, Waterfowl, Water Quality, Vegetation, and Invertebrates. Year 1 Summary to US Army Corps of Engineers, St. Louis District. 135 pages.

Garvey, **J.E.**, M.L. Lydy, M.R. Whiles, and R.C. Heidinger. 2004. Aquatic environmental assessment of the Sparta Illinois National Guard Training Facility. Final Report. 137 pages.

Garvey, J.E., and M.R Whiles. 2004. An assessment of national and Illinois dissolved oxygen water quality criteria. Illinois Association of Wastewater Agencies. 56 pages.

Garvey, **J.E.**, M.L. Lydy, M.R. Whiles, and R.C. Heidinger. 2004. Aquatic environmental assessment of the Sparta Illinois National Guard Training Facility. Annual Progress Report. 62 pages.

Hrabick, R.A., K. J. Killgore, T. Spier, and **J.E. Garvey**. 2004. Pallid sturgeon recovery update. Issue 14. Edited by R. Wilson. Publication of the Pallid Sturgeon Recovery Team. p. 15.

Garvey, J.E., S.Welsh, and K.J. Hartman. 2003. Winter habitat used by fishes in Smithland Pool and Belleville Pool, Ohio River. Final Report. U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers. 295 pages.

Spier, T. and **J.E. Garvey**. 2003. Demographics of pallid sturgeon project. Annual Report. U.S. Army Corps of Engineers. 3 pages.

Garvey, J.E., B.D. Dugger, M.R. Whiles, S.R. Adams, M.B. Flinn, B.M. Burr, and R.J. Sheehan. 2003. Responses of fish, waterbirds, invertebrates, vegetation, and water quality to environmental pool management: Mississippi River Pool 25. U.S. Army Corps of Engineers. 181 pages.

Garvey, J.E. 2002. Winter habitat used by fishes in Smithland Pool, Ohio River. U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers, 90 pages.

Garvey, J.E., and R.J. Sheehan. 2001. Winter habitat associations of riverine fishes: predictions for the Ohio River, U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers, 39 pages.

Garvey, J.E., R.A. Wright, R.A. Stein, E.M. Lewis, K.H. Ferry, and S.M. Micucci. 1998. Assessing the influence of size on overwinter survival of largemouth bass in Ohio on-stream impoundments. Ohio Division of Wildlife Final Report. Federal Aid in Sport Fish Restoration Program 29, 288 pages.

Stein, R.A., and **J.E. Garvey**. 1996. A review of a technical report prepared for the Cuyahoga River (Ohio) Community Planning Organization by EnvironScience Inc.

Theses and Dissertations

Garvey, J.E. 1997. Strong interactors and community structure: testing predictions for reservoir food webs, Ph.D. dissertation, 235 pages.

Garvey, J.E. 1992. Selective predation as a mechanism of crayfish species replacement in northern Wisconsin lakes. M.S. thesis, The Ohio State University, 88 pages.

Policy Statements/Editorials

Garvey, J.E. (Written as Chair of Farm Bill Advisory Committee). 2007. Farm Bill 2007: placing fisheries upstream of conservation provisions. Fisheries 32(8):399-404.

Popular Press

Garvey, J.E. 2005. A tale of two sturgeons. Outdoor Illinois. April, pp. 11-13.

Book Chapters

4. Phelps, Q.E, S.J. Tripp, **J.E. Garvey**, D.P. Herzog, D.E. Ostendorf, J.W. Ridings, J.W. Crites, and R.A. Hrabik. In press. Ecology and habitat use of larval and age-0 paddlefish in the unimpounded Middle Mississippi River. Paddlefish Management, Propagation, and Conservation in the 21st Century: Building From 20 Years of Research and Management. American Fisheries Society, Bethesda, Maryland. (Peer reviewed)

3. Chipps, S.R., and **J.E. Garvey.** 2007. Chapter 11: Assessment of food habits and feeding patterns. Pages 473-514 in M.L. Brown and C.S. Guy, editors. Analysis and Interpretation of Freshwater Fisheries Data. American Fisheries Society, Bethesda, Maryland. (Peer reviewed)

2. DeVries, D.R., **J.E. Garvey**, and R.A. Wright. 2009. Chapter 5: Early life history and recruitment. Pages105-133 *in* S. Cooke and D. Philipp, editors. Centrarchid fishes: diversity, biology, and conservation. Wiley-Blackwell Scientific.

1. **Garvey, J.E.,** and S.R. Chipps. Accepted pending revision. Quantifying diets and energy flow. Third edition of Fisheries Techniques, American Fisheries Society. 97 MS pages, 1 table, 4 figures, 8 boxes. (Peer reviewed)

Book Reviews

2. **Garvey, J.E.** 2005. Sustaining hope for fisheries in the 21st century. Review of "Sustainable Management of North American Fisheries" Edited by E.E. Knudsen, D.D. MacDonald, and Y. K Muirhead. American Fisheries Society, Bethesda. 2004. 281 pp. Appeared in BioScience 55(10):3-5. (Invited)

1. **Garvey, J.E.** 2003. Searching for scales in fisheries. Review of "Hierarchical Perspectives on Marine Complexities: Searching for Systems in the Gulf of Maine" by Spencer Apollonio. Columbia University Press, New York. 2002. 229 pp. Appeared in BioScience 53(10):1004-1006. (Invited)

Peer-Reviewed Publications

49. Wahl, N.C., Q.E. Phelps, **J.E. Garvey**, S.T. Lynott, and W.E. Adams. 2009. Comparisons of scales and sagittal otoliths to back-calculated lengths-at-age of crappies collected from Midwestern waters. Journal of Freshwater Ecology 24(3):469-475.

48. Phelps, Q.E., D.P. Herzog, R.C. Brooks, V.A. Barko, D.E Ostendorf, J.W. Ridings, S.J. Tripp, R.E. Colombo, **J.E. Garvey**, and R.A. Hrabik. In press. Seasonal comparison of catch rates and size structure using three gear types to sample sturgeon in the Middle Mississippi River. North American Journal of Fisheries Management.

47. Colombo, R., Q. Phelps., **J.E. Garvey**, R.C. Heidinger, and N. Richards. Accepted pending revision. Comparison of channel catfish age estimates and resulting population demographics using two common structures. North American Journal of Fisheries

Management.

46. Schrey, A., R. Colombo, **J. Garvey**, and E. Heist. In press. Stock structure of shovelnose sturgeon analyzed with microsatellite DNA and morphological characters. Journal of Applied Ichthyology.

45. **Garvey, J.E.**, R.A. Wright, and E.A. Marschall. 2009. Searching for threshold shifts in spawner recruit relationships. Canadian Journal of Fisheries and Aquatic Sciences 66:312-320.

44. Tripp, S., Q. Phelps, R. Colombo, **J. Garvey**, B. Burr, D. Herzog, and R. Hrabik. 2009. Maturation and reproduction of shovelnose sturgeon in the Middle Mississippi River. North American Journal of Fisheries Management 29(3):730-738.

43. Tripp, S.J, R.E. Colombo, and **J.E. Garvey**. 2009. Declining recruitment and growth of shovelnose sturgeon in the Middle Mississippi River: implications for conservation. Transactions of the American Fisheries Society 138:416-422.

42. Lohmeyer, A.M., and **J.E. Garvey**. 2009. Placing the North American invasion of Asian carp in a spatially explicit context. Biological Invasions 11:905-916.

41. DeGrandchamp, K.L., **J.E. Garvey**, and R.E. Colombo. 2008. Habitat selection and dispersal of invasive Asian carps in a large river. Transactions of the American Fisheries Society 137:33-44.

40. Csoboth, L.A., and **J.E. Garvey**. 2008. Lateral exchange of larval fish between a restored backwater and a large river in the east-central U.S. Transactions of the American Fisheries Society 137:45-56.

39. Flinn, M.R. Whiles, S.R. Adams, and **J.E. Garvey**. 2008. Biological responses to contrasting hydrology in backwaters of Upper Mississippi River Navigation Pool 25. Environmental Management 41:468-486.

38. **Garvey, J.E.**, M.R. Whiles, and D. Streicher. 2007. A hierarchical model for oxygen dynamics in streams. Canadian Journal of Fisheries and Aquatic Sciences 64:1816-1827.

37. Colombo, R.E., **J.E. Garvey**, N.D. Jackson, R. Brooks, D.P. Herzog, R.A. Hrabik, and T.W. Spier. 2007. Harvest of Mississippi River sturgeon drives abundance and reproductive success: a harbinger of collapse? Journal of Applied Ichthyology 23:441-451.

36. DeGrandchamp, K.L., **J.E. Garvey**, and L.A. Csoboth. 2007. Linking reproduction of adult Asian carps to their larvae in a large river. Transactions of the American Fisheries Society 136:1327-1334.

35. Jackson, N.J., **J.E. Garvey**, and R.E. Colombo. 2007. Comparing aging precision of calcified structures in shovelnose sturgeon. Journal of Applied Ichthyology 23:444-451.

34. Colombo, R.E., Q.E. Phelps, **J.E. Garvey**, and R.C. Heidinger. 2008. Gear-specific population demographics of channel catfish in a large unimpounded midwestern river. North American Journal of Fisheries Management 28:241-246.

33. Colombo, R.E., **J.E. Garvey**, and P.S. Wills. 2007. A guide to the embryonic development of the shovelnose sturgeon (*Scaphirhynchus platorynchus*), reared at a constant temperature. Journal of Applied Ichthyology 23:402-410.

32. Schultz, D., **J.E. Garvey**, and R. Brooks. 2007. Backwater immigration by fishes through a water control structure: implications for connectivity and restoration. North American Journal of Fisheries Management 27:172-180.

31. Colombo, R.E., **J.E. Garvey**, and P.S. Wills. 2007. Gonadal development and sex-specific demographics of the shovelnose sturgeon in the Middle Mississippi River. Journal of Applied Ichthyology 23:420-427.

30. Adams, S.R., M.B. Flinn, B.M. Burr, M.R. Whiles, and **J.E. Garvey**. 2006. Ecology of larval blue sucker (*Cycleptus elongatus*) in the Mississippi River. Ecology of Freshwater Fish 15:291-300.

29. Koch, B.T, **J.E. Garvey**, M.J. Lydy. 2006. Elevated organochlorines in the brain-hypothalamic-pituitary complex of intersexual shovelnose sturgeon. Environmental Toxicology and Chemistry 25:1689-1697.

28. Heatherly, T., II, M.R. Whiles, D. Knuth, and **J.E. Garvey**. 2005. Diversity and community structure of littoral zone macroinvertebrates in southern Illinois reclaimed surface mine lakes. American Midland Naturalist 154(1):67-77.

27. Vanni, M.J., K.K. Arend, M.T. Bremigan, D.B. Bunnell, **J.E. Garvey**, M.J. González, W. H. Renwick, P.A. Soranno, and R.A. Stein. 2005. Linking landscapes and food webs: effects of omnivorous fish and watersheds on reservoir ecosystems. BioScience 55:155-167.

26. Williamson, C.J., and **J.E. Garvey**. 2005. Growth, mortality, fecundity, and diets of newly established silver carp in the Middle Mississippi River. Transactions of the American Fisheries Society 134:1423-1430.

25. Flinn, M.B., M.R. Whiles, S.R. Adams, and **J.E. Garvey**. 2005. Macroinvertebrate and zooplankton responses to emergent plant production in upper Mississippi River floodplain wetlands. Archiv für Hydrobiologie 162:187-210.

24. Ostrand, K.G., S.J. Cooke, **J.E. Garvey**, and D.H. Wahl. 2005. The energetic impact of overwinter prey assemblages on age-0 largemouth bass. Environmental Biology of Fishes 72(3):305-311.

23. **Garvey, J.E.**, K.G. Ostrand, and D.H. Wahl. 2004. Interactions among allometric scaling, predation and ration affect size-dependent growth and mortality of fish during winter. Ecology 85(10):2860-2871.

22. Whiles, M.J., and **J.E. Garvey**. 2004. Aquatic resources of the Shawnee and Hoosier National Forests, USDA Forest Service. Aquatic resources of the Shawnee-Hoosier National Forest. Pages 81-108 in Frank R. Thompson, III editor. The Hoosier-Shawnee Ecological Assessment. General Technical Report, NC-244. USDA, Forest Service, North Central Research Station. (peer-reviewed)

21. Colombo, R.E., P.S. Wills, and **J.E. Garvey**. 2004. Use of ultrasound imaging to determine sex of shovelnose sturgeon *Scaphirhynchus platorynchus* from the Middle Mississippi River. North American Journal of Fisheries Management 24:322-326.

20. Roberts, M.R., JE. Wetzel, III, R.C. Brooks, and **J.E. Garvey**. 2004. Daily incrementation in the otoliths of the red spotted sunfish, *Lepomis miniatus*. North American Journal of Fisheries Management 24:270-274.

19. **Garvey, J.E**., and E.A. Marschall. 2003. Understanding latitudinal trends in fish body size through models of optimal seasonal energy allocation. Canadian Journal of Fisheries and Aquatic Sciences 60(8):938-948.

18. Micucci, S.M., **J.E. Garvey**, R.A. Wright, and R.A. Stein. 2003. Individual growth and foraging responses of age-0 largemouth bass to mixed prey assemblages during winter. Environmental Biology of Fishes 67(2):157-168.

17. **Garvey, J.E**., J.E. Rettig, R.A. Stein, D.M. Lodge, and S.P. Klosiewski. 2003. Scale-dependent associations among fish predation, littoral habitat, and distributions of native and exotic crayfishes. Ecology 84(12): 3339-3348.

16. **Garvey, J.E**., R.A. Stein, R.A. Wright, and M.T Bremigan. 2003. Largemouth bass recruitment in North America: quantifying underlying ecological mechanisms along environmental gradients Black bass: ecology, conservation and management. Edited by D. Philipp and M. Ridgway. American Fisheries Society Symposium 31:7-23. (peer-reviewed)

15. **Garvey, J.E.**, D.R. DeVries, R.A. Wright, and J.G. Miner. 2003. Energetic adaptations along a broad latitudinal gradient: implications for widely distributed communities. BioScience 53(2):141-150.

14. **Garvey, J.E.**, T.P. Herra, and W.C. Leggett. 2002. Protracted reproduction in sunfish: the temporal dimension in fish recruitment revisited. Ecological Applications 12:194-205.

13. **Garvey, J.E.**, R.A. Wright, K.H. Ferry, and R.A. Stein. 2000. Evaluating how local- and regional- scale processes interact to regulate growth of age-0 largemouth bass. Transactions of the American Fisheries Society 129:1044-1059.

12. Fullerton, A.H., **J.E. Garvey**, R.A. Wright, and R.A. Stein. 2000. Overwinter growth and survival of largemouth bass: interactions among size, food, origin, and winter duration. Transactions of the American Fisheries Society 129:1-12.

11. Wright, R.A., **J.E. Garvey**, A.H. Fullerton, and R.A. Stein. 1999. Using bioenergetics to explore how winter conditions affect growth and consumption of age-0 largemouth bass. Transactions of the American Fisheries Society 128:603-612.

10. **Garvey, J.E.**, and R.A. Stein. 1998. Competition between larval fishes in reservoirs: the role of relative timing of appearance. Transactions of the American Fisheries Society 127:1023-1041.

9. **Garvey, J.E.**, R.A. Wright, and R.A. Stein. 1998. Overwinter growth and survival of age-0 largemouth bass: revisiting the role of body size. Canadian Journal of Fisheries and

Aquatic Sciences 55:2414-2424.

8. **Garvey, J.E.**, N.A. Dingledine, N.S. Donovan, and R.A. Stein. 1998. Exploring spatial and temporal variation within reservoir food webs: predictions for fish assemblages. Ecological Applications 8:104-120.

7. **Garvey, J.E.**, and R.A. Stein. 1998. Linking bluegill and gizzard shad assemblages to growth of age-0 largemouth bass in reservoirs. Transactions of the American Fisheries Society 127:70-83.

6. Lodge, D.M., R.A. Stein, K.M. Brown, A.P. Covich, C. Brönmark, **J.E. Garvey**, and S.P. Klosiewski. 1998. Predicting impact of freshwater exotic species on native biodiversity: challenges in spatial and temporal scaling. Australian Journal of Ecology 23:53-67.

5. **Garvey, J.E**., E.A. Marschall, and R.A. Wright. 1998. From star charts to stoneflies: detecting relationships in continuous bivariate data. Ecology 79(2):442 447.

4. Schaus, M.H., M.J. Vanni, T.E. Wissing, M. Bremigan, **J.E. Garvey**, and R.A. Stein. 1997. Nitrogen and phosphorus excretion by the detritivorous gizzard shad (*Dorosoma cepedianum*) in a reservoir ecosystem. Limnology and Oceanography 42(6):1386-1397.

3. **Garvey, J.E**., R.A. Stein, and H.M. Thomas. 1994. Assessing how fish predation and interspecific prey competition influence a crayfish assemblage. Ecology 75:532-547.

2. **Garvey, J.E.**, and R.A. Stein. 1993. Evaluating how chela size influences the invasion potential of an introduced crayfish, *Orconectes rusticus*. American Midland Naturalist 129:172-181.

1. **Garvey, J.E.**, H.A. Owen, and R.W. Winner. 1991. Toxicity of copper to the green alga, *Chlamydomonas reinhardtii* (Chlorophycea), as affected by humic substances of terrestrial and freshwater origin. Aquatic Toxicology 19:89-96.

Oral Presentations and Posters (Since 2005)

97. Calkins, H., and **J.E. Garvey**. Linking habitat use and phytoplankton consumption of silver carp in the upper and middle Mississippi River. National American Fisheries Society Meeting, Nashville, TN, September 2009 (Oral presentation by Calkins)

96. Brooks, R., S. Tripp, **J. Garvey**, and 5 co-authors. Fish passage throughout pools 20-26 of the Upper Mississippi River. National American Fisheries Society Meeting, Nashville, TN, September 2009 (Oral presentation by Tripp)

95. Boley, R., A. Schrey, D. Sechler, **J.E. Garvey**, and E. Heist. Genetic identification of larval pallid sturgeon, shovelnose sturgeon, and their hybrids in the middle Mississippi River. National American Fisheries Society Meeting, Nashville, TN, September 2009 (Poster presentation)

94. Heist, E., **J.E. Garvey**, and 8 co-authors. Status of pallid sturgeon. Invited presentation. Acipenseriformes Symposium, National American Fisheries Society Meeting, Nashville, TN, September 2009 (Oral presentation by Heist)

93. Whitledge, G., Q. Phelps, and **J.E. Garvey**. Identifying river of origin for age-0 sturgeon in the middle Mississippi River using fin ray microchemistry. National American Fisheries Society Meeting, Nashville, TN, September 2009 (Oral presentation by Whitledge)

92. Colombo, R., **J.E. Garvey**, and 11 co-authors. Distribution, life history, and population status of shovelnose sturgeon. Invited presentation. Acipenseriformes Symposium, National American Fisheries Society Meeting, Nashville, TN, September 2009 (Oral presentation by Colombo)

91. Brooks, R., **J. Garvey**, M. Hill, S.J. Tripp, H.A. Calkins, T. Spier, N. Bloomfield, T. Moore, D. Herzog, and R. Hrabik. Fish Passage Throughout Pools 20-26 of the Upper Mississippi River. 41st annual Mississippi River Research Consortium, LaCrosse WI, 30 April 2009. (Oral presentation by Tripp)

90. Sechler, D., Q. Phelps, and **J.E. Garvey**. Diet composition of young-of-year *Scaphirhynchus* sturgeon in the middle Mississippi River: Does foraging behavior change with season, macrohabitat and total length of fish? Meeting of the IL Chapter of the American Fisheries Society, Quad Cities, IL. March 2009. (Oral presentation by Sechler)

89. Calkins, H.A., and **J.E. Garvey**. Linking habitat use of silver carp to phytoplankton consumption in the Mississippi River. Meeting of the IL Chapter of the American Fisheries Society, Quad Cities, IL. March 2009. (Poster presentation)

88. Calkins, H.A., and **J.E. Garvey**. Movement, Habitat Use and Phytoplankton Consumption of Silver Carp in the Mississippi River. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation).

87. Tripp, S.J., Q.E. Phelps, D. Herzog, and **J.E. Garvey**. Habitat Use of Young-of-Year Pallid Sturgeon in the Middle Mississippi River. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation).

86. Ratterman, N., N. Wahl, Q.E. Phelps, and **J.E. Garvey**. Comparing Scale and Sagittal Otolith Back-Calculated Lengths at Age in Crappies. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation)

85. Seibert, J.R., Q.E. Phelps, S.J.Tripp, and **J.E. Garvey**. Seasonal Diet Composition of Adult Shovelnose Sturgeon in the Middle Mississippi River. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation)

84. Sechler, D.R., Q.E. Phelps, N.C. Wahl, and **J.E. Garvey**. Diet Composition of Young-of-Year Sturgeon in the Middle Mississippi River. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation)

83. Phelps, Q.E., S.J. Tripp, D. Herzog, and **J.E. Garvey**. Early life history of pallid sturgeon in the Middle Mississippi River. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Oral presentation by Phelps)

82. Wagner, C., M. Nannini, **J.Garvey**, and D. Wahl. Influence of fall condition and prey

abundance on overwinter success of age 0 largemouth bass. 69th Midwest Fish and Wildlife Conference, Columbus, Ohio, December 2008. (Poster presentation)

81. Phelps, Q., R. Colombo, **J.E. Garvey**, and R.C. Heidinger. Comparison of channel catfish age estimates and resulting population demographics using two common structures. American Fisheries Society Meeting, Ottawa, Canada, August 2008. (Poster presentation)

80. Sechler, D., Q. Phelps, and **J.E. Garvey**. Diet composition of juvenile shovelnose sturgeon in the Middle Mississippi River. American Fisheries Society Meeting, Ottawa, Canada, August 2008. (Poster presentation)

79. **Garvey, J.E.**, S.M. Bartell, and T. Keevin. Predicting local extinction of pallid sturgeon in the Mississippi River. American Fisheries Society Meeting, Ottawa, Canada, August 2008. (Oral presentation)

78. **Garvey J.E.** Asian carp in cyberspace. Illinois River Barrier Panel Meeting, Chicago, IL, June 2008. (Oral presentation)

77. **Garvey, J.E.** Searching for thresholds in spawner-recruit data. Annual Meeting of the Illinois Chapter of the American Fisheries Society, Rockford, Illinois, March 2008. (Oral presentation)

76. Phelps, Q.P., A.M. Lohmeyer, G.W. Whitledge, and **J.E. Garvey**. 2007. Black crappie nest site selection: habitat characteristics and anthropogenic influences in a small reservoir. Midwest Fish and Wildlife Conference, Madison, Wisconsin. December 2007. (Poster presentation).

75. **Brooks, R.**, J.E. Garvey, S.J. Tripp, M. Hill, T. Spier, D. Herzog, and R. Hrabik. Fish movement in the middle and upper Mississippi River. Midwest Fish and Wildlife Conference, Madison, Wisconsin. December 2007. (Oral presentation by Brooks).

74. Lohmeyer, A.M., and **J.E. Garvey**. Larval Asian Carp in the Upper and Middle Mississippi River: an index of establishment and dispersal potential. National meeting of the American Fisheries Society, San Francisco, CA. September 2007. (Poster presentation).

73. Phelps, Q.P., T.C. Allen, R.D. Davinroy, and **J.E. Garvey**. A laboratory examination of substrate, water depth, and light use at two water velocity levels by juvenile pallid and shovelnose sturgeon. National meeting of the American Fisheries Society, San Francisco, CA. September 2007. (Oral presentation by Phelps).

72. Lohmeyer, A.M., and **J.E. Garvey**. Larval Asian Carp in the Upper and Middle Mississippi River: an index of establishment and dispersal potential. Annual meeting of the IL Chapter of the American Fisheries Society, Findlay, Illinois. February 2007. (Oral presentation by Lohmeyer).

71. Tripp, S.J., R.C. Brooks, M. Hill, M. Mangan, T. Spier, D. Herzog, R. Hrabik, and **J.E. Garvey**. Fish movement in the Mississippi River. Annual meeting of the IL Chapter of the American Fisheries Society, Findlay, Illinois. February 2007. (Oral presentation by Tripp).

70. **Garvey, J.E.** and R.E. Colombo. Comparative stock assessment between the Wabash and Mississippi Rivers. Annual meeting of the IL Chapter of the American Fisheries Society, Findlay, Illinois. February 2007. (Oral presentation by Garvey).

69. DeVries, D.R., **J.E. Garvey**, and R.A. Wright. Searching for generality in centrarchid recruitment: a prescription for research. National Meeting of the American Fisheries Society, Lake Placid, New York. September 2006. (Oral presentation by DeVries).

68. Colombo, R.E., **J.E. Garvey**, and R.C. Brooks. Effect of harvest on demographics of sturgeon. National Meeting of the American Fisheries Society, Lake Placid, New York. September 2006. (Oral presentation by Colombo).

67. **Garvey, J.E.** Spatial reproductive patterns of Asian carp in the Illinois River and Upper Mississippi River. Habitat use of Asian carps in the Illinois River. Asian Carp Symposium, Peoria, Illinois. August 2006. (Oral presentation by Garvey).

66. DeGrandchamp, K.L., and **J.E. Garvey.** Habitat use of Asian carps in the Illinois River. Asian Carp Symposium, Peoria, Illinois. August 2006. (Oral presentation by DeGrandchamp).

65. **Garvey, J.E.** Spatial reproductive patterns of Asian carp in the Illinois River and Upper Mississippi River. Meeting of the Chicago Barrier Advisory Committee. (Oral presentation by Garvey).

64. Colombo, R.E., **J.E. Garvey**, and R.C. Brooks. Effect of harvest on demographics of sturgeon. Annual Meeting of the Mississippi River Research Committee, LaCrosse, Wisconsin. April 2006. (Oral presentation by Colombo; won best student paper).

63. DeGrandchamp, K.L., and **J.E. Garvey.** Habitat use of Asian carps in the Illinois River. Illinois Chapter of the American Fisheries Society Annual Meeting, Rend Lake, IL. March 2006. (Oral presentation by DeGrandchamp).

62. Tripp, S.J., **J.E. Garvey**, and R.C. Brooks. Reproductive status of shovelnose sturgeon in the Middle Mississippi River. Illinois Chapter of the American Fisheries Society Annual Meeting, Rend Lake, IL. March 2006. (Oral presentation by Tripp).

61. Colombo, R.E., **J.E. Garvey**, and R.C. Brooks. Effect of harvest on demographics of sturgeon. Illinois Chapter of the American Fisheries Society Annual Meeting, Rend Lake, IL. March 2006. (Oral presentation by Colombo).

60. DeGrandchamp, K., **J.E. Garvey**, and R. Brooks. Habitat use and movement patterns of Asian carp in the lower Illinois River. American Fisheries Society Annual Meeting, Anchorage, Alaska. Sept. 2005. (Oral presentation by DeGrandchamp).

59. Knuth, D. and **J.E. Garvey**. Effect of adult size and littoral habitat on larval sunfish production in unexploited lakes. American Fisheries Society Annual Meeting, Anchorage, Alaska. Sept. 2005. (Oral presentation by Knuth).

58. Colombo, R., **J.E. Garvey**, and R. Heidinger. Comparing the demographics of channel catfish populations from fished and un-fished regions of the Wabash River. American Fisheries Society Annual Meeting, Anchorage, Alaska. Sept. 2005. (Oral presentation by

Colombo).

57. Csoboth, L., **J.E. Garvey**, and R. Brooks. Seasonal ichthyoplankton exchange between a restored backwater and a large river. American Fisheries Society Annual Meeting, Anchorage, Alaska. Sept. 2005. (Oral presentation by Csoboth).

56. Schultz, D., **J.E. Garvey**, K. DeGrandchamp, and L. Csoboth . Seasonal Fish Movement between the Illinois River and a Restored Backwater. American Fisheries Society Annual Meeting, Anchorage, Alaska. Sept. 2005. (Poster presentation by Schultz).

55. Csoboth, L., **J.E. Garvey**, and R. Brooks. Seasonal ichthyoplankton exchange between a restored backwater and a large river. 29th Annual Larval Fish Conference, Early Life History Section, American Fisheries Society, Barcelona, Spain. July 2005. (Oral presentation by Csoboth).

54. **Garvey, J.E.** Dynamics of shovelnose and pallid sturgeon in the Middle Mississippi River. River Resources Action Team Annual Meeting, June 2005. (Oral presentation by Garvey).

53. DeGrandchamp, K., **J.E. Garvey**, and R. Brooks. Habitat use and movement patterns of Asian carp in the lower Illinois River. Midwest Ecology and Evolution Conference, Carbondale, IL, March 2005. (Oral presentation by DeGrandchamp).

52. Colombo, R., **J.E. Garvey**, and R. Heidinger. Comparing the demographics of channel catfish populations from fished and un-fished regions of the Wabash River. Midwest Ecology and Evolution Conference, Carbondale, IL, March 2005. (Oral presentation by Colombo).

51. Knuth, D. and **J.E. Garvey**. Effect of adult size and littoral habitat on larval sunfish production in unexploited lakes. Midwest Ecology and Evolution Conference, Carbondale, IL, March 2005. (Oral presentation by Knuth).

50. Csoboth, L., **J.E. Garvey**, and R. Brooks. Seasonal ichthyoplankton exchange between a restored backwater and a large river. Illinois Chapter of the American Fisheries Society Meeting, Moline, Illinois, March 2005. (Oral presentation by Csoboth).

49. Colombo, R., **J.E. Garvey**, and R. Heidinger. Population dynamics of catfish in fished and unfished reaches of the Wabash River. Illinois Chapter of the American Fisheries Society Meeting, Moline, Illinois, March 2005. (Oral presentation by Colombo; won Best Paper Award).

48. Schultz, D., **J.E. Garvey**, K. DeGrandchamp, and L. Csoboth. Fish movement between the Illinois River and lower Swan Lake, an associated backwater. Illinois Chapter of the American Fisheries Society Meeting, Moline, Illinois, March 2005. (Oral presentation by Schultz).

47. DeGrandchamp, K., **J.E. Garvey**, and R. Brooks. Movement Patterns and Habitat Use of Bighead and Silver Carp in the Lower Illinois River. Illinois Chapter of the American Fisheries Society Meeting, Moline, Illinois, March 2005. (Oral presentation by DeGrandchamp).

Workshops and Miscellaneous Activities (Since 2005)

2009-	List moderator, sturgeon inter-basin communication mailing list (> 150 participants), STURGEON-L@siu.edu
2009	Invited judge, Illinois Junior Science and Humanities Symposium oral presentations, March 2009 at SIUC
2009	Interviewed, Heartland News (local television), fisheries interaction with SIUC Child Development Laboratory, February 2009
2008-	Adviser, SIUC Student Subunit of the American Fisheries Society
2008	Interviewed by Southeastern Missourian newspaper on pallid sturgeon telemetry
2007-	Webmaster & LAN Administrator, SIUC Fisheries and Illinois Aquaculture Center
2007	Interviewed on WSIU Radio for piece on conservation genetics and sturgeon, November 2007
2007	Invited participant, Research Needs and Management Strategies for Pallid Sturgeon Recovery, St. Louis, MO. Hosted by Ruckelshaus Institute; July 31-August 2
2007	Participant, BioSonics hydroacoustics workshop, Seattle, WA, January 22-27
2006	Interviewed on Marketplace, nationally syndicated radio show
2006	Research featured on the SIUC Media Communications and Southern Spotlights outlets
2005	Participant, multi-state shovelnose sturgeon regulation meeting (invited), Cape Girardeau, Missouri, April 2005
2004-2006	Technical consultant, four hearings before the Illinois Pollution Control Board, produced numerous reports and exhibits

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Raymond C. P. Beamesderfer

Senior Fish Scientist

Education and Training

B.S. in Wildlife & Fisheries Biology 1979, University of California, Davis.

M.S. in Fishery Resources 1983, University of Idaho.

Employment History

Cramer Fish Sciences, Senior Fish Scientist, 2000-Present.

Oregon Department of Fish and Wildlife, Fishery Management Biologist, 1997-2000.

ODFW, Staff Biologist/ Analyst, 1994-1997.

ODFW, Fish Research, 1983-1993.

Professional Activities

Certified Fisheries Scientist, American Fisheries Society, 1989.

Associate Editor, North American Journal of Fisheries Management, 1992-1993.

Speaker at numerous regional, national, and international symposiums of fisheries scientists.

Ray has analyzed applied problems of fish biology and management for over 25 years:

- extensive experience with salmon, steelhead, trout, sturgeon, warmwater gamefish, and nongame species;
- work in Oregon, Washington, Alaska, Idaho, California, and British Columbia;
- numerous reports, biological assessments, management plans, and scientific articles on fish population dynamics, fish conservation, fishery management, sampling, and species interactions;
- special expertise in the use of quantitative analysis, statistics, and computer modeling to solve difficult fish questions and in synthesizing and translating scientific analyses for a variety of audiences;
- widely-recognized expertise in sturgeon population dynamics, biological assessment, conservation, and management.

With *Fish Sciences*, Ray has completed a wide variety of fishery management, biological assessment, and conservation or recovery planning projects for State and Federal Agencies, Indian Tribes, Private Industry, and Non-Governmental Organizations. Significant sturgeon-related projects have included conservation and recovery plans for upper Columbia River white sturgeon and Sacramento green sturgeon, status assessments and hatchery evaluations of Kootenai sturgeon, biological assessments of the effects of water project operations, and design of monitoring and evaluation programs. Ray has also provided extensive technical review and input on pallid sturgeon issues.

Previously, he worked for the Oregon Department of Fish and Wildlife as a management biologist for Columbia River salmon and sturgeon fisheries; staff analyst and agency representative for inter-jurisdictional Columbia River salmon, resident fish, and hydropower issues; and program and project leader for research on sturgeon stock assessments, predator control evaluation, warmwater fish management alternatives, adult and juvenile salmon passage at dams and diversions, and design and implementation of a system to facilitate exchange of salmon and steelhead data for the Columbia River basin (*StreamNet*).

Projects

Biological Assessment

Comments on green sturgeon portions of the Oroville Dam Draft Biological Opinion by the National Marine Fisheries Service. 2009. *California State Water Contractors.*

Comments on green sturgeon portions of the Biological Opinion on the Long-term Central Valley Project and State Water Project Operations Criteria and Plan. 2009. *California State Water Contractors.*

Kenai River Habitat Assessment. 2008. *Alaska Department of Fish and Game and the Kenai River Sportfishing Association.*

Status and limiting factors of ESA-listed lower Columbia and Willamette River chum, Chinook, coho, and steelhead in supplemental comprehensive analysis of the federal Columbia River power system and mainstem effects of the upper Snake and other tributary actions. 2007. *National Oceanic and Atmospheric Administration and the Bonneville Power Administration*.

Independent technical review of predation scenarios on juveniles salmonids in the Columbia River. 2007. *Battelle Pacific Northwest Laboratory*.

Independent technical review of evaluation of ladder use at John Day Dam by chinook salmon and steelhead trout. 2006. *Battelle Pacific Northwest Laboratory*.

Oregon Native Salmon and Steelhead Conservation Assessment. 2005. *Oregon Department of Fish and Wildlife*.

Population dynamics and extinction risks of Kootenai River burbot. 2004. *Kootenai Tribe of Idaho and Idaho Department of Fish and Game*.

Historical and current information on green sturgeon occurrence in the Sacramento and San Joaquin Rivers and tributaries. 2004. *California State Water Contractors*.

Stranding of juvenile fall chinook salmon in the Hanford Reach of the Columbia River as a result of hydropower operations. 2003. *Columbia River Intertribal Fish Commission for Alaska Department of Fish and Game*.

Green sturgeon status review. 2002. *Metropolitan Water District of Southern California*.

Indirect effects of water export on juvenile salmon in the Sacramento-San Joaquin Delta: a conceptual Foundation. 2002. *Metropolitan Water District of Southern California*.

Analysis of cutthroat trout population viability in Timothy Lake, Oregon. 2002. *Portland General Electric*.

Evaluation and modeling of steelhead capacity, population dynamics, and reintroduction potential above impoundments in the upper Deschutes River, Oregon. 2001. *Portland General Electric*.

Analysis of salmon rearing, migration, survival, and passage based on PIT tag detections for the Clackamas River. 2001. *Portland General Electric*.

Biological assessment of effects of Sherman Island Levee repairs on listed Delta smelt and Sacramento splittail. 2001. *James C. Hanson Engineers*.

Review of conservation assessment of steelhead populations in Oregon. 2001. *American Forest Resources Council*.

Documentation of existing and historic habitat, and native and introduced fish in the Clackamas basin, Oregon. 2001. *Portland General Electric*.

Relicensing studies of fish populations in the upper Stanislaus River, California. 2001. *Pacific Gas and Electric Company and Tri-dam Project*.

Assessments of biological and habitat effects of Otter Creek and South Fork to Black Bear Creek projects. 2001. *Alaska Power and Telephone*.

Conservation & Recovery Planning

Assessment of adult population objectives and monitoring needs for Pallid Sturgeon. March 23-24, 2009. Pallid Sturgeon Conference and Workshop. Billings MT.

Peer review of critical habitat designation for white sturgeon populations in British Columbia, Canada under the Species At Risk Act. 2009. *Department of Fisheries and Oceans Canada.*

Preparation of background materials for the development of the recovery plan for the southern distinct population segment of North American green sturgeon. 2009. *National Marine Fisheries Service Southwest Region.*

Lower Columbia salmon and steelhead recovery plan. 2009. *Washington Lower Columbia River Fish Recovery Board*.

Research, monitoring and evaluation program for Lower Columbia Salmon and Steelhead. 2008. *Washington Lower Columbia River Fish Recovery Board.*

Estimation of salmon recovery targets for ESA-listed lower Columbia and Willamette river coho, Chinook, Chum, and steelhead using population viability analysis. 2007. *Oregon Department of Fish and Wildlife and Washington Lower Columbia River Fish Recovery Board.*

Lower Columbia salmon and steelhead recovery plan (interim). 2002-2004. *Washington Lower Columbia River Fish Recovery Board*.

Kootenai River Burbot conservation plan. 2004. *Kootenai Tribe of Idaho*.

Upper Columbia River white sturgeon recovery plan. 2002. *Spokane Tribe of Indians, British Columbia Ministry of Water, Land and Air Protection, and BC Hydro Corporation*.

Fishery Management

Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. 2009. *Pacific Fishery Management Council.*

Biometrics and fishery analysis support for the Pacific Fishery Management Council Scientific and Statistical Committee. 2009. *Oregon Department of Fish and Wildlife.*

Risk Analysis of All-H Recovery Strategies for Tule Fall Chinook. 2009. *Washington Lower Columbia River Fish Recovery Board.*

Peer review of Marine Stewardship Council assessment of the sustainability of British Columbia commercial salmon fishery. 2009. *TAVEL Certification.*

Problems and solutions in escapement goal management of upper Cook Inlet salmon fisheries. 2008. *American Fisheries Society Alaska Chapter Meeting.*

Marine Stewardship Council assessment of the sustainability of Russia's JSC Gidrostroy commercial salmon fishery on Iturup Island in the south Kuriles. 2008. *Scientific Certification Systems*.

Upper Cook Inlet salmon fishery model for analyzing harvest, allocation, and escapement effects of alternative management strategies. 2008. *Kenai River Sportfishing Association*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2008. *Kenai River Sportfishing Association*.

Fishery risk assessment for Columbia River coho based on population viability analysis. 2007. *Washington Department of Fish and Wildlife and the Lower Columbia Fish Recovery Board*.

Biological analysis of population and fishery effects of *de minimis* fisheries for Klamath Fall Chinook. 2007. *Pacific Fishery Management Council*.

Marine Stewardship Council assessment of the sustainability of Alaska commercial salmon fisheries. 2007. *Scientific Certification Systems and the Alaska Department of Fish and Game*.

Kasilof sockeye escapement goal analysis. 2007. Kenai River Sportfishing Association.

Analysis of size-selective Kenai King salmon fisheries and regulations. 2007. *Alaska Department of Fish and Game*.

ESA fisheries management and evaluation plan for lower Columbia River coho in Oregon freshwater fisheries of the lower Columbia River. 2005. *Oregon Department of Fish and Wildlife*.

Analysis of the potential effects and alternatives for selective fishing in the lower Columbia River commercial and recreational fisheries. 2005. *Bonneville Power Administration*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2005. *Kenai River Sportfishing Association*.

Review of the Coded Wire Marking Program for Columbia Basin Hatchery Salmon and Steelhead, Phase I. 2004. *Bonneville Power Administration*.

Review of live capture selective harvest methods study for Columbia River spring chinook. 2003. *Salmon for All*.

Report to the Alaska Board of Fisheries on the biological basis of Upper Cook Inlet fishery management proposals. 2002. *Kenai River Sportfishing Association*.

Effects of large-mesh gillnet use on steelhead and salmon catch in Columbia River Zone 6 gillnet fisheries. 2001. *Yakama Nation and the Bonneville Power Administration*.

ESA fisheries management and evaluation plan for lower Columbia River chinook in Oregon freshwater fisheries of the lower Columbia River. 2001. *Oregon Department of Fish and Wildlife*.

ESA fisheries management and evaluation plan for upper Willamette Spring chinook in freshwater fisheries of the Willamette basin and lower Columbia River. 2000. *Oregon Department of Fish and Wildlife*.

Conservation risks of mixed stock fisheries for wild spring chinook salmon from Oregon's McKenzie River based on a population viability analysis. 2000. *Oregon Department of Fish and Wildlife.*

Peer review of certification report on sustainability of Alaska salmon fisheries. 2000. *Marine Stewardship Council*.

Hatchery Evaluation

Strategic and Hatchery Master Plans for impounded white sturgeon populations of the lower Columbia and Snake rivers. 2008-2009. Columbia River Inter-tribal Fish Commission.

Sturgeon hatchery planning and evaluation technical assistance. 2009. *Yakama Nation Fisheries.*

Upper Columbia sturgeon hatchery release strategy. 2008. *British Columbia Ministry of Environment and BC Hydropower*.

Kootenai River White Sturgeon Conservation Aquaculture Program Overview, 1990-2007. 2008. *Kootenai Tribe of Idaho*.

Kootenai River sturgeon hatchery and endangered species evaluations. 2001-2009. *Kootenai Tribe of Idaho*.

Hatchery genetic management plans for the Sandy and Clackamas River Hatcheries. 2005. *Oregon Department of Fish and Wildlife*.

Coeur d'Alene Tribe Trout Production Master Plan. 2002. *Coeur d'Alene Tribe*.

Scientific Publications

2009. Evidence of density- and size-dependent mortality in hatchery-reared juvenile white sturgeon in the Kootenai River. Canadian Journal of Fisheries and Aquatic Sciences 66:802-815. *(Justice, Pyper, Beamesderfer, Paragamian, Rust, Neufeld & Ireland).*

2008 Population dynamics and extinction risk of burbot in the Kootenai River, Idaho, USA and British Columbia, Canada. American Fisheries Society Symposium 59:213-234. *(Paragamian, Pyper, Daigneault, Beamesderfer & Ireland).*

2007 Use of life history information in a population model for Sacramento green sturgeon. Environmental Biology of Fishes 79:315-337. *(Beamesderfer, Simpson, & Kopp).*

2005 Status, population dynamics, and future prospects of the endangered Kootenai River white sturgeon population with and without hatchery intervention. Transactions of the American Fisheries Society 134:518-532. *(Paragamian, Beamesderfer & Ireland).*

2004 Dilemma on the Kootenai River - The risk of extinction or when does the hatchery become the best option? American Fisheries Society Symposium 44:377-385. *(Paragamian & Beamesderfer).*

2003 Growth estimates from tagged white sturgeon suggest that ages from fin rays underestimate true age in the Kootenai River, USA and Canada. Transactions of the American Fisheries Society 132:895-903. *(Paragamian & Beamesderfer).*

2002 Success of hatchery-reared juvenile white sturgeon (Acipenser transmontanus) following release in the Kootenai River, Idaho, USA. Journal of Applied Ichthyology 18: 642-650. *(Ireland, Beamesderfer, Paragamian, Wakkinen & Siple)*.

2000 Managing fish predators and competitors: Deciding when interspecific intervention is effective and appropriate. Fisheries 25(6):18-23. *(Beamesderfer).*

1997 Alternatives for the protection and restoration of sturgeons and their habitat. Environmental Biology of Fishes 48:407-417. *(Beamesderfer & Farr).*

1996 Evaluation of the biological basis for a predator control program on northern squawfish (*Ptychocheilus oregonensis*) in the Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 53:2898-2908. *(Beamesderfer, Ward & Nigro).*

1995 Growth, natural mortality, and predicted response to fishing for largemouth and smallmouth bass populations in North America. North American Journal of Fisheries Management 15:688-704. *(Beamesderfer & North).*

1995 Differences in the dynamics and production of impounded and unimpounded white sturgeon populations in the lower Columbia River. Transactions of the American Fisheries Society 126:857-872. *(Beamesderfer, Rien & Nigro).*

1994 Accuracy and precision in age estimates of white sturgeon using pectoral fin rays. Transactions of the American Fisheries Society 123:255-265. *(Rien & Beamesderfer).*

1994 Retention, recognition, and effects on survival of several tags and marks on white sturgeon. California Fish and Game 80:161-170. *(Rien, Beamesderfer & Foster).*

1993 Distribution and movements of white sturgeon in three lower Columbia River reservoirs. Northwest Science 67:105-111. *(North, Beamesderfer & Rien).*

1993 A standard weight equation for white sturgeon. California Fish and Game 79:63-69. *(Beamesderfer).*

1992 Book review of "Pacific Salmon Life Histories." Fisheries 17:56-58. *(Beamesderfer).*

1992 Reproduction and early life history of northern squawfish (*Ptychocheilus oregonensis*) in Idaho's St. Joe River. Environmental Biology of Fishes 35:231-241. *(Beamesderfer).*

1991 Abundance and distribution of northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:439-447. *(Beamesderfer & Rieman).*

1991 Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458. *(Rieman, Beamesderfer & Poe).*

1990 Management implications of a model of predation by a resident fish on juvenile salmonids migrating through a Columbia River reservoir. North American Journal of Fisheries Management 10:290-304. *(Beamesderfer, Rieman, & Vigg).*

1990 Comparison of efficiency and selectivity of three gears used to sample white sturgeon in a Columbia River reservoir. California Fish and Game 76:174-180. *(Elliott & Beamesderfer).*

1990 Dynamics of a northern squawfish population and the potential to reduce predation on juvenile salmonids in a Columbia River reservoir. North American Journal of Fisheries Management 10:228-241. *(Rieman & Beamesderfer).*

1990 White sturgeon in the lower Columbia River: Is the stock overexploited? North American Journal of Fisheries Management 10:388-396. *(Rieman & Beamesderfer).*

1988 Size selectivity and bias in estimates of population statistics of smallmouth bass, walleye, and northern squawfish in a Columbia River reservoir. North American Journal of Fisheries Management 8:505-510. *(Beamesderfer & Rieman).*

CURRICULUM VITAE

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Bishop Museum
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Education

Louisiana State University
Ph.D. in Biological Sciences, May 2002
Major Professor: J. Michael Fitzsimons
Dissertation: Spatial models of Hawaiian streams and stream fish habitats.
Internet location: http://etd.lsu.edu:8085/docs/available/etd-0419102-000538/

University of Guam
Master of Science Degree in Biology, December 1995
Major Professor: Stephen G. Nelson
Thesis: Habitat use by an assemblage of tropical oceanic island streamfishes.

Virginia Polytechnic Institute and State University
Bachelor of Science Degree in Fisheries Management, December 1989

Professional Experience – Research

Parham and Associates Environmental Consulting, LLC.
President, January 2008 to present

Owns and operates a consulting company focused on providing comprehensive instream flow and habitat assessments for riverine fishes.

Bishop Museum
Hydrologist and Aquatic Biologist, July 2005 to present

Responsible for project developing a rainfall to runoff model for estimating stream flow in Hawaiian streams for coordination with GIS habitat models. Also responsible for creating an Atlas of Hawaiian Watersheds covering all watersheds and aquatic resource data for the state of Hawaii.

University of Nebraska – School of Natural Resources Sciences
Postdoctoral Research Associate, December 2001 to June 2005

Developed GIS models to allow coordination among findings of multiple research projects on the habitat use of sturgeon with spatial data on habitat availability and river discharge in the lower Platte River. Additional responsibilities focused on the continuation of developing GIS habitat models for Hawaiian Streams.

Louisiana State University - Museum of Natural Science
Research Assistant, January 1998 to 2001

Designed and developed GIS models of Hawaiian streams for the Hawai'i Division of Aquatic Resources

Louisiana State University - Museum of Natural Science
Curatorial Assistant, July 1997 to December 1997

Maintained the collection of fishes, approximately 122,000 specimens, and processed loan requests.

University of Guam - Marine Laboratory
Research Assistant, September 1993 to February 1996

Monitored of the fishes and macrofauna of a tropical stream on Guam. Duties included field survey modification and implementation, comparison of the previous years results with current years survey and report writing.

University of Guam - Marine Laboratory
Research Assistant, January 1995 and January 1996

Surveyed the streamfishes of Palau and Pohnpei (Micronesia) to aid in mitigating the effects of proposed development projects. This project entailed surveys and collections in remote watersheds. Additional duties included data analysis and report preparation.

University of Guam - Water and Energy Research Institute
Research Assistant, May 1994 to May 1995

Determined the microhabitats of the streamfishes of the Asmafines River, a small tropical stream on Guam, with respect to instream flow requirements. Helped write proposal, determined site and survey method, carried out visual surveys, and wrote technical report.

Environmental Systems Planners, Inc.
Biologist, January 1991 to March 1992
Worked on mangrove restoration projects and environmental impact statements in Southwest Florida.

Certified in ArcView GIS, Spatial Analyst, and ArcHydro by ESRI.
Certified Advanced Scuba Diver by PADI.
Certified Research Scuba Diver by AAML.

Professional Experience - Teaching

University of Nebraska – School of Natural Resources Sciences
Instructor, Spring 2004
Co-Instructor for undergraduate Introduction to GIS in Natural Resources class

University of Nebraska – School of Natural Resources Sciences
Instructor, Fall 2003 - Spring 2004
Designed and taught a distance-learning course for biologists, hydrologists, and land managers in Hawaii on GIS modeling of fish habitats and surface flows.

China Tropical Lands Project – Guangzhou, China
Assistant Coordinator – November 2003
Assisted with a conference and workshop on improving natural resource management in China's degraded lands for environmental NGO's and scientists.

University of Nebraska – School of Natural Resources Sciences
Instructor, Spring 2003
Instructor for graduate/undergraduate Fisheries Biology Class

University of Nebraska – School of Natural Resources Sciences
Instructor, Spring 2002
Instructor for undergraduate Natural Resources Seminar

Louisiana State University - Department of Zoology
Teaching Assistant, January 1997 to June 1997
Laboratory Instructor for two classes of Introductory Biology.

University of Guam - College of Arts and Science
Teaching Assistant, September 1993 to December 1994
Laboratory instructor for Environmental Biology class for three semesters.

Publications

Parham, J.E., G.R. Higashi, E.K. Lapp, D.G.K. Kuamo'o, R.N. Nishimoto, S. Hau, D.A. Polhemus, J.M. Fitzsimons, and W.S. Devick. 2008. Atlas of Hawaiian Watersheds and their Aquatic Resources. Division of Aquatic Resources, DLNR, Hawaii. 5 volumes. 4,500+ pgs.

Shuman, DA, JE Parham, and EJ. Peters. 2007. Stock characteristics of shovelnose sturgeon in the lower Platte River, Nebraska. Journal of Applied Ichthyology. 23 (2007), 484–488

Swigle, BD, JE Parham, and EJ Peters. 2007. Movement and Habitat Use by Shovelnose and Pallid Sturgeon in the Lower Platte River, Nebraska. Transactions of the American Fisheries Society.

Kuamo'o, D. G. K., G. R. Higashi, and J. E. Parham. 2007. Structure of the Division of Aquatic Resources Survey Database and use with a Geographic Information System. In: Biology of Hawaiian Streams and Estuaries, N. L. Evenhuis & J. M. Fitzsimons, eds. Bishop Museum Bulletin in Cultural and Environmental Studies 3:315-322.

Steinauer, ML, JE Parham, and BB Nickol. 2005. Geographic Information System Analysis of the Patterns of Host Use, Habitat Use and Development of a Fish Parasite *Leptorhyncoides thecatus* (Acanthocephala: rhadniorhynchidae). Journal of Parasitology.

Parham. JE. 2005. Aquatic Survey Techniques on Oceanic Islands: Important Design Considerations for the PABITRA Methodology. Pacific Science. 59:2. pgs 283-291.

Fitzsimons JM, JE Parham, LK Benson, MG McRae, and RT Nishimoto. 2005. Biological Assessment of Kahana Stream, Island of O'ahu, Hawai'i, with the Use of Procedures from the PABITRA Manual for Interactive Ecology and Management. Pacific Science. 59:2. pgs 273-281.

Fitzsimons, JM, RT Nishimoto, and JE Parham. 2005. Methods for Analyzing Stream Ecosystems. Chapter 7 in Biodiversity Assessment of Tropical Island Ecosystems: PABITRA Manual for Interactive Ecology and Management (D. Mueller-Dombois, KW Bridges and CC Daehler, eds.)

Fitzsimons, JM, JE Parham, and RT Nishimoto. 2002. Similarities in behavioral ecology among amphidromous and catadromous fishes on the oceanic islands of Hawai'i and Guam. Environmental Biology of Fishes. 65:123-129.

Nelson, SG, JE Parham, RB Tibbatts, FA Camacho, TA Leberer, and BD Smith. 1997. Distributions and microhabitats of the amphidromous gobies in streams of Micronesia. Micronesica. pg 83-91.

Technical Reports

Parham, JE. 2008. Development of a Database Modeling Tool to Predict Aquatic Species Distributions within Hawaiian Streams. Division of Aquatic Resources, DLNR, State of Hawaii. 56 p.

Parham, JE. 2008. Development of Database Reporting Tools and Results from DAR Rapid Bioassessment Surveys Conducted on Nine North Shore Streams, Oahu, Hawaii. Division of Aquatic Resources, DLNR, State of Hawaii. 55 p.

King, C, E.K. Lapp, J.E. Parham, G.R. Higashi, S. Hau and D.G.K Kuamo'o. 2008. Survey report on Waihe'e Stream, Maui, Hawai'i. Division of Aquatic Resources, DLNR, State of Hawaii.

King, C, E.K. Lapp, J.E. Parham, G.R. Higashi, S. Hau and D.G.K Kuamo'o. 2008. Survey report on Piinaau Stream, Maui, Hawai'i. Division of Aquatic Resources, DLNR, State of Hawaii.

King, C, E.K. Lapp, J.E. Parham, G.R. Higashi, S. Hau and D.G.K Kuamo'o. 2008. Survey report on Waiehu Stream, Maui, Hawai'i. Division of Aquatic Resources, DLNR, State of Hawaii.

King, C, E.K. Lapp, J.E. Parham, G.R. Higashi, S. Hau and D.G.K Kuamo'o. 2008. Survey report on Honopou Stream, Maui, Hawai'i. Division of Aquatic Resources, DLNR, State of Hawaii.

King, C, E.K. Lapp, J.E. Parham, G.R. Higashi, S. Hau and D.G.K Kuamo'o. 2008. Survey report on Waiokamilo Stream, Maui, Hawai'i. Division of Aquatic Resources, DLNR, State of Hawaii.

Higashi, GR, JE Parham, S Hau, RT Nishimoto, D Polhemus, E Lapp, L Nishihara, T Shindo, and T Sakihara. 2008. Report on Honopou Stream, Maui. For the Commission on Water Resources Management. DLNR, Honolulu, HI. 50p.

Higashi, GR, JE Parham, S Hau, RT Nishimoto, D Polhemus, E Lapp, L Nishihara, T Shindo, and T Sakihara. 2008. Report on Hanehoi Stream, Maui. For the Commission on Water Resources Management. DLNR, Honolulu, HI. 46p.

Higashi, GR, JE Parham, S Hau, RT Nishimoto, D Polhemus, E Lapp, L Nishihara, T Shindo, and T Sakihara. 2008. Report on Piinaau Stream, Maui. For the Commission on Water Resources Management. DLNR, Honolulu, HI. 43p.

Higashi, GR, JE Parham, S Hau, RT Nishimoto, D Polhemus, E Lapp, L Nishihara, T Shindo, and T Sakihara. 2008. Report on Wailuanui Stream, Maui. For the Commission on Water Resources Management. DLNR, Honolulu, HI. 34p.

Higashi, GR, JE Parham, S Hau, RT Nishimoto, D Polhemus, E Lapp, L Nishihara, T Shindo, and T Sakihara. 2008. Report on Waiokamilo Stream, Maui. For the Commission on Water Resources Management. DLNR, Honolulu, HI. 32p.

Parham, JE. 2007. Hydrologic Analysis of the lower Platte River from 1954 -2004, with special emphasis on habitats of the Endangered Least Tern, Piping Plover, and Pallid Sturgeon. 2007. Nebraska Game and Parks Commission. Lincoln, NE. 175p.

Peters EJ and JE Parham. 2007. Ecology and management of pallid sturgeon and sturgeon chub in the Platte River, Nebraska. Nebraska Game and Parks Commission. Lincoln, NE. 232 p.

Parham, JE, EJ Peters, CN Reade, and J Olnes. 2005. Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River. Final report May 2005. The Pallid Sturgeon and Sturgeon Chub Task Force. 544 p.

Parham, JE. 2003. GIS Habitat Modeling of Native Hawaiian Stream Fishes: Project Report. Division of Aquatic Resources, Department of Land and Natural Resources, State of Hawaii.

Fitzsimons, JM, JE Parham, LK Benson, and MG McRae. 2002. Biological Assessment of Kahana Stream, Island of O'ahu: Final Report. Division of Aquatic Resources and Commission on Water Resources Management, Department of Land and Natural Resources, State of Hawaii.

Peters, EJ, M Kaminski, J Olnes, JE Parham, CN Reade, R Ruskamp, S Sedlacek, D Shuman, and B Swigle. 2002. Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River: Progress report May 2001 / May 2002. The Pallid Sturgeon and Sturgeon Chub Task Force.

Peters, EJ, J Olnes, JE Parham, CN Reade, R Ruskamp, D Shuman, VA Snook, and B Swigle. 2001. Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River: Progress report May 2000 / May 2001. The Pallid Sturgeon and Sturgeon Chub Task Force.

Olnes, J, R Ruskamp, JE Parham, and EJ Peters. 2001. Water quality monitoring within the lower Platte River Basin: Annual report for 2000/2001. US Fish and Wildlife Service.

Smith, BD, JE Parham, and SG Nelson. 1996. Annual report on the monitoring of the Ugum River Weir for the Public Utility of Guam 1995.

Nelson, SG, BD Smith, JE Parham, B Tibbatts, and F Camacho. 1995. A survey of the streamfishes of the upper reaches of the Ngermeskang River, Palau, with recommendations for conservation and monitoring. University of Guam Marine Laboratory, Technical Report # 100, pp. 18.

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Parham, J.E., G.R. Higashi, E.K. Lapp, D.G.K. Kuamo'o, R.N. Nishimoto, S. Hau, D.A. Polhemus, J.M. Fitzsimons, and W.S. Devick. 2009. Synthesizing results from current and historical stream surveys in Hawaii to determine fish distribution and habitat use at multiple spatial scales. National Fish Habitat Mapping Symposium. Annual Meeting of the American Fisheries Society, Nashville, TN.

Parham, J.E. 2009. The use of GIS and database systems to facilitate collaboration and improve information flow in large fisheries projects. Tennessee Chapter of the American Fisheries Society. Montgomery Bell State Park, TN.

E.J. Peters and J.E. Parham. 2009. Pallid Sturgeon Literature Review. Platte River Recovery Implementation Program. Columbus, NE.

Parham, J.E., **G.R. Higashi**, E.K. Lapp, D.G.K. Kuamo'o, R.N. Nishimoto, S. Hau, D.A. Polhemus, J.M. Fitzsimons, and W.S. Devick. 2008. Atlas of Hawaiian Watersheds and Their Aquatic Resources – an important tool to aid in statewide watershed management. Workshop on the Ecology, Restoration, and Management of Hawaii Stream and Riparian Systems. Kaneohe, HI.

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Parham, J.E., **G.R. Higashi**, E.K. Lapp, D.G.K. Kuamo'o, R.N. Nishimoto, S. Hau, D.A. Polhemus, J.M. Fitzsimons, and W.S. Devick. 2008. Atlas of Hawaiian Stream Species – describing habitat and distribution of stream animals statewide. Hawaii Conservation Conference. Honolulu, HI.

JE Parham. 2007. DLNR Stream Program. Presentation for the special envoy representing the President of the United States. Honolulu, HI.

JE Parham. 2007. Rule of Thumb Instream Flow Standards. Division of Aquatic Resources and Commission on Water Resources Management. Honolulu, HI.

Higashi, GR, DGK Kuamo'o, and **JE Parham.** 2006. Division of Aquatic Resources' Aquatics Surveys Database: Use and Applications. State of Hawaii Commission on Water Resources. Honolulu, HI.

Parham, JE. 2005. Instream Flow Modeling for Hawaiian Streams. State of Hawaii Commission on Water Resources. Honolulu, HI.

Parham, JE, **EJ Peters**, CN Reade, and JJ Olnes. 2005. Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River. The pallid sturgeon and sturgeon chub task force. Columbus, NE.

Parham JE, 2005. The Basis for an Instream Flow Program in the Hawaiian Islands. Symposium on Hawaiian Streams and Estuaries. Hilo, HI.

Kuamo'o, DGK, GR Higashi, and JE Parham. 2005. Structure of the Division of Aquatic Resources Surveys Database and Use with a Geographic Information System. Symposium on Hawaiian Streams and Estuaries. Hilo, HI.

Parham, JE. 2005. Instream flows for sturgeon habitat and movement in the Platte River, Nebraska. Fisheries and Wildlife Departmental Seminar, University of Missouri. Columbia, MO.

Peters, EJ, Parham, JE, and JJ Olnes. 2005. Estimates of Shovelnose and Pallid Sturgeon Densities in the Platte River, Nebraska, 2000-2004. Scaphirhynchus Conference. St. Louis, MO.

Parham, JE, BD Swigle, and EJ Peters. 2005. River Connectivity for Migrating Shovelnose Sturgeon in the Lower Platte River, Nebraska. Scaphirhynchus Conference. St. Louis, MO.

Parham, JE, BD Swigle, DA Shuman, VA Snook and EJ Peters. 2005. The Relationship between River Discharge and Instream Habitat for Sturgeons in the Lower Platte River, Nebraska. Scaphirhynchus Conference. St. Louis, MO.

Shuman, DA, JE Parham, and EJ Peters. 2005. Evaluation of the Condition, Distribution, Structure, and Growth of Shovelnose Sturgeon in the Lower Platte River, Nebraska. Scaphirhynchus Conference. St. Louis, MO.

Parham, JE. 2004. Determining Suitable Habitat for Endangered Species in the Lower Platte River. US Fish and Wildlife Service. Grand Island, NE.

Parham, JE and EJ Peters 2004. Instream Flow Estimation for Endangered Species in the Lower Platte River, Nebraska. Wildlife Club Seminar. Lincoln, NE.

Parham, JE. 2003. Degraded Lands and Water Resources. International Workshop on Degraded Lands and Sustainable Agriculture. South China Agricultural University. Guangzhou, China.

Parham, JE. 2003. Statewide Instream Flow Estimations – Model version 1. Hawai'i Division of Aquatic Resources. Honolulu, HI.

Parham, JE. 2002. Habitat Modeling for Fish Conservation – Examples from Hawai'i and Nebraska, School of Natural Resources Sciences, University of Nebraska. Lincoln, NE.

Parham, JE. 2002. Pallid Sturgeon Habitat Availability Assessment on the Lower Platte River, Nebraska. Lower Platte River Corridor Alliance. Lincoln, NE.

Parham, JE. 2002. The Ecology and Management of Sturgeon on the Lower Platte River, Nebraska. Papio-Missouri Natural Resource District. Omaha, NE.

Parham, JE. 2002. Determining Habitat Availability on the Lower Platte River. Nebraska Game and Parks Commission. Lincoln, NE.

Parham, JE. 2002. Multi-spatial Modeling and Instream Flow Management: an Example from Hawaiian Streams. Instream Flow Council Biennial Meeting. Crossnore, NC.

Parham, JE and JM Fitzsimons. 2002. Habitat Assessment and Geographic Information Systems. Hawaii Water Quality Conference. Honolulu, HI.

Parham, JE. 2002. Spatial Models of Hawaiian Stream Fishes. Habitat Modeling Workshop. Pallid Sturgeon\ Sturgeon Chub Recovery Taskforce, Lincoln, NE.

Parham, JE and JM Fitzsimons. 2000. Multi-dimensional GIS: a Powerful Tool for the Conservation of Stream Fishes. GIS Symposium at the Annual Meeting of the American Fisheries Society, St. Louis, MO.

General Presentations (presenter in **bold**)

Parham, JE, BD Swigle, DA Shuman, VA Snook, and EJ Peters. 2004. Relationships between habitat availability and river discharge for *Scaphirhynchus* sturgeons in the lower Platte River, Nebraska. 4th World Fisheries Congress. Vancouver, BC.

Parham, JE, BD Swigle, DA Shuman, VA Snook, and EJ Peters. 2003. Comparisons between river discharge and habitat availability for sturgeons in the lower Platte River, Nebraska. 64th Midwest Fish & Wildlife Conference. Kansas City, MO.

Parham, JE. 2003. Predicting instream habitat and reach occupancy for native Hawaiian stream fishes. Ecological Society of America's Annual Conference, Savannah, GA.

Steinauer ML and **JE Parham**. 2003. Geographic distribution of host and habitat use of an acanthocephalan parasite, *Leptorhynchoides thecatus*. Ecological Society of America's Annual Conference, Savannah, GA.

Peters, EJ, JE Parham, DA Shuman, and BD Swigle. 2003. Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River, Nebraska. Pallid Sturgeon\ Sturgeon Chub Recovery Taskforce meeting. Ponca State Park, Ponca, NE.

Peters, EJ, MT Kaminski, JE Parham, CN Reade, DA Shuman, BD Swigle, and LA Vrtiska. 2003. Current Research on Pallid Sturgeon in the lower Platte River, NE. Middle Basin Pallid Sturgeon Recovery Work Group, St. Louis, MO.

Kuamo'o, DL and JE Parham. 2002. Using ArcView 3.x to Edit USGS Attribute Tables with Tributary Codes for Use With HDAR Stream Database. Waipi'o Valley Conference, sponsored by Bishop Museum and USDA NRCS. Honolulu, HI, USA.

Parham, JE. 2002. Summary and Recommendations from the Habitat Workshop – Determining Habitat Availability on the Lower Platte River. Pallid Sturgeon\ Sturgeon Chub Recovery Taskforce meeting. Gavins Point, NE.

Parham, JE. 2002. Spatial Modeling at the Island Scale and its Implications on Larval Recruitment Dynamics. Hawai'i Division of Aquatic Resources. Honolulu, HI.

Parham, JE. 2002. Development of a Geospatial Database. Habitat Modeling Workshop. Pallid Sturgeon\ Sturgeon Chub Recovery Taskforce. Lincoln, NE.

Parham, JE and JM Fitzsimons. 2001. Habitat Modeling for Native Hawaiian Stream Fishes. Annual Meeting of the American Fisheries Society. Phoenix, AZ.

Parham, JE. 2001. Spatial Models of Hawaiian Streams and Stream Fish Habitats. Dissertation Exit Seminar, Louisiana State University Museum of Natural Sciences. Baton Rouge, LA.

Parham, JE and JM Fitzsimons. 2001. The Use of Geographic Information Systems (GIS) in Water Resources Planning, Management and Allocation Issues in the Hawaiian Islands – Project Update. State of Hawaii Commission on Water Resources. Honolulu, HI.

Parham, JE and JM Fitzsimons. 2001. Spatial Modeling to Aid in Instream Flow determination of Native Hawaiian Stream Fishes. Annual Meeting of the Society of Conservation Biology. Hilo, HI.

Parham, JE and JM Fitzsimons. 2000. The Use of Geographic Information Systems (GIS) in Water Resources Planning, Management and Allocation Issues in the Hawaiian Islands. State of Hawaii Commission on Water Resources. Honolulu, HI.

Parham, JE. 2000. The Spatial Ecology and Conservation of Native Hawaiian Stream Fishes. Ecology and Evolution Seminar at the University of Nebraska. Lincoln, NE.

Parham, JE and JM Fitzsimons. 1999. Spatial Modeling of Habitat Dynamics for Native Hawaiian Stream Fishes. XVIII Pacific Science Congress. Sydney, Australia.

Parham, JE. 1999. Revisiting the Niche as an N^{th} Dimensional Hypervolume: a Multi-dimensional GIS Analysis for the Conservation of Native Freshwater Fishes in the Hawaiian Islands. Louisiana State University Annual Biograds Symposium. Baton Rouge, LA.

Parham, JE and JM Fitzsimons. 1999. A Multi-scale GIS Analysis for the Management of Native Freshwater Fishes in the Hawaiian Islands. Annual Meeting of the American Fisheries Society. Charlotte, NC.

Parham, JE and **JM Fitzsimons**. 1999. GIS Modeling Predicts Gain and Loss of Fish Habitat Associated with Changes of Flow in Hawaiian Streams. LSU Ecology Forum. Baton Rouge, LA.

Parham, JE. 1998. Island Hopping in Paradise: An Ichthyologist in Micronesia. Audubon Society of Louisiana. Baton Rouge, LA.

Parham, JE. 1997. Integrating GIS and Microhabitat Surveys for the Conservation of Native Fishes. Louisiana State University Museum of Natural Science. Baton Rouge, LA.

Nelson, SG and JE Parham. 1995. Diversity and Microhabitat: a Study of Stream Fishes of Micronesia. XVII Pacific Science Congress. Beijing, China.

Nelson, SG and JE Parham. 1994. Within Stream Distributions and Microhabitats of Micronesian Stream Fishes. Symposium on the Tropical Biosphere, University of the Ryukyus. Okinawa, Japan.

Computer Models, Spatial Datasets, and Databases developed

Parham, JE**. Hawaiian Stream Habitat Evaluation Protocol.** 2009. A multi-spatial model to provide standardized evaluation for stream animal habitat in Hawaiian streams to assess the impacts of land use change, flow diversion, habitat manipulation, and water quality issues. Hawaii Division of Aquatic Resources

Parham, JE. **Predictive habitat models for Hawaiian stream fishes.** 2008. GIS models that show expected distributions of stream fishes throughout Hawaii. Version 1. Hawai'i Division of Aquatic Resources.

Parham, JE. **Reach Classification for Hawaiian Streams.** 2006. A GIS model that classified streams into reaches using their major geomorphological characteristics. Version 1. Hawai'i Division of Aquatic Resources.

Parham, JE. **Lower Platte River Habitat Availability Model.** 2005. A GIS-based river discharge to habitat availability model for the lower 150 km of the Platte River. Version 1.0.

Parham, JE. **Lower Platte River Connectivity Model.** 2005. A GIS-based river discharge to river connectivity model for fish passage for the lower 150 km of the Platte River. Version 1.0.

Parham, JE and J Gilsdorf. **UNL Deer Project Database,** 2005. Designed database for long term tracking of deer throughout Nebraska for behavior, habitat use, and Chronic Wasting Disease studies by the University of Nebraska - School of Natural Resources. Version 1.0

Parham, JE, J Fisher, and T Barada. **Nebraska Statewide Stream Survey Database.** 2004. Designed database for a 3 year statewide stream surveys of 119 streams in Nebraska for the University of Nebraska - School of Natural Resources and Nebraska Game and Parks Commission. Version 1.0

Parham, JE. **Lower Platte River Fish Survey Database**. 2002 and continuous updates to 2005. Designed database for integration of multiple projects focused on endangered fishes in the lower Platte River. University of Nebraska - School of Natural Resources. Versions 1 to 6.0.

Parham, JE. **Statewide Instream Flow Estimator**. 2003. A GIS model for estimating stream discharge from annual rainfall, solar radiation, and topography data for Hawaiian streams. Version 1. Hawai'i Division of Aquatic Resources. Version 2 is currently being developed to calculate daily discharge.

Parham, JE. **Hawaii Stream Type Classification Model.** 2003. A GIS model that classified streams by their major geomorphological characteristics based on data from 150 Hawaiian streams. Version 1. Hawai'i Division of Aquatic Resources. Version 2 is near completion with data from all Hawaiian watersheds.

Parham, JE, DGK Kuamo'o, and GR Higashi. **Hawai'i Division of Aquatic Resources Surveys Database.** 2002-2006. A database to store historical and current fisheries surveys in nearshore, esturine, and stream environments. Versions 1-4. Hawai'i Division of Aquatic Resources.

Professional Affiliations

The American Fisheries Society
Community of Science
Fellow at the Center for Great Plains Studies

CURRICULUM VITA

EDWARD JAMES PETERS
PROFESSOR-EMERITUS
School of Natural Resource Sciences
UNIVERSITY OF NEBRASKA-LINCOLN
LINCOLN, NEBRASKA

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EDUCATIONAL BACKGROUND

Ph D 1974 BRIGHAM YOUNG UNIVERSITY
MAJOR: ZOOLOGY MINOR: GEOLOGY
DISSERTATION TITLE: The effects of highway construction on the fish populations in the Weber River near Henefer, Summit County, Utah.

M S 1970 BRIGHAM YOUNG UNIVERSITY
MAJOR: ZOOLOGY MINOR: BOTANY
THESIS TITLE: Changes with growth in selected body proportions of the woundfin minnow (*Plagopterus argentissimus* Cope: Cyprinidae).

B S 1967 WISCONSIN STATE UNIVERSITY-STEVENS POINT
MAJORS: CONSERVATION and BIOLOGY

TEACHING EXPERIENCE

UNIVERSITY OF NEBRASKA - LINCOLN: SCHOOL OF NATURAL RESOURCE SCIENCES (1997 to 2005)

FISHERIES SCIENCE
ICHTHYOLOGY
FISHERIES BIOLOGY
FOOD, AGRICULTURE, AND NATURAL RESOURCE SYSTEMS (recitation)

UNIVERSITY OF NEBRASKA-LINCOLN: DEPARTMENT OF FORESTRY, FISHERIES AND WILDLIFE (1975 to 1997)

FISHERIES SCIENCE: Developed and taught since 1976. This was the first Fisheries course taught in the College of Agriculture and it emphasized the estimation of biological statistics of fish populations and their application to fish management.

INTRODUCTION TO NATURAL RESOURCES: Developed and taught since 1976. This was the first Natural Resources course taught at UNL and was currently the basic course in the Natural Resources Major.

FISHERIES BIOLOGY: Developed and taught since 1978. Emphasized the study of factors which influence fish productivity in freshwater.

ICHTHYOLOGY: Taught since 1980. This course emphasized the anatomy, physiology, ecology, evolution and systematics of fishes.

INTEGRATED RESOURCES MANAGEMENT: Developed and taught 1990 to 1993. This capstone course for Natural Resources Majors emphasized the interrelated nature of management decisions.

MOUNT MERCY COLLEGE: DEPARTMENT OF BIOLOGY (1972 to 1975)

INVERTEBRATE ZOOLOGY
VERTEBRATE ZOOLOGY
NONVASCULAR PLANTS
VASCULAR PLANTS
ECOLOGY
EVOLUTION
DESERT ECOLOGY (field trip course)

BRIGHAM YOUNG UNIVERSITY: DEPARTMENT OF ZOOLOGY (1971 to 1972)

GENERAL ZOOLOGY

RESEARCH EXPERIENCE

2008
Initiated work on a literature review on pallid sturgeon funded by the Platte River Recovery Implementation Program

2006
Completed the Final Report on the Nebraska stream fisheries inventory project.

2005
Completed field work and submitted the Final Report on the jointly funded Platte River project.
Completed field work on the Nebraska stream fisheries inventory project.

2004
Continued field work on the jointly funded Platte River project.
Continued field work on the Nebraska stream fisheries inventory project.

2003
Continued field work on the jointly funded Platte River project.
Initiated field work on the Nebraska stream fisheries inventory project funded by the Nebraska Game and Parks Commission.
Graduated three MS students.

2002
Continued field work on the jointly funded Platte River project.
Completed field work and submitted the Final Report on the Branched Oak lake project.

2001
Continued field work on the jointly funded Platte River project.
Completed field work and submitted the Final Report on the Lake Ogallala project.
Graduated three MS students.

2000
Continued work on the Lake Ogallala project.
Continued work on the Branched Oak Lake project.
Completed work on U. S. Fish and Wildlife Service grants on Platte River.
Initiated work five year project on the lower Platte River funded jointly by a consortium of Natural Resources Districts, the Nebraska Game and Parks Commission and the US Fish and Wildlife Service.

1999
Continued work on the Platte River and Lake Ogallala projects.
Initiated work on the Branched Oak Lake project funded by the Nebraska Game and Parks Commission.

1998
Initiated work on the Platte River project which included larval fish sampling and pallid sturgeon telemetry and habitat use funded by the US Fish and Wildlife Service.
Continued work on the Lake Ogallala project.
Graduated two MS students.

1997
Continued work on the Lake Ogallala project.
Participated in the Lake Ogallala chemical renovation.
Graduated one MS Student.

1996
Completed the final report on the initial lake Ogallala project.
Completed Final Report on the EPA R-EMAP project.
Initiated work on the revised Lake Ogallala Project funded by the Nebraska Game and Parks Commission.
Completed field work on the Sturgeon Project.
Graduated three MS students and two PhD students.

1995
Completed work and submitted the Final Report on the thermal tolerance study.
Continued work on the Lake Ogallala project
Continued work EPA R-EMAP project.
Initiated work on the biology of sturgeon in the Platte River funded by the US Fish and wildlife Service.
Graduated four M.S. students.

1994
Completed the final report for the Platte River project.
Continued work on the thermal tolerance study.
Initiated work on the Lake Ogallala project funded by the Nebraska Game and Parks Commission
Initiated work on a stream survey project funded by the US EPA through R-EMAP.

1993
Completed research on development of suitability criteria for Platte River fishes and the creel survey of the lower Platte River.
Initiated work on thermal tolerances of selected Platte River fishes supported by the US Fish and Wildlife Service.

1992
Initiated a creel survey study on the lower Platte River and began comparison of habitat suitability criteria between the lower Platte and the central Platte fishes.
Graduated one M.S. student.

1991
Initiated study on Biodiversity of the central Platte River (fishes) funded by the US Fish and Wildlife Service.
Finalized contracts with four Natural Resources Districts, the Platte River Whooping Crane Trust and the Nebraska Game and Parks Commission under the title "Biological and economic analyses of the fish communities in the Platte River".
Completed work and prepared the final report for the Studies of Channel catfish in the lower Platte River project.

1990
Continued work on the Platte River project.

1989
Continued work on the Platte River project.
Graduated one M.S. student.

1988

Completed work and prepared the final report for on the Platte River project.
Initiated study on the Platte River funded by the U.S. Army Corps of Engineers and the Nebraska Game and Parks Commission.
Completed faculty development leave.
Graduated one M.S. student.

1987
Continued work on the Platte River project.
Began faculty development leave.
Graduated two M.S. students.

1986
Developed contracts with the Lower Platte North Natural Resources District and the Nebraska Game and Parks Commission for study of instream flow requirements of fish and aquatic invertebrates in the lower Platte River.
Completed courses on the use and application of Instream Flow Incremental Methodology.
Graduated one M.S. student.

1985 Began negotiations for the study of instream flow requirements of fish and aquatic invertebrates in the Platte River. Research appointment adjusted to 30%.

1984 Completed introductory course in the Instream Flow Incremental Methodology. Graduated four M.S. students.

1983 Completed work on the Maple Creek Model Implementation Plan study. Continued fish population surveys in the Little Blue River drainage. Graduated one M.S. student.

1982 Continued work on Maple Creek. Continued fish population surveys in the Little Blue River drainage.

1981 Continued work on Maple Creek. Continued fish population surveys in the Little Blue River drainage.

1980 Completed study of white perch in Buckley Creek Reservoir and completed evaluation of liming project. Continued work on Maple Creek. Conducted fish population survey of the Big Blue River Basin for the U.S. EPA.

1979 Conducted application of lime to Buckley Creek Reservoir to reduce turbidity. Initiated study of channel catfish movement and growth in the Little Blue River. Continued the Maple Creek project.

1978 Completed work on the Nine Mile Creek irrigation return flow study. Continued work on the white perch project. Conducted research on the impacts of the Guernsey silt run on fish and macroinvertebrates in the North Platte River. Initiated an evaluation of watershed erosion and sediment control on the fishes of Maple Creek. Obtained research appointment of 21 %. Graduate two M.S. students.

1977 Began study of the impact of an introduced fish species (white perch) on the fisheries of Buckley Creek reservoir. Started a study of the impacts of irrigation return flow on the invertebrates and trout spawning habitat of Nine Mile Creek. Awarded a summer faculty research fellowship to develop an Experiment Station project.

1976 Initiated research program at UNL (no official research appointment). Received two University Research Council grants to support graduate thesis research projects on the study of fish distribution in the Salt Creek drainage and a study of the production rates of aquatic insects in a turbid reservoir.

1974 to 1975 Directed undergraduate independent study research studies in biology at Mount Mercy College.

1967 to 1974 Graduate thesis and dissertation research under the direction of Dr. David White. Assisted with a variety of aquatic and terrestrial research projects.

1966 Wild rivers fish, macroinvertebrate and water chemistry survey of northeast Wisconsin under the direction of Dr. George Becker. Conducted an undergraduate research project on the distribution of fishes in the Wisconsin River in Portage County, Wisconsin.

RELATED PROFESSIONAL EXPERIENCE
American Fisheries Society: member since 1968, active in state chapter activities, regular participant in North Central Division meetings, elected to and served on state, division and national committees.

American Society of Ichthyologists and Herpetologists: member since 1970.

North American Benthological Society: member since 1970, irregular participant in national meetings.

Nebraska Academy of Sciences: member since 1975, regular participant and contributor to annual meetings, elected biological and medical sciences section coordinator, session chairman on several occasions.

Wisconsin Academy of Sciences, Arts and Letters: member since 1965 (life member 2000).

Society of Sigma Xi: elected to membership 1970, elected to Nebraska chapter offices: membership coordinator 1984-1986, President 1989-1990.
Center for Great Plains Studies: elected a Fellow 1982.

State and University committees including; the Aquaculture Task Force, the Prairie Bend Technical Advisory Group, the 404 Task Force, the UN Water Policy Steering Committee, UNL Faculty Senate, College of Agriculture Instructional Improvement Committee, the Natural Resources Curriculum Committee, the Agricultural Research Division Advisory Council and the Curriculum Revitalization Task Force.

FUNDED RESEARCH PROJECTS (chronological listing)

1976
A distributional study of the fishes in the Salt Creek drainage, UNL Research Council, $700, (1976-1978)

Production rates of aquatic insects in a turbid reservoir, UNL Research Council, $813, (1976-1978)

1977
Effects of irrigation return flow on Nine-Mile Creek, Nebraska Natural Resources Commission, $14,299, (1977-1978)

Impact of an introduced species on the fisheries resources of Nebraska, Nebraska Water Resources Center, $20,000, (1977-1980)

Summer faculty research fellowship, Nebraska Agricultural Experiment Station, $1,500 (1977)

1978
Effects of a silt run on the biota of the North Platte River near Guernsey, Wyoming, Nebraska Water Resources Center, $8,500 (1978)

Impact of watershed sediment control on the biota of Maple Creek, Nebraska Department of Environmental Control, $75,000 (1978-1983)

1979
Effects of applications of lime on the turbidity in Buckley Creek Reservoir, Nebraska Water Center and the Little Blue Natural Resources District, $6,600 (1979-1984)

1980

A fish population survey of the Big Blue River basin, U.S. Environmental Protection Agency, $873 (1980)

1986
Instream flow requirements of fish and aquatic invertebrates in the lower Platte River, Nebraska Game and Parks Commission, $190,400 (1986-1988)

Instream flow requirements of fish and aquatic invertebrates in the lower Platte River, Lower Platte North Natural Resources District, $40,000 (1986-1988)

1988
Platte River Fisheries Study, U.S. Army Corps of Engineers, $40,000 (1988-1990)

Studies of Channel Catfish in the lower Platte River, Nebraska Game and Parks Commission, $196,140 (1988-1991)

1991
Distribution and abundance of fishes in the central Platte River, U.S. Fish and Wildlife Service, $22,300 (1991-1992)

1992
Biological and economic analyses of fish communities in the Platte River, (1992-1993)
Nebraska Game and Parks Commission, $176,264
Central Platte Natural Resources District, $10,000
Lower Platte North Natural Resources District, $10,000
Lower Platte South Natural Resources District, $10,000
Papio/Missouri Natural Resources District, $10,000

Development of an aquatic mesocosm facility, U.S. Fish and Wildlife Service, $50,000 (1992-1993)

Influences of vegetation on wildlife and fisheries populations in the central Platte, River, U.S. Fish and Wildlife Service, $80,000 (1992-1994)

1993
Critical thermal maxima of selected fishes in the Platte River, U.S. Fish and Wildlife Service, $80,000 (1993-1995)

1994
Population structure and food habit analyses of alewife, rainbow trout and other selected fishes in Lake Ogallala, Nebraska Game and Parks commission, $133,500 (1994-1996)

Measuring the health of Nebraska's fisheries, Nebraska Department of Environmental Quality, $156,235 (1994-1995)

1995
Studies of sturgeon in the Platte River, U.S. Fish and Wildlife Service, $54,000 (1995-1997)

1996
Alewife and trout studies in Lake Ogallala, Nebraska Game and Parks Commission, $170,010 (1996-1999)

1998
Pallid sturgeon in the lower Platte River, U. S. Fish and Wildlife Service, $96,720 (1998 - 2001)
Endangered fishes of the lower Platte River, U.S. Fish and Wildlife Service, $76,560 (1997 - 2001)

1999
Branched Oak Reservoir evaluation project, Nebraska Game and Parks Commission, $193,413 (1999 - 2001)

2000
Ecology and management of sturgeons in the lower Platte River, Nebraska Game and Parks Commission, $701,000 (2000 - 2005)
Ecology and management of pallid sturgeon and sturgeon chub in the lower Platte River, Pallid sturgeon / sturgeon chub task force, $550,000 (2000 - 2005)

2003
Nebraska statewide stream fisheries inventory, Nebraska Game and Parks Commission, $459,575 (2003-2006)

2006
Publication of the Ecology and management of sturgeon in the lower Platte River, Nebraska, Nebraska Game and Parks Commission, $40,000 (2006 – 2008)

2008
A review of literature which pertains to the use of the lower Platte River by pallid sturgeon, Platte River Recovery Implementation Program, $32,000 (2008)

GRADUATE STUDENT THESES (all at the University of Nebraska – Lincoln)

1978

Lund, J.C.

Production rates of benthic insects in a turbid reservoir. M.S.

Maret, T.R.

The fishes of the Salt Creek basin, Nebraska. M.S.

1983

Winter, R.L.

A test of lake chubsucker, *Erimyzon succetta*, as forage for largemouth bass, *Micropterus salmoides*, in small eastern Nebraska impoundments. M.S.

1984

Chapin, C.A.

Effects of agricultural lime on the water quality and benthic fauna in a turbid Nebraska reservoir. M.S.

Klammer, J.A.

Food and feeding of rainbow trout (*Salmo gairdneri*) and brown trout (*Salmo trutta*) in two Nebraska sandhills streams. M.S.

Shadle, J.J.

A study of the crayfish (*Orconectes immunis*) in an intermittent Nebraska stream. M.S.

Walker, S.R.

Abundance and movement of channel catfish, *Ictalurus punctatus*, in the Little Blue River, Nebraska. M.S.

1986

Schleiger, S.L.

Interspecific interactions of a green sunfish (*Lepomis cyanellus*) and creek chub (*Semotilus atromaculatus*) in small stream in southeast Nebraska. M.S.

1987

Angle, L.A.

Effects of sediment addition on the drift of aquatic macroinvertebrates in Nine Mile Creek, Nebraska. M.S.

Zaroban, D.W.

A field test of habitat evaluation procedures for creek chub (*Semotilus atromaculatus*) and channel catfish (*Ictalurus punctatus*). M.S.

1988

Bunnell, D.B.

Habitat utilization and movement of adult channel catfish and flathead catfish in the Platte River, Nebraska. M.S.

1989

Callam, M.A.

Use of prepositioned electrofishing grids to assess habitat suitability for *Notropis stramineus*, *N. lutrensis* and *N. blennius* in the Platte River, Nebraska. M.S.

1992

Yu, Shyi-Liang

Logistic regression models of habitat use by three cyprinids in the Platte River, Nebraska. M.S.

1995

Chapman, R.C.

Movements of channel catfish in the Platte River, Nebraska. M.S.

Ihrie, D.B.

A test of the ecoregion classifications of Nebraska streams using discriminant analysis. M.S.

McBride, M.J.

Aquatic macroinvertebrates of the central Platte River, Nebraska. M.S.

Michl, G.T.

A test of the Index of Biotic Integrity for streams in the sandhills region of Nebraska. M.S.

1996

Fessell, B.P.

Thermal tolerances of Platte River fishes: Field and laboratory studies. M.S.

Laux, E.A.

The biology of alewife *Alosa pseudoharengus* in Lake Ogallala, Nebraska. M.S.

Messaad, I.A.

Histological responses of red shiner (*Cyprinella lutrensis*) to atrazine terbufos, and their mixture. PhD

Porath, M.T.

Influence of prey availability on walleye *Stizostedion vitreum*. M.S.

Yu, S.L.

Factors affecting habitat use by fish species in the Platte River, Nebraska. PhD

1997

Hofpar R.L.

Biology of shovelnose sturgeon in the lower Platte River, Nebraska M.S.

1998

Barrow, T. M.

Factors affecting movements of rainbow trout (*Oncorhynchus mykiss*) in Lake Ogallala, Nebraska. M.S.

2000

Pearson, T. J.

The use of benthic macroinvertebrates by rainbow trout (*Oncorhynchus mykiss*) in Lake Ogallala, Nebraska. M.S.

Reade. C. N.

Larval fish drift in the lower Platte River, Nebraska. M.S.

2001

Hodkin, C. A.

Population characteristics and food habits of the white perch (*Morone americana*) in Branched Oak Lake, Nebraska. M.S.

Huxoll, C. M.

Movement of rainbow trout and brown trout in relation to water quality and food availability in Lake Ogallala, Nebraska. M.S.

Snook, V. A.

Movements and habitat use by hatchery-reared pallid sturgeon in the lower Platte River, Nebraska. M.S.

2003

Kopf, S. M.

Habitat use by chubs of the genera *Macrhybopsis* and *Platygobio* in the lower Platte River, Nebraska. M.S.

Shuman, D. A.

The age and size distribution, condition, and diet of the shovelnose sturgeon *Scaphirhynchus platorynchus* in the lower Platte River, Nebraska. M.S.

Swigle, B. D.

Movements and habitat use by shovelnose sturgeon and pallid sturgeon in the lower Platte River, Nebraska. M.S.

PUBLICATIONS (chronological listing)

White, D.A. and E.J. Peters. 1969. A method of preserving color in aquatic vertebrates and invertebrates. Turtox News, 47:296-297.

Barton, J.R., D.A. White, P.V. Winger, and E.J. Peters. 1971. The effects of highway construction on the hydrology and hydrobiology of the Weber River near Henefer. Final report to the Utah Division of Fish and Game and the Utah Department of Highways. 86p.

Barton, J.R., E.J. Peters, D.A. White, and P.V. Winger. 1972. Bibliography on the physical alteration of the aquatic habitat (channelization) and stream improvement. Brigham Young University, Multilith Series, Provo, Utah. 30p.

Barton, J.R., D.A. White, P.V. Winger, and E.J. Peters. 1972. The effects of highway construction on fish habitat in the Weber River, near Henefer, Utah, p. 17-29 In Ecological impact of water resource development. U.S. Bureau of Reclamation Report Number, REC-ERC-27-17.

Winger, P.V., E.J. Peters, M.J. Donahoo, J.R. Barnes, and D.A. White. 1972. A checklist of the macroinvertebrates of the Provo River, Utah. Great Basin Naturalist, 32:211-219.

Peters, E.J. 1976. New course emphasizes total resource concept. Farm, Ranch and Home Quarterly, 23:17.

Maret, T.R. and E.J. Peters. 1979. Food habits of the white crappie, *Pomoxis annularis*, Rafinesque, in Branched Oak Lake, Nebraska, Transactions of the Nebraska Academy of Sciences, 7:75-82.

Maret, T.R. and E.J. Peters. 1980. The fishes of Salt Creek basin, Nebraska. Transactions of the Nebraska Academy of Sciences, 8:35-54.

Lund, J.C. and E.J. Peters. 1981. Production rates of aquatic insects in a turbid reservoir. Transactions of the Nebraska Academy of Sciences, 9:23-34.

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HONORS AND AWARDS

1979
Elected President of the Nebraska Chapter of the American Fisheries Society

1991
Elected President of the Nebraska Chapter of the American Fisheries Society

1989
Elected President of the University of Nebraska Chapter of the Society of Sigma Xi

Outstanding Professor Award
by Delta Tau Delta Fraternity

1993
University of Nebraska-Lincoln, Outstanding Teaching Award

2003
Appointed to the Committee on Endangered and Threatened Species of the Platte River
by the National Research Council of the National Academy of Science

2004
Holling Family Award for Teaching Excellence
by the University of Nebraska-Lincoln, College of Agricultural Sciences and Natural Sciences

Outstanding Club Advisor Award
by the University of Nebraska Wildlife Club

2005
Award of Excellence
by the Nebraska Chapter of the American Fisheries Society

Citation of Achievement
by the State of Nebraska, Game and Parks Commission

Lifetime Achievement Award
by the Nebraska Wildlife Federation

Appendix 2: Documents Reviewed by the Panel

MRRIC Questions and Responses (October 6, 2009 version)

Draft EA (September 11, 2009 version – Note: The structure of the portable document format file provided by Reclamation was not suitable for inclusion in this appendix and is incorporated by reference.)

Missouri River Recovery Implementation Committee Questions on the Intake Project

A. Larval Drift

A. 1 Question: Where above Intake on the Yellowstone River does spawning substrate exist? What is the likelihood of the pallid using the newly opened area for spawning? And if they use it, is adequate drift distance/time provided for larvae survival?

A.1 Answer: Spawning Substrate Location Specific spawning substrate has not been identified in the upper Missouri River Basin including the Yellowstone River; however, there are data supporting the existence of spawning substrates above Intake.

Pallid sturgeon spawning currently occurs in the Yellowstone River downstream of Intake Diversion Dam (Fuller et al. 2008). Intensive relocation and spatial analysis of telemetered pallid sturgeon of known gender and sex stage suggest that fish spawn in bluff pool habitats in the Yellowstone River. In 2007 seven male and one gravid female pallid sturgeon aggregated in a bluff pool for about three days and subsequent recapture of the female pallid sturgeon indicated that spawning had occurred (Fuller et al. 2008).

Similar aggregations in this bluff pool were observed by Bramblett and White (2001) who speculated that spawning occurred downstream of Intake. This observation is supported by telemetry data from the middle and lower Missouri River where female pallid sturgeon in spawning condition are believed to have spawned over or adjacent to hard, coarse substrates in relatively deep water on outside bends where flows converge (Aaron DeLonay, U.S.Geological Survey (USGS), personal communication).

Bluff pool habitats occur when the outside bend of the channel scours against bedrock at the valley margin. These habitats are generally longer, have lower average and bottom velocities, higher maximum and average depths, and a higher percentage of coarse, hard boulder and bedrock substrates than other habitats in the valley bottom (Jaeger et al. 2008). Terrace pool habitats are similar in their attraction to pallid sturgeon but are found adjacent to alluvial terraces (Jaeger et al 2005a). There are over 4,000 acres of bluff and terrace pool habitats between Intake and Cartersville Diversions (Matthew Jaeger, FWP, personal communication) and substrates throughout this reach are predominately hard gravel and cobble (Bramblett and White 2001).

In general, other sturgeon species spawn over hard substrates, which supports the conclusion that pallid sturgeon most likely spawn over hard substrates. Other sturgeon spawning substrates are as follows:

- Short nose sturgeon (*Acipenser brevirostrum*) spawn over rubble (Taubert 1980);

- Lake sturgeon (*A. fulvescens*) spawn over coarse gravel and rounded cobble (Manny and Kennedy 2002) and where substrates were predominantly cobble (Chiotti et al. 2008);
- White sturgeon (*A. transmontanus*) spawn over a diversity of substrates, including boulder, bedrock, cobble, and sand (Parsley et al. 1993; Perrin et al. 2003); and
- Gulf sturgeon (*A. oxyrinchus*) spawning areas consist of hard substrates and gravel (Heise et al. 2004).

Given the association of pallid sturgeon spawning with hard substrates and bluff pool habitats and the abundance of hard substrates and high habitat diversity, including bluff pools, upstream of Intake Dam it is reasonable to infer that suitable spawning substrate for the species exists upstream of Intake Dam.

<u>Pallid Sturgeon Using the Newly Opened Area for Spawning</u> The likelihood of pallid sturgeon using a newly opened area for spawning is uncertain, as with most restoration actions for endangered species. However, like most sturgeon species, pallid sturgeon generally move upstream to spawn, and spawning is believed to occur at or near the apex of this movement (Aaron DeLonay, USGS, Personal Communication). Telemetry data indicate that almost all remaining pallid sturgeon in RPMA 2 move into the Yellowstone River in the spring and that each year some move upstream to Intake Diversion Dam but not above (Bramblett and White 2001; Fuller et al. 2008).

Work specifically studying fish in known spawning condition documented at least one gravid female and several male pallid sturgeon moving up to Intake Diversion Dam, staging immediately below the dam for several days, and then moving back downstream (Fuller et al. 2008; M. Jaeger, personal communication). Intensive netting studies have also documented relatively high numbers of pallid sturgeon immediately below Intake Diversion Dam (Backes et al. 1994), and historic accounts documented pallid sturgeon upstream of Intake Diversion Dam during the putative spawning period (Brown 1955).

It is reasonable to conclude that if Intake Diversion Dam was not a barrier to movement, pallid sturgeon would continue to move above this point to satisfy various life history needs, including spawning.

<u>Adequate Drift Distance/Time</u> Natural variability in water temperature and velocity will result in a wide range of drift distances for pallid sturgeon larvae produced upstream of Intake Diversion Dam in the Yellowstone River. The free-drifting phase of pallid sturgeon larvae is a developmental stage that occurs between hatching and yolk sac absorption. The duration of this developmental stage is influenced by water temperature. At 16^{o}C the time between hatching and yolk sac absorption is 13 to 15 days, but at 24^{o}C it is reduced to 7 to 9 days (Kevin Kappenman, U.S. Fish and Wildlife Service (Service), personal communication). Temperatures on the lower Yellowstone River when larvae are expected to hatch and enter the free drifting phase typically range between 20^{o}C and 25^{o}C, which result in an expected drift time of 7 to 10 days.

While total drift time is dictated by water temperature, both laboratory and field trials indicate that drift rates of larval pallid sturgeon are related to water velocity. Thus, cumulative drift distance is related to both drift time and drift rate. Simply put, at a given temperature larvae drift farther at higher velocities (Kynard et al. 2007; Braaten et al. 2008), but in reality it is much more complex.

Larval drift rates decrease from average water velocities as habitat complexity increases due to entrainment of drifting larvae in areas of reduced velocity, such as eddies (Kynard et al. 2007; Braaten et al. 2008). Continuous exposure to eddies and channel complexity during the entire larval drift period will likely reduce cumulative distance drifted by larvae, as suggested by Braaten et al. (2008) and observed during 2007 when larval pallid sturgeon were allowed to free drift throughout a 180-km [112 miles] reach of the mainstem Missouri River (Braaten et al., in preparation).

For example, Bratten et al. (2008) observed a three-fold increase in the average durations for all observed 1 to 9 day old larvae to drift 4,265 feet compared to 328 feet. Similarly, the deviation from water traveling at average velocity for the entire observed distributions of 1 to 9 day old larvae was 3 times greater at 4,265 feet than at 328 feet (Braaten et al. 2008). The further larvae drift through complex habitat, the greater the range of time it will take all larvae to drift a given distance. Based on the observations of Braaten et al. (2008), it is expected that the entire distribution of drifting larvae would require an additional 4 days of travel time to cover the same distance as a drop of water traveling at average column velocity over a distance of 317 miles, which is the cumulative amount of riverine habitat between Cartersville Diversion and the present headwaters of Sakakawea Reservoir.

Higher habitat complexity in the Yellowstone River as compared to previous studies suggests that drifting larvae will be more frequently exposed to and resultantly entrained in lower velocity habitats, such as eddies, secondary channels, and boundary layers associated with coarser substrates. This will likely reduce drift rates and cumulative drift distance relative to average water velocity more than previously reported.

Previous larval drift studies were conducted in smooth-bottomed tanks with limited rock material (Kynard et al. 2007) or over sand and silt substrates (Braaten et al. 2008), whereas Yellowstone River substrate above Intake Diversion Dam is predominately gravel and cobble (Bramblett and White 2001). Increased roughness associated with gravel and cobble substrates results in a thicker, low-velocity boundary layer on the stream bottom. In other words, the water traveling along the river bed substrate interface moves more slowly over coarse substrates than it does over sand or silt substrates (Gordon et al. 1992). Because larval pallid sturgeon drift at or near the stream bottom (Kynard et al. 2007; Braaten et al. 2008), entrainment in low-velocity boundary layers or interstitial spaces within the substrate could reduce drift rates and distances from those predicted based on average column velocity alone.

Laboratory studies incorporating limited rock cover provide somewhat contradictory results. Pallid sturgeon did not attempt to use rock cover at low velocities (Kynard et al. 2002) but did try to hold position behind rocks at higher velocities (Kynard et al. 2007). Larval drift rates associated with gravel substrates are lower than those associated with sand substrates for other sturgeon species (Nechako White Sturgeon Recovery Initiative 2007).

There are approximately 176 miles of seasonal and perennial secondary channels accompanying 236 miles of mainstem channel below Cartersville Dam on the Yellowstone River (Jaeger 2004). Average and bottom velocities of secondary channel habitats are significantly lower than those of mainstem habitats ($P < 0.001$; Jaeger et al. 2008). These lower velocities effectively reduce drift rates of fish entering these habitats.

The Yellowstone River has 35% - 50% more area of slow current velocity habitat patches than the Missouri River during periods when larval drift occurs (Bowen et al. 2003). This likely reduces larval drift rates on the lower Yellowstone River relative to average water velocity than modeled in the Missouri River. Accordingly, increased habitat complexity in the Yellowstone River may make direct extrapolation of larval drift distances modeled under lower habitat complexity or considering only average water velocity inappropriate.

In summary, it is anticipated that the average larvae will drift faster in the Yellowstone River than described in laboratory (Kynard et al. 2007) or field investigations (Braaten et al. 2008) because of higher velocities. A combination of other physical factors, i.e. temperature, habitat complexity, etc., will shorten total drift time and thus drift distances for some larvae relative to those predicted by water velocities alone. Based on the amount of variation in temperature and drift rate, it is expected that a wide range of larval drift distances will occur within and among years.

It is expected that the fastest drifting larvae traveling at approximately the same rate as the average water column velocity at relatively cool temperatures and resultantly long drift times (10 days) will require over 497 miles of drift distance on the Yellowstone River. However, it is also expected that the slowest drifting larvae, which will deviate by several days from drift times predicted by water traveling at average velocity, at relatively warm temperatures and resultantly short drift times (7 days) will requires less than 217 miles of drift distance. Thus, we anticipate that adequate larval drift distance will be available for a portion of any naturally produced larvae spawned in currently inaccessible reaches upstream of Intake Diversion Dam during most years.

<u>Summary</u> The potential for natural recruitment and enhancement by providing passage at Intake Diversion Dam has been a position long held by pallid sturgeon biologists (Service 2000a; Service 2003). This was confirmed more recently by the Upper Missouri Basin Pallid Sturgeon Workgroup (Workgroup). The Workgroup was asked by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) and the U.S. Army Corps of Engineers (Corps) to address habitat availability and larval drift issues for pallid sturgeon in the Yellowstone River. The Workgroup (2009) concurred that additional ecosystem and connectivity restoration efforts could further increase the amount of habitat available for larval drift in the Yellowstone River. Furthermore, the Workgroup agreed that if pallid sturgeon passage at Intake Diversion Dam results in spawning at upstream locations, then it is possible that adequate larval drift distances exist for natural recruitment to occur. Details of the Workgroup's assessment are summarized in their report (Workgroup 2009).

A.2 Question: What is the current speed during the high water period on the Yellowstone May 15--to July 15, at Cartersville and below and what velocity rate (or range of rates) is appropriate to calculate larval drifts?

A.2 Answer: In regard to spawning and larval drift, Question A.2 proposes too broad a time period. Spawning does not occur until about mid-June through early July (Fuller et al. 2008). Larvae hatch and begin drifting about 3 to 5 days following egg fertilization and drift for 7 to 10 days at temperatures common for the Yellowstone River (K. Kappenman, personal communication). This answer, therefore, focuses on the period when larvae are drifting, which is typically during the descending hydrograph from mid- to late-June through mid-July.

Determining "what velocity rate (or range of rates) is appropriate to calculate larval drifts" on the Yellowstone River is difficult because of the range of physical factors. These factors include velocities and temperatures during the time of larval drift and the complexity and diversity of habitats in the river. However, information collected by biologists over time can give us a picture of what is appropriate to calculate larval drift. Assuming a fish is drifting in the main channel in late June to early July, it is reasonable to use 2.9 feet per second.

Velocity will vary among years in relation to discharge and within years at a given discharge. This will occur at different locations in the Yellowstone River. River velocities generally increase as discharge increases (Leopold et al. 1964). At average discharges of 4,400 cubic foot per second (cfs) average velocities between Cartersville Diversion and the confluence with the Missouri River are 2.77 feet per second (f/s) (M. Jaeger, personal communication). By comparison, at flood stage (i.e. discharges of over 100,000 cfs) average velocity measurements at a single station with an artificially confined channel at Sidney Bridge are about 10 f/s (Leopold et al. 1964).

Average discharge on the Yellowstone River over the past 20 years from mid-June to early July is about 25,000 cfs near Sidney, Montana. Although river-wide average velocities have not been measured at this specific discharge, it is expected that average velocities during periods of larval drift may exceed 3.28 f/s (Workgroup 2009) but will be less than 6.56 f/s. For example, Bramblett (1996) measured velocity at points associated with sturgeon locations at discharges ranging from about 2,000 cfs to 50,000 cfs and the maximum average velocity recorded was 5.93 f/s while mean average velocity was 3.34 f/s.

However, it is also expected that velocity will vary considerably in the Yellowstone River at a given discharge. Jaeger et al. (2008) reported significant differences in average velocities among different habitat types in the Yellowstone River. Measurement of velocity at 4,400 randomly selected points indicated that average velocities ranged from 11.05 f/s to 0.00 f/s (M. Jaeger personal communication). Additionally, larval pallid sturgeon drift at or near the stream bottom (Kynard et al. 2007; Braaten et al. 2008) where velocities can be significantly lower than average velocities. Bottom and average velocities are substantially different on the Yellowstone River ($P < 0.001$); bottom velocities are about 21% lower than average velocities (M. Jaeger, personal communication).

As discussed above, increased habitat complexity in the Yellowstone River may make direct extrapolation of larval drift distances based only on average water velocity inappropriate. It is anticipated that the average larvae will drift faster in the Yellowstone River than described in laboratory (Kynard et al. 2007) or field investigations (Braaten et al. 2008) because of higher velocities. However, a combination of other physical factors, i.e. temperature, habitat complexity, etc., will shorten total drift distances for some larvae relative to those predicted by water velocities alone.

Based on the amount of variation in temperature and drift rate, it is expected that a wide range of larval drift distances will occur within and among years. Yellowstone River temperatures during periods of larval drift indicate that larvae will likely drift for 7 to 10 days. Distributions of larval drift rate and distance relative to water traveling at average velocity in the Missouri River suggests that some larvae will lag up to 4 days behind water traveling at average velocity over distances comparable to providing passage at Intake Diversion (510 km). Additionally, given the higher complexity of the Yellowstone River, it is expected that the deviation of the entire distribution of drifting larvae from water traveling at average velocity would be greater on the Yellowstone River than described above on the Missouri River.

It is expected that the fastest drifting larvae traveling near the velocity of average water at relatively cool temperatures and resultantly long drift times (10 days) will require over 800 km of drift distance on the Yellowstone River. However, it is also expected that the slowest drifting larvae at relatively warm temperatures and resultantly short drift times (7 days) will require less than 350 km of drift distance. Thus, we anticipate larval drift distance would be adequate for some larvae spawned upstream of Intake Diversion Dam during most years.

Reclamation asked the Upper Basin Pallid Sturgeon Recovery Workgroup to provide their best biological judgment about drift issues. This paper (Workgroup 2009) is appended.

A.3 Question: What data is available to support the conclusion that any larvae would actually survive without ending up in the head waters of Lake Sakakawea where they would die?

A.3 Answer: Hatchery-reared larvae released when 5 to 17 days old have been recaptured months or years later in the Yellowstone River and Missouri River below the confluence. This indicates that habitat in these river reaches is suitable for survival of pallid sturgeon larvae (M. Jaeger, personal communication). However, these findings are based on fish that have artificially reduced drift rates because a portion of their drift phase was spent in a hatchery environment. By increasing drift distance, it is anticipated that naturally-produced larval pallid sturgeon would settle in the same areas capable of supporting these hatchery-reared study fish.

The Workgroup (2009) reports:

> "The near-natural hydrograph and associated temperature and sediment regimes characteristic of the unimpounded Yellowstone River (White and Bramblett 1993) combine to provide one of the best habitat templates and opportunities to support pallid sturgeon recovery in the upper Missouri River basin. Current habitat conditions include intact migration and spawning cues and habitats; most extant adult pallid sturgeon in [Recovery-Priority Management Area] RPMA 2 migrate into the lower Yellowstone

> River each spring (Bramblett and White 2001) and subsequent spawning has been documented (Fuller et al. 2008). However, inadequate larval drift distances (~150 kilometers) [93 miles] between known spawning reaches and the present headwaters of Sakakawea Reservoir may not exist. Accordingly, inadequate larval drift distances are one of the leading hypotheses to explain recruitment failure in RPMA 2."

While there is no way to guarantee survival of larval pallid sturgeon that may result following implementation of passage and entrainment protection at Intake Diversion Dam, the data provided above suggest that habitat diversity in the Yellowstone River may make larval drift rate data from other studies (i.e. Kynard et al. 2002; Kynard et al. 2007; Braaten et al. 2008) difficult to directly extrapolate to the Yellowstone River. However, data available from these studies suggest that not all pallid larvae drift at the same rate (Braaten et al. 2008), and development of larvae influences drift (Kynard et al. 2007). The Workgroup paper (2009) also addresses larval drift distances.

Furthermore, water temperature influences larval development rates; larvae develop faster in warm water. Temperature profiles for the Yellowstone River indicate that larval development rates (based on degree days) are higher than the Missouri River downstream from Fort Peck Dam. Therefore, we anticipate that while some larvae will drift into Lake Sakakawea, a portion of the slowest drifters likely will not**.**

A.4 Question: What are the anticipated drift rate and distance required for larval pallid sturgeon in the relevant reaches? What is the required water level in Lake Sakakawea to attain this distance? How often should these conditions exist? What is the level of uncertainty in the drift rate and distance calculations? How was this data considered when planning the Intake project?

A.4 Answer: Not all larvae drift at the same rate – some drift faster than mean velocity, some drift at about mean velocity, and some drift slower than mean velocity. Although there are uncertainties relative to larval drift speed and distance in relation to high velocities and coarse substrates in the Yellowstone River, it is likely that at least a portion of the larvae hatched upstream of Intake Diversion Dam would survive (note previous discussions above).

If pallid sturgeon passage at Intake Diversion Dam results in spawning at upstream locations, then it is possible that larval drift distances would be adequate for some natural recruitment to occur (Workgroup 2009). Construction of a fish passage alternative at Intake Diversion Dam would provide between 253 and 317 miles of natural free-flowing river between Cartersville Dam, which is the next upstream barrier on the Yellowstone River and Lake Sakakawea.

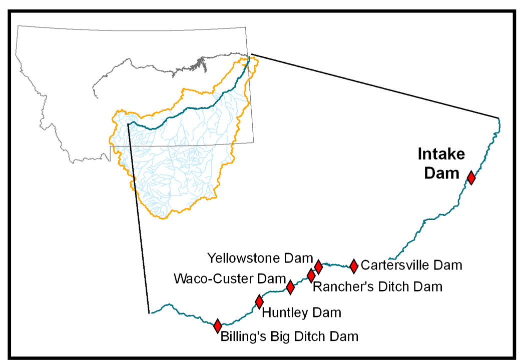
While the range of available habitat is related to pool elevations of Lake Sakakawea, any requirements for specific pool elevations have not been determined, because the current focus is on providing passage to as much upstream habitat as possible. This additional increase in the length of free-flowing riverine habitat likely would provide adequate drift distance for at least a portion of the larvae (Workgroup 2009). Further discussion of drift rates and distance calculations can be found in the Workgroup's (2009) white paper and above. Specific calculations on drift distances can also be found in the recent Montana Fish, Wildlife & Parks (FWP) presentation to MRRIC (Jaeger 2009).

Any specific recommendations for pool elevation manipulations may be discussed through the adaptive management process as pallid spawning and recruitment success is monitored. It is not known how often this species needs to accomplish a successful spawn/recruitment year class, but the spawning periodicity of adult females is every two to three years. With the long-lived nature of pallid sturgeon, it is likely they do not need to successfully spawn every year in order to accommodate a wild population of naturally reproducing fish, as evidenced by the natural fluctuations in historic flow regimes.

In planning the Intake Diversion Dam Modification, Lower Yellowstone Project (Intake Project), the best available scientific data were considered. This is documented in the draft environmental assessment (EA) prepared for the Intake Project. The Service's Biological Review Team, as well as researchers from Reclamation's Denver Technical Service Center, the Workgroup, the Pallid Sturgeon Recovery Coordinator, and other Reclamation staff, Corps, Service, USGS, and state biologists have all participated in planning the Intake Project.

A.5 Question: Is there a need to modify other upstream dams to allow enough drift distance for larvae? What progress/plans have been made on modifying upstream structures?

A.5 Answer: There are six low-head diversion dams on the Yellowstone River downstream from Billings, Montana (see Intake EA, page 3-6). Huntley Dam and Intake are federally-owned, while the middle four (Waco-Custer, Rancher's Ditch, Yellowstone, and Cartersville) are privately-owned and managed by the local irrigation districts. These structures present some degree of impediment to fish passage; however, the extent of fish blockage at these dams seems to depend on river stage and the swimming ability of the various species trying to negotiate the dams (see Helfrich et al. 1999).



Diversion Dams Along the Yellowstone River (adapted from Jenkins 2007).

At present, three of these diversion structures fall within what is generally considered to be the historical range of pallid sturgeon. In addition to Intake, fish passage needs at the Cartersville Dam near Forsyth, Montana, are under discussion. The Cartersville Dam is privately owned but FWP, the Service, the Corps, and the Nature Conservancy are working together to find a solution. To date, a value engineering study has identified a suite of potential options for passage of native species, including sturgeon (FWP and Enlien Consultants 2009). FWP has hired an engineering and consulting firm to analyze these potential passage options, prepare an environmental assessment, and identify a preferred alternative.

Dams on tributaries to the Yellowstone have also been modified to address fish passage issues including the T&Y Dam and the Mobley Dam on the Tongue River. These new fish passage projects open additional miles of pallid sturgeon habitat on the Tongue River.

A.6 Question: Can/should a study be conducted on the Yellowstone River to provide drift information specific to this reach?

A.6 Answer: The best available scientific information, many biologists, and researchers concur that larval drift distance on this reach would be adequate for a portion of pallid sturgeon larvae most of the time once the passage issue at Intake has been resolved. A study could be conducted, but there are several complicating factors involved with such a study on the Yellowstone, such as:

- Are there sufficient numbers of pallid sturgeon larvae available for study? Adult female pallid sturgeon typically produce between 0 to 243,450 larvae, although average production is about 100,000 larvae (Rob Holm, Service, personal communication). Previous mainstem drift tests required about 428,285 larvae at a discharge of about 6,400 cfs (R. Holm, personal communication). At discharges expected in the Yellowstone River during times of larval drift (25,000 cfs) about 1,672,988 larvae would be required for a comparable drift test to account for dilution associated with increased discharges.

  Because the slowest drifting portion of larvae are of most interest, it would be essential to release adequate numbers of larvae to accurately describe the entire distribution of drift times and distances in the Yellowstone River for the study to be worthwhile. About 17 gravid adult female pallid sturgeon would be needed to produce the required number of larvae. It is estimated that there are currently 40 female pallid sturgeon remaining in RPMA 2 (Gillian Hadley, personal communication), about half of which will spawn in any given year (Fuller et al. 2008). The highest number of gravid female pallid sturgeon ever captured in a year was 16 in 2007. In 2009 one of the lengthiest broodstock collection efforts to date resulted in capture of only seven gravid female pallid sturgeon. Accordingly, it is unlikely that an adequate number of gravid female pallid sturgeon could be captured to provide the number of larvae necessary to accurately characterize the full distribution of drift times and distances on the Yellowstone River.

- Would these larvae be better used for a different recovery project or study? Although applied research remains a high priority for pallid sturgeon recovery efforts within the Upper Missouri River Basin, preventing extinction of the species through a conservation stocking program is the highest priority for hatchery-reared pallid sturgeon (Upper Basin Pallid Sturgeon Workgroup Workshop, Billings, Montana, 2009). As such, the propagation and conservation stocking program will require at least the first seven gravid female pallid sturgeon captured in any year until stocking goals in each RPMA are attained (Upper Basin Pallid Sturgeon Workgroup Workshop, Billings, Montana, 2009). Most larvae allocated to a drift study on the

Yellowstone River would need to be produced by gravid female pallid sturgeon captured subsequent to the seven fish required by the propagation program. Accordingly, it is increasingly unlikely that an adequate number of gravid female pallid sturgeon could be captured to provide the number of larvae necessary to accurately characterize the full distribution of drift times and distances on the Yellowstone River.

- The presence of naturally produced shovelnose sturgeon larvae concurrent with the time that pallid sturgeon larvae will be available for a Yellowstone River drift test will require genetic analysis of all captured sturgeon larvae. Gravid shovelnose sturgeon occupy the entire reach of the Yellowstone River between Cartersville Diversion and the confluence with the Missouri River each year (Haddix and Estes 1976; M. Jaeger, personal communication). It is suspected that shovelnose sturgeon spawning occurs throughout this reach (Haddix and Estes 1976; M. Jaeger, personal communication) and naturally produced shovelnose sturgeon larvae are commonly captured (Penkal 1981; Braaten and Fuller 2005). To distinguish pallid sturgeon larvae captured as part of the drift test from naturally produced shovelnose sturgeon genetic analyses of all captured sturgeon larvae likely will be necessary. Analysis costs are about $50 per fish (G. Jordan, personal communication). Braaten et al. (2008) recaptured about 5,800 larvae during a side channel drift test on the Missouri River. Although it is unknown what number of pallid and shovelnose sturgeon larvae would be captured by a comparable Yellowstone River drift test, analysis costs for the number of fish captured during the side channel study would be about $290,000.

- There is little time left before wild pallid sturgeon are extirpated in the Upper Missouri River Basin. While there is some debate over the year that local extirpation will occur (2017 – 2024), maintaining the status quo is not addressing long-term pallid sturgeon recovery goals.

- Conservation of genetic variability within pallid sturgeon is an important component of long-term recovery goals. The upper Missouri River Basin pallid sturgeon are genetically distinct from those in the lower parts of the species' range (Campton et al. 2000; Schrey and Heist 2007; Tranah et al. 2001). The wild pallid sturgeon population is facing extirpation due to several decades of failed spawning and/or recruitment (Service 2007). Furthermore, approximately 136 wild pallid sturgeon remain in RPMA 2 (Service 2007) that would likely benefit from these recovery efforts on the Yellowstone River.

FWP, Reclamation, the Service, and the Corps have been studying pallid sturgeon issues at Intake for 20 years. Unfortunately, the declining population of mostly mature wild pallid sturgeon in the Yellowstone River and Missouri River between Fort Peck Dam and Lake Sakakawea is expected to be locally extirpated in the near future if reproduction and survival of the young fish does not improve. Given the limited time to resolve the problem, it was decided that priority should be given to resolving passage and entrainment issues at Intake instead of continuing to study the problem.

B. <u>Fish Passage</u>

B.1 Question: Will the project allow passage of pallid sturgeon for spawning and will it allow larval pallid sturgeon passage downstream and lead to their survival?

B.1 Answer: The Corps and Reclamation are using the best available science to design a fish passage structure for pallid sturgeon at Intake, Montana, and will use adaptive management to make sure that it works. Although there are no fish passage projects in existence specifically built for pallid sturgeon, successful fish passage projects for other sturgeon species have been constructed in the western United States.

An example is the Glen Colusa Irrigation District gradient facility built by the Corps on the Sacramento River for salmonids. This facility is similar to the Rock Ramp Alternative proposed for the Intake Project. The Glen Colusa passage successfully provides passage for other sturgeon species, specifically the green and white sturgeon. Other successful projects for sturgeon species include:

- Red Bluff Diversion Dam in the Sacramento River,
- Through Delta Project facility in California,
- Heiberg Dam and a dozen other passage projects for lake sturgeon on the Red River Basin in North Dakota/Minnesota.

The Corps and Reclamation, in consultation with the Service and FWP, are working cooperatively to ensure that the best available science and fish passage technology is used in the design of the preferred alternative. Therefore, we are reasonably certain that this design will work to pass pallid sturgeon. Any problems would be corrected through adaptive management.

Once pallid sturgeon can pass over or around the Intake Diversion Dam, they will have access to an additional 165 miles of river for spawning. They will also have access to the tributaries within this reach, including the Powder and Tongue Rivers.

The available options at this time to increase larval drift distances in the upper Missouri River basin are:

1) removal of Fort Peck Dam,
2) removal of Garrison Dam,
3) maintaining Lake Sakakawea at lower reservoir pool elevations to increase riverine habitats upstream of this reservoir, and
4) providing access to habitats further up the Yellowstone river via implementation of fish passage and entrainment protection measures.

When these options are compared, the Intake Project provides one of the best opportunities to achieve natural pallid sturgeon recruitment in the upper Missouri River Basin with the lowest ancillary costs, i.e. no adverse effects to hydropower generation, water intakes, flood control, navigation, irrigation, etc.

B.2 Question: Will the rock ramp design allow passage of pallid sturgeon?

B.2 Answer: There is an opportunity for pallid sturgeon passage with a rock ramp design (also known as a gradient facility), which is similar to other dams that have been modified in the western United States to allow passage of other sturgeon species (see answer to question B.1). Performance tests to quantify the swimming capabilities of pallid sturgeon and identify physiological and behavioral parameters were completed prior to design of the Intake Project alternatives (White and Medford 2002). The results were used in the design specifications.

Several Yellowstone River riffles and rapids of relatively high gradient that adult and juvenile pallid sturgeon are known to pass at a variety of discharges were extensively surveyed to provide further design criteria. A physical model is currently being built at Reclamation's Denver Technical Research Center to refine the rock ramp design and ensure its effectiveness for pallid sturgeon. In addition, an adaptive management plan would be implemented to fine-tune the selected alternative after construction.

B.3 Question: What data is available to support the thesis the majority of the fish even would go up to Cartersville if there was a fish passage?

B.3 Answer: Although we have not suggested that the majority of fish would go up to Cartersville with fish passage at Intake, pallid sturgeon have been documented at least 112 miles upstream of Intake, Montana, which is about 267 miles above the present headwaters of Lake Sakakawea (Brown 1955; Brown 1971). They were observed at this location consistent with times of the year when spawning is known to occur in the Yellowstone River (Fuller et al. 2008). Watson and Stewart (1991) captured a pallid sturgeon near Fallon, Montana, in 1991 in conjunction with studies associated with the Tongue River Project. There are other reports from the 1920s and 1930s that document pallid sturgeon above Intake Diversion Dam and in the vicinity of the Tongue River (Service 2000b).

Furthermore, if we generalize based on what is known about pallid and other sturgeon species spawning habitats in combination with the historical record, then suitable spawning substrate exists above Intake. Telemetry data indicates that almost all remaining pallid sturgeon in RPMA 2 move into the Yellowstone River in the spring and that each year some move upstream to Intake Diversion Dam but not above (Bramblett and White 2001; Fuller et al. 2008). Work specifically studying fish in known spawning condition documented at least one gravid female and several male pallid sturgeon moving up to Intake Diversion Dam, staging immediately below the dam for several days, and then moving back downstream (Fuller et al. 2008; M. Jaeger, personal communication).

Intensive netting studies have also documented relatively high numbers of pallid sturgeon immediately below Intake Diversion Dam (Backes et al. 1994) and historic accounts documented pallid sturgeon upstream of Intake Diversion Dam during the putative spawning period (Brown 1955). It is reasonable to conclude that if Intake Diversion Dam was not a barrier to movement pallid sturgeon would continue to move above this point to satisfy various life history needs including spawning. Additionally, telemetered juvenile pallid sturgeon have traveled up to the

Intake Diversion Dam, were unavailable to pass, and turned to swim back downstream (Jaeger et al. 2008). Initial study results indicate that spawning habitats upstream of the Intake Diversion Dam are suitable for pallid sturgeon restoration efforts (Jaeger et. al 2008).

B.4 Question: Is the project design the best available technology for migration and protection of the pallid sturgeon population?

B.4 Answer: Yes, the collective opinion of fisheries biologists working on this Project, including those from FWP, the Service, the Corps, and Reclamation, agree that it is the best available technology. The action alternatives evaluated in the Intake EA were formulated through an iterative and collaborative process initiated during informal Endangered Species Act (ESA) consultations with the Service in 1997. The following documents were developed to help formulate and evaluate alternatives:

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

After careful consideration of more than 110 alternatives, two were further evaluated in the Intake Project EA – the Rock Ramp Alternative and the Relocate Main Channel Alternative.

B.5 Question: Is the screening system the best design for the pallid sturgeon?

B.5 Answer: Yes, the collective opinion of fisheries biologists working on this Project, including those from Montana FWP, the Service, the Corps, and Reclamation, agree that it is. The screen design uses the best available technology, including the smallest effective screen size and velocities recommended by the Service's Biological Review Team. This screen system is designed to meet Yellowstone River conditions, Lower Yellowstone Irrigation Project needs, and provide the best protection for pallid sturgeon and other native fish at Intake, Montana. The screen size is the smallest that can be used effectively, in accordance with the National Oceanic and Atmospheric Administration (NOAA) juvenile salmonid criteria.

A laboratory study evaluated the best technology available to use to meet the NOAA screening criteria for juvenile and larval pallid sturgeon that are < 3.9 inches long (Mefford and Sutphin 2008). The study evaluated four related topics: 1) swimming endurance, 2) impingement survival, 3) screening effectiveness, and 4) recovery of impinged fish from traveling fish screens. The study was used to identify and design fish screens for the Intake Project. It was conducted at the Reclamation Water Resources Research Laboratory in Denver, Colorado, using hatchery-spawned pallid sturgeon larvae.

Results of the study indicated that larvae <0.8 inches long displayed little swimming ability and easily passed through NOAA criteria fish screen material. Fish larger than about 1.6 inches long were capable of swimming several minutes against a typical fish screen approach velocity of 0.4 feet/second. This study indicates that NOAA criteria effectively protect pallid sturgeon >1.6 inches long. Screen impingement for periods up to 10 minutes (maximum impingement time evaluated) had no effect on fish mortality, when fish were recovered by back-flushing the screen.

B.6 Question: Is the by-pass design the best for pallid sturgeon?

B.6 Answer: Appendix E, Intake EA uses scoring criteria developed by the Biological Review Team (Jordan 2009) and hydraulic modeling (Corps 2009) to score alternatives on relative comparison scales. Although the Corps used pallid sturgeon life history, biology, and ecology to design the Relocate Main Channel Alternative, Intake EA Appendix E found that this alternative scores lower and less favorably for pallid sturgeon than the Rock Ramp Alternative.

B.7 Question: Will the new diversion designs effectively prevent entrainment of pallid sturgeon or other species that impact pallid sturgeon (e.g. chubs that are a food source for pallid sturgeon)?

B.7 Answer: The screen designs evaluated to date are anticipated to prevent entrainment of pallid sturgeon ≥ 1.5 inches long (Mefford and Sutphin 2008) While the success of this screen with other fish species has not been tested, it is reasonable to assume that it will prevent entrainment of other fish species ≥ 1.5 inches long. Monitoring post-Project construction and adaptive management will be implemented to ensure effectiveness.

B.8 Question: (if so what design)? Supporting information?

B.8 Answer: See discussion above in answer B.5. The fish screen is described in chapter two of the Intake EA, pages 2.9 – 2.10.

B.9 Question: Given the location where pallid sturgeon larvae drift, will larvae either be trapped in the pool behind the Intake dam or end up in the diversion?

B.9 Answer: Given what we know from larval drift studies, it would be unlikely that the larvae would be trapped in the pool behind the dam, because the smooth concrete dam design would allow for free flow over the dam. Furthermore, chapter three of the Intake EA documents sedimentation behind the dam. Corps bathymetry data indicate there is not a characteristic wedge of sediment deposited directly upstream of the dam structure, as often occurs with such structures (figure 3.6, page 3-11). Therefore larvae would likely flow over the dam along with sediments and flow. However, it is possible that upstream larvae could flow toward the Intake headworks main canal screens. Entrainment would be monitored post-construction. If significant issues affecting the survival of pallid sturgeon larvae are identified, adaptive management would be used to resolve this survival issue.

B.10 Question: If pallid sturgeon did go up to Cartersville what data is available regarding predation in that location, that would convince anyone the eggs or larvae would survive?

B.10 Answer: Not all fish eggs and larvae survive in natural settings. However, fish species have evolved mechanisms to mitigate for natural mortality rates associated with things like predation. One mechanism relies on the amount of progeny produced annually. Individual female pallid sturgeon in the upper Missouri River basin release as many as 150,000 – 170,000 eggs when spawning (Rob Holm, personal communication). Not all of these eggs need to hatch nor do all hatching fry need to survive to perpetuate the species. In a self sustaining population, the life history goal is to achieve natural recruitment into the adult population at a level comparable to natural adult mortality. Recruitment is the number of fish hatched in a given year that survive to a specified age.

The physical traits of pallid sturgeon, i.e. small eyes, sensory barbels, etc, suggest this species evolved in low-visibility environments. In rivers suspended particles, often referred to as turbidity, and other materials reduce the amount of available light, which in turn reduces visibility, thus affording some level of concealment from sight-feeding predators, like walleye, goldeye, and sauger. Thus, the occupied environment of the species and conditions during and post-spawning can serve as natural mechanisms to offset predation.

Turbidity is quantified with nephelometric turbidity units (NTU); a measure of how much light can pass through a water sample. On the NTU scale, low values equate to clear water. Relative to the range of pallid sturgeon, Jordan et al. (2006) reported turbidity levels < 12 NTU downstream of Fort Randall Dam, South Dakota. The smallest level reported was 5 NTU. In Lake Sharpe, South Dakota, measured turbidity levels were 80-100 NTU (Erickson 1992). Conversely in a more natural system like the Yellowstone River, turbidity levels seasonally exceed 1,000 NTU (Braaten and Fuller 2002; Braaten and Fuller 2003; Matt Jaeger, personal communication, 2008). To put these reported Yellowstone River values in perspective, the U.S. Environmental Protection Agency's national primary drinking water regulations (http://www.epa.gov/safewater/contaminants/index.html#primary) turbidity may never exceed 1

NTU and must not exceed 0.3 NTU in 95% of daily samples in any month. With high turbidity on the Yellowstone River, predation of pallid sturgeon larvae on the Yellowstone River is not likely a significant issue.

Additionally, there are studies that document predation on other sturgeon species eggs and juveniles (Miller and Beckman 1996; Gadomski and Parsley 2005a). Most of these studies explore predation rates in altered environments downstream of dams or in laboratory settings in tanks with low turbidity levels, e.g. Gadomski and Parsley (2005a) report study with turbidity levels < 1 NTU. Outside of the laboratory, these studies are downstream of structures similar to the mainstem Missouri River dams that trap sediment and result in clear water downstream.

In many of these studies, predation rates are high and often because of altered conditions below dams (Gadomski and Parsley 2005b). However, none of the irrigation diversion structures on the Yellowstone River (i.e. Cartersville or Intake Diversion dams) significantly trap sediment and alter the resultant seasonally high turbidity levels on the Yellowstone River. Given the relatively high fecundity of pallid sturgeon, the high turbidity levels in the Yellowstone River during and post spawning, and the diversity of habitats in this river, it is reasonable to assume that predation can and will occur, though not at a level exceeding those with which this species evolved.

The most convincing data available regarding larval survival comes from recaptures of hatchery-reared pallid sturgeon initially stocked as larvae. As described above, it is expected that larvae originating from reconnecting reaches upstream of Intake Dam would be distributed throughout the lower Yellowstone River and Missouri River below the confluence. Pallid sturgeon larvae stocked from 5 to 17 days old have been recaptured in subsequent months and years in the Yellowstone River and Missouri River below the confluence, indicating that habitats and biotic conditions (i.e. the presence of predatory fishes) in these reaches of river allow for survival of pallid sturgeon larvae and juveniles (M. Jaeger, personal communication).

C. <u>Impacts on Pallid Populations</u>

C.1 Question: What level of certainty would you attach to this proposal and its claimed positive effect on Pallid sturgeon?

C.1 Answer: When dealing with an endangered species like the pallid sturgeon, there will always be some level of uncertainty. In planning the Intake Project, the best available scientific data were considered. This is documented in the draft Intake EA prepared for the Intake Project. The Service's Biological Review Team, as well as researchers from Reclamation's Denver Technical Service Center, the Workgroup, the Pallid Sturgeon Recovery Coordinator, and other Reclamation staff, the Corps, the Service, the USGS, and state biologists have all participated in planning the Intake Project. The best available science suggests that conditions on the Yellowstone River are suitable for pallid sturgeon restoration, including intact migration and spawning clues, suitable spawning habitats, adequate larval drift distances, and suitable rearing habitats.

The Corps and Reclamation, in consultation with the Service and FWP, are continuing to work cooperatively to ensure that the best available science and fish passage technology are used in the final design of the preferred alternative. Therefore, we are reasonably certain that this design will work to pass pallid sturgeon. Of the available options despite a moderate level of uncertainty with regard to the level of benefit to the species and the native fish community, this one is technically feasible, comparatively cost-effective, acceptable and amenable to most users. It is justifiable given the immediate risk of extirpation and the potential benefit to species recovery in the foreseeable future.

As with passage and entrainment projects across the west, including those successful ones mentioned above in response B.1, there will be benefits, but it is difficult to precisely quantify them prior to implementation. We are reasonably certain the proposed Intake Project will pass native fish, including pallid sturgeon, and will reduce entrainment of hundreds of thousands of native fish annually. It could ultimately create an opportunity for the recovery of the pallid sturgeon. This Project would also allow the Lower Yellowstone irrigation districts to continue to operation in compliance with the ESA.

C.2 Question: How much will this project improve the pallid's survivability?

C.2 Answer: The Service's 5-year species review (Service 2007) states that without artificial supplementation in areas like the Yellowstone River, pallid sturgeon could face extirpation. The Service's Pallid Sturgeon Recovery Plan (1993 and most recent agency review draft pallid sturgeon recovery plan) also supports the Intake Project.

Current recruitment of pallid sturgeon in the Upper Missouri River Basin is zero. While adult fish have been found in spawning condition, there has been no documented recruitment in this aging pallid sturgeon population. If just one juvenile is recruited into the population, then the implementation of passage and entrainment protection will benefit pallid sturgeon. Even if 1-5% of the larvae make it to recruitment, it would be significantly greater than current conditions.

Available data indicate that today sturgeon are entrained into the lower Yellowstone Project (Hiebert et al. 2000) and that specifically, pallid sturgeon can be lost to this system (Jaeger et al. 2005b). This project will significantly reduce the likelihood of entrainment and increase survivability of hatchery and wild fish. Substantial loss of sturgeon chub and other minnow species have also been documented at Intake (Hiebert et al. 2000). These minnow species are believed to be a primary food source for pallid sturgeon (Gerrity et al. 2006). Thus, entrainment protection will help conserve adult pallid sturgeon food resources and may increase adult pallid sturgeon capacity in this system.

Benefits of upstream passage will increase available habitats on the Yellowstone River by 165 miles and will allow stocked fish to disperse into suitable habitats. This would also increase the accessibility of fish to major tributaries like the Tongue River with 106 miles of riverine habitats and the Powder River with 217 of additional potential habitat. Overall, the agencies working on this Project generally agree this is the best opportunity available to facilitate pallid sturgeon toward recovery in the upper Missouri River Basin.

C.3 Question: Will the project as proposed provide meaningful benefit to the pallid sturgeon population given the hydrological and biological information available to date?

a. Drift rate and survival
b. Velocities
c. Reservoir survival
d. Sturgeon migration

C.3 Answer: Yes, see all of the information in above answers.

C.4 Question: What happens to the pallid sturgeon populations in the Recovery Priority Management Area 2 if they do nothing on Yellowstone at intake?

C.4 Answer: The pallid sturgeon could likely be extirpated in the Recovery Priority Management Area 2 (Service 2007). Wild pallid sturgeon in the Yellowstone and Missouri rivers, downstream of Fort Peck Dam and upstream of Lake Sakakawea will continue to exist only as a hatchery-augmented population as older adults die out or are removed for hatchery purposes. The conservation stocking program would be required long-term to artificially maintain the species in this reach.

Conservation stocking does not meet current or future delisting or downlisting requirements of the ESA. Rehabilitation of the reach of the Missouri River below Ft. Peck Dam and above the Yellowstone confluence or dramatically drawing down Lake Sakakawea reservoir levels remain as options to provide for some level of natural recruitment and achieving delisting or downlisting requirements. And at this point in time the options at Ft. Peck and Lake Sakakawea reservoirs are expensive and/or may not be publically acceptable.

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Appendix 3: Discharge, Velocity, and Drift Distance Estimates

Appendix 3, Table 1. Annual discharge, velocity, and pallid sturgeon larval drift distances estimated for the Yellowstone River, MT.

	Discharge (cfs)				Velocity (m/s)		Drift distance for average velocity (miles)			Drift distance for reduced velocity (miles)		
Year	May	June	July	min	v	60%v	1%	10%	25%	1%	10%	25%
1911	16,000	55,200	33,100	16,000	0.86	0.52	413	444	464	210	241	261
1912	26,400	55,200	56,800	26,400	1.02	0.61	507	538	558	266	297	318
1913	21,400	59,800	38,100	21,400	0.95	0.57	465	496	517	242	273	293
1914	45,000	50,800	27,500	27,500	1.03	0.62	515	546	567	271	302	323
1915	17,700	42,200	33,100	17,700	0.89	0.53	430	461	482	221	252	272
1916	18,600	40,800	61,400	18,600	0.91	0.54	439	470	491	226	257	277
1917	38,100	55,200	72,200	38,100	1.16	0.69	587	618	638	314	345	366
1918	21,400	89,250	34,300	21,400	0.95	0.57	465	496	517	242	273	293
1919	20,900	10,350	4,440	4,440	0.56	0.33	234	265	285	102	133	154
1920	25,400	53,800	53,800	25,400	1.01	0.60	499	530	550	262	293	313
1921	20,400	52,250	23,900	20,400	0.93	0.56	456	487	508	236	267	287
1922	20,000	49,000	21,400	20,000	0.93	0.56	453	484	504	234	265	285
1923	16,400	47,150	33,100	16,400	0.87	0.52	417	448	468	212	243	264
1924	45,700	43,600	37,200	37,200	1.15	0.69	581	612	632	311	342	362
1925	36,000	50,850	47,900	36,000	1.13	0.68	574	605	625	306	337	358
1926	31,600	28,600	23,200	23,200	0.98	0.59	481	512	532	251	282	302
1927	36,000	76,050	47,900	36,000	1.13	0.68	574	605	625	306	337	358
1928	45,000	33,250	56,800	33,250	1.10	0.66	556	587	607	296	327	347
1929	20,500	47,150	28,900	20,500	0.94	0.56	457	488	509	237	268	288
1930	13,600	24,600	15,200	13,600	0.81	0.49	385	416	437	194	225	245
1931	17,700	30,800	7,920	7,920	0.68	0.41	305	336	356	145	176	197
1934	12,400	12,900	4,670	4,670	0.57	0.34	239	270	291	106	137	157
1935	12,900	41,750	33,400	12,900	0.80	0.48	377	408	428	188	219	240
1936	22,400	31,300	11,100	11,100	0.76	0.46	353	384	405	174	205	226
1937	18,600	38,450	24,500	18,600	0.91	0.54	439	470	491	226	257	277
1938	22,000	47,700	40,400	22,000	0.96	0.58	471	502	522	245	276	296
1939	19,000	25,200	17,600	17,600	0.89	0.53	429	460	481	220	251	271
1940	17,400	26,600	11,700	11,700	0.77	0.46	361	392	413	179	210	231
1941	20,400	27,250	11,800	11,800	0.78	0.47	363	394	414	180	211	231
1942	26,100	39,950	28,900	26,100	1.02	0.61	504	535	556	265	296	316
1943	16,600	59,600	62,700	16,600	0.87	0.52	419	450	470	214	245	265
1944	32,500	61,100	48,600	32,500	1.09	0.66	551	582	602	293	324	344
1945	15,600	40,400	37,000	15,600	0.85	0.51	408	439	460	207	238	259
1946	12,500	35,350	25,400	12,500	0.79	0.47	372	403	423	185	216	237
1947	28,100	38,100	40,800	28,100	1.04	0.62	520	551	571	274	305	325
1948	26,300	56,700	31,100	26,300	1.02	0.61	506	537	557	266	297	317
1949	24,200	35,450	18,200	18,200	0.90	0.54	435	466	487	224	255	275
1950	15,400	40,500	40,700	15,400	0.85	0.51	406	437	457	206	237	257
1951	22,200	32,400	29,100	22,200	0.96	0.58	472	503	524	246	277	297
1952	22,000	37,150	16,000	16,000	0.86	0.52	413	444	464	210	241	261
1953	9,340	31,100	20,600	9,340	0.72	0.43	328	359	379	159	190	210
1954	23,600	17,400	25,200	17,400	0.88	0.53	427	458	479	219	250	270
1955	18,100	26,700	17,100	17,100	0.88	0.53	424	455	476	217	248	268
1956	23,900	40,600	19,300	19,300	0.92	0.55	446	477	497	230	261	281
1957	25,400	55,550	44,000	25,400	1.01	0.60	499	530	550	262	293	313
1958	19,400	27,850	17,600	17,600	0.89	0.53	429	460	481	220	251	271
1959	10,600	37,750	24,900	10,600	0.75	0.45	346	377	398	170	201	222
1960	7,200	22,550	7,720	7,200	0.66	0.39	292	323	344	138	169	189
1961	5,780	23,750	6,100	5,780	0.61	0.37	264	295	316	121	152	172
1962	23,000	48,700	32,200	23,000	0.97	0.58	479	510	531	250	281	301

Appendix 3, Table 1. Annual discharge, velocity, and pallid sturgeon larval drift distances estimated for the Yellowstone River, MT.

	Discharge (cfs)				Velocity (m/s)		Drift distance for average velocity (miles)			Drift distance for reduced velocity (miles)		
Year	May	June	July	min	v	60%v	1%	10%	25%	1%	10%	25%
1963	21,700	52,900	26,300	21,700	0.95	0.57	468	499	519	243	274	295
1964	24,200	48,150	47,800	24,200	0.99	0.59	489	520	541	256	287	307
1965	21,300	56,050	60,400	21,300	0.95	0.57	464	495	516	241	272	292
1966	12,000	16,400	11,000	11,000	0.76	0.45	352	383	403	174	205	225
1967	14,400	57,000	63,800	14,400	0.83	0.50	395	426	446	199	230	251
1968	13,800	51,100	27,700	13,800	0.82	0.49	388	419	439	195	226	246
1969	21,200	26,100	31,600	21,200	0.95	0.57	464	495	515	240	271	292
1970	27,900	47,500	37,600	27,900	1.04	0.62	518	549	570	273	304	325
1971	24,700	54,000	36,100	24,700	1.00	0.60	493	524	545	258	289	310
1972	25,100	41,800	20,600	20,600	0.94	0.56	458	489	510	237	268	289
1973	30,900	29,500	17,900	17,900	0.89	0.54	432	463	484	222	253	273
1974	14,000	42,600	43,500	14,000	0.82	0.49	390	421	442	196	227	248
1975	32,100	47,950	64,200	32,100	1.09	0.65	548	579	599	291	322	343
1976	35,400	40,000	28,800	28,800	1.05	0.63	525	556	576	277	308	329
1977	11,700	16,500	6,530	6,530	0.63	0.38	280	311	331	130	161	181
1978	46,600	47,900	42,200	42,200	1.20	0.72	611	642	662	329	360	380
1979	16,300	24,300	20,100	16,300	0.87	0.52	416	447	467	212	243	263
1980	16,100	25,300	18,700	16,100	0.86	0.52	414	445	465	211	242	262
1981	21,100	38,350	20,300	20,300	0.93	0.56	455	486	507	236	267	287
1982	15,300	29,500	45,100	15,300	0.85	0.51	405	436	456	205	236	257
1983	14,000	30,350	32,800	14,000	0.82	0.49	390	421	442	196	227	248
1984	27,300	31,450	30,500	27,300	1.03	0.62	514	545	565	270	301	322
1985	9,220	15,050	6,100	6,100	0.62	0.37	271	302	322	125	156	176
1986	15,700	45,250	22,400	15,700	0.85	0.51	409	440	461	208	239	259
1987	15,000	14,250	6,110	6,110	0.62	0.37	271	302	323	125	156	176
1988	20,100	18,450	6,370	6,370	0.63	0.38	276	307	328	128	159	180
1989	21,000	23,450	13,700	13,700	0.82	0.49	387	418	438	194	225	246
1990	11,200	23,350	21,400	11,200	0.76	0.46	355	386	406	175	206	227
1991	37,400	50,650	27,200	27,200	1.03	0.62	513	544	564	270	301	321
1992	16,900	17,500	25,900	16,900	0.88	0.53	422	453	474	216	247	267
1993	31,500	33,950	32,500	31,500	1.08	0.65	544	575	595	289	320	340
1994	21,900	15,850	6,940	6,940	0.65	0.39	287	318	339	135	166	186
1995	29,100	40,750	37,300	29,100	1.05	0.63	527	558	578	278	309	330
1996	30,700	49,000	35,400	30,700	1.07	0.64	538	569	590	285	316	337
1997	39,700	65,700	33,900	33,900	1.11	0.67	560	591	611	298	329	350
1998	12,500	19,600	33,500	12,500	0.79	0.47	372	403	423	185	216	237
1999	18,100	41,500	28,000	18,100	0.90	0.54	434	465	486	223	254	274
2000	14,100	22,800	14,500	14,100	0.82	0.49	391	422	443	197	228	249
2001	11,600	15,150	7,500	7,500	0.66	0.40	298	329	349	141	172	192
2002	12,300	24,000	12,400	12,300	0.79	0.47	369	400	421	184	215	235
2003	10,900	26,350	11,900	10,900	0.75	0.45	351	382	402	173	204	224
2004	6,940	12,850	13,100	6,940	0.65	0.39	287	318	339	135	166	186
2005	23,400	22,150	19,900	19,900	0.93	0.56	452	483	503	233	264	285
2006	26,500	19,000	10,100	10,100	0.74	0.44	339	370	391	166	197	217
2007	21,700	21,550	6,560	6,560	0.64	0.38	280	311	331	130	161	182
2008	21,900	41,350	46,100	21,900	0.96	0.57	470	501	521	244	275	296
2009	31,000	41,100	37,500	31,000	1.08	0.65	540	571	592	287	318	338

Appendix 4: Estimates of Average Velocity from Discharge Data

To estimate average river velocity from discharge, the Panel used the standard relationship of

$$V = K * Q^a$$

where V = mean velocity, K is a constant, Q = discharge, and a = 0.34 (see Jobson 1996).

K was determined from transect data on the lower Platte River, NE. The transect data collected by Nebraska Game and Parks Commission for an IFIM study of the lower Platte River and used in Peters and Parham (2008) to model pallid sturgeon habitat. The Yellowstone River (Appendix 4, Figure 1) is similar in geomorphology to the lower Platte River, NE (Appendix 4, Figure 2).

Appendix 4, Figure 1. Aerial image of the Yellowstone River upstream of the Yellowstone Diversion Intake near Schaffer Island. Note multiple channel and sandbar islands. Source: Google Earth.

Appendix 4, Figure 2. Aerial image of the Platte River downstream of Louisville, Nebraska. Note multiple channel and sandbar islands. Source: Google Earth.

To confirm that the value for K was similar to the K for the Yellowstone River the average of all K estimates from the Platte River transect data were compared with the estimate of 25,000 cfs having a 3.23 ft/sec average velocity on the Yellowstone River (MRRIC Questions and Responses 2009; Appendix 2).

Appendix 4, Table 1. Result for estimated K for lower Platte River transects and comparison with Yellowstone River estimate.

Location	Discharge (cfs)	Discharge (cms)	Average Velocity (m/s)	Estimated K
Platte River near Cedar Creek	1,451	41	0.38	0.11
Platte River near Cedar Creek	1,555	44	0.42	0.12
Platte River near Cedar Creek	1,626	46	0.34	0.09
Platte River near Cedar Creek	1,710	48	0.40	0.11
Platte River near Cedar Creek	3,838	109	0.41	0.08
Platte River near Cedar Creek	4,320	122	0.49	0.09
Platte River near Cedar Creek	5,116	145	0.46	0.08
Platte River near Cedar Creek	5,723	162	0.53	0.09
Platte River near Louisville	1,498	42	0.40	0.11
Platte River near Louisville	1,513	43	0.39	0.11
Platte River near Louisville	1,650	47	0.40	0.11
Platte River near Louisville	1,864	53	0.44	0.11

Appendix 4, Table 1. Result for estimated K for lower Platte River transects and comparison with Yellowstone River estimate.

Location	Discharge (cfs)	Discharge (cms)	Average Velocity (m/s)	Estimated K
Platte River near Louisville	4,935	140	0.62	0.12
Platte River near Louisville	5,571	158	0.48	0.09
Platte River near Louisville	5,986	170	0.53	0.09
Platte River near Louisville	6,767	192	0.59	0.10
Platte River near North Bend	1,181	33	0.36	0.11
Platte River near North Bend	1,208	34	0.34	0.10
Platte River near North Bend	1,251	35	0.41	0.12
Platte River near North Bend	1,264	36	0.35	0.10
Platte River near North Bend	1,280	36	0.41	0.12
Platte River near North Bend	1,379	39	0.42	0.12
Platte River near North Bend	1,380	39	0.33	0.09
Platte River near North Bend	2,456	70	0.53	0.13
Platte River near North Bend	2,487	70	0.51	0.12
Platte River near North Bend	2,530	72	0.54	0.13
Platte River near North Bend	2,577	73	0.54	0.13
Platte River near North Bend	2,799	79	0.51	0.12
All transect average				0.11
Yellowstone River estimate	25,000	708	1.00	0.11

The estimated values for the lower Platte River and for the Yellowstone River were 0.11. So the final equation used to estimate average velocity for the Yellowstone River from gage discharge information was:

$$\mathbf{V = 0.11 * Q^{0.34}}$$

where V = mean velocity in m/s and Q = discharge in cms.

Further confirmation would require data from transects on the Yellowstone River. These data should be available by request from the regional USGS water resources office.

Appendix N – Responses to Comments Received on the Draft Intake EA

Introduction

The Draft Intake EA was distributed to the public for review on February 12, 2010, and the review and comment period ended on March 16, 2010. During this public comment period, public meetings were held in Glendive and Sidney Montana. Comments offered during these meetings were documented and considered along with the letters, e-mails and telephone comments received during the public comment period.

All comments on the Draft Intake EA were carefully considered and substantive comments are addressed in this appendix and, where appropriate, additional information was included in the Final Intake EA. Reclamation and the Corps reviewed each comment and considered them individually and collectively. For issues that were raised by more than one commentor or several times by the same commentor in the comment letters and/or during the public meetings, Reclamation and the Corps developed one general response. Unique substantive comments were addressed with individual responses.

Alternatives

Comment: **I saw no discussion of an alternative to place a fish screen down the canal at a much better site. It was pointed out at a public meeting and by comment that there are much better places for a fish screen down the canal than right in the bottom of a huge new diversion excavation just so it can be right next to the river. At canal mile 6 is an existing canal spill site that would work well as a fish screen site where fish can go back to the river very easy. At mile 7 is the Bums Creek siphon where again a fish screen would be much cheaper and easier to build and maintain and the fish caught can go directly back to the river. At both sites a screen would cost less than $500,000 - far less than if it is built in the deep abyss next to the river diversion. These two sites need to be analyzed and become part of an alternative.**
Response: A v-shaped in-canal fish screen was analyzed during the EA process. During the analysis, this type of screen was eliminated from further study as documented in Appendix A.1. Regardless of the screen's location in the canal, an on-river trashrack would be necessary. The estimated cost of the trashrack would be approximately $11million making the in-canal screen alternative more expensive than the on-river screening structure. The in-canal screen would also expose entrained fish to an unnatural environment, e.g., the canal, for a longer duration than the other screen option and concentrate entrained fish as they are returned to the river, thereby making it a less desirable alternative biologically.

***Comment:* How will we prevent debris damage?**
Response: Debris deflection options are still under evaluation. The rotating drum screens will be raised out of the river during periods of ice flow. Most floating debris will be present during high flow events and will pass above the screens near the river surface. Also, the proposed structure would be longer than the current structure and designed for much lower intake velocities, resulting in less debris attraction.

***Comment:* What impact will increased flows during spring runoff have on the rock ramp?**
Response: Design engineering and physical modeling will evaluate stability of project features for high flow events. It is not anticipated that increased flows experienced during spring runoff will adversely impact the headworks or rock ramp structure.

***Comment*: How much will the rock ramp raise the bottom of the river bed? Will the height of the rock ramp affect potential water runoff in the spring or cause flooding of the campground and alfalfa fields during high flows?**
Response: Flow levels downstream of the proposed ramp structure should remain unaffected. Higher water surfaces in the vicinity of the ramp structure are likely. Increased flooding in the campground area will either be mitigated or prevented. Prevention of campground flooding, up to flows that would flood the campground with existing conditions, could potentially be prevented with a levee. Further analysis of the frequency of campground flooding and need for flood prevention measures will be conducted during the final design phase of the rock ramp.

While river stages downstream from the proposed ramp structure will be unaffected, it is recognized that flow entering the campground area can potentially reach the alfalfa fields. The frequency of inundation of the alfalfa fields will be analyzed and mitigated or preventive measures will be taken.

***Comment*: Are Corps engineers aware of the existing jetties that the railroad has on the north side of the riverbank? How will or does the rock ramp design take these jetties into account?**
Response: Jetties on the north side of the riverbank upstream of the diversion dam were not considered in the ramp design. The new headworks structure will provide bank stability at the structure location and prevent river movement toward the railroad tracks.

***Comment*: Can the physical model of the proposed rock ramp simulate all aspects of the natural environment?**
Response: The physical model is an additional tool used to evaluate the proposed alternative. However, it does not replicate natural conditions entirely. It does provide insights into anticipated flow velocities, depths, and elevations, as well as providing insight to identify areas of potential depositional patterns. The physical model results are combined with detailed numerical modeling during the design process to ensure that adequate flows can be provided for irrigation and fish passage criteria can be met.

***Comment*: Can the rock ramp alternative be manipulated at the end to have water with enough velocity to scour the north shore to keep water there deep enough for a boat ramp?**
Response: Final configuration for the boat ramp at the downstream campground is still being evaluated. This is one of the options to be considered; however, it is likely that reliable boat access on the rock ramp will be difficult to achieve. If relocating the boat ramp is necessary, Reclamation and the Corps will work with FWP to identify and/or acquire a new location as discussed in chapter 4.

***Comment*: The Relocate Main Channel Alternative will result in increased flooding.**
Response: Levees would compensate for increased flood levels associated with this alternative; however this alternative was not identified as the preferred alternative.

***Comment:* What will happen to the bollards during ice flows?**
Response: Bollards are sized according to anticipated ice forces. The initial evaluations of bollard performance indicate there may be other options than the bollards for debris protection. Those options as well as the bollards will be further evaluated during the final design phase.

***Comment:* Ice flow concentrates on the left bank so will the bollards act as jetties?**
Response: Final design to evaluate the need for the inclusion of bollards or the final configuration has not been completed. The initial evaluations of bollard performance indicate there may be other options for debris protection. Those options as well as the bollards will be further evaluated. It should also be noted that the bollards will not be configured as jetties and are not intended to perform the same function. Local breakup of ice sheets may occur around the bollards. It is not anticipated that this would initiate an ice jam.

***Comment*: Silty muddy water may cause trouble with parts of the screens and headworks.**
Response: Rotating brushes clean the screens of accumulated debris. Evaluations indicate sweeping velocities to be high enough in front of the screens to prevent sediment deposition.

***Comment*: Where does debris go that is cleaned off the screens?**
Response: Debris will be swept away from the headworks structure and back to the river by river flows.

***Comment*: Can the bollards be put in front of the boat ramp to create backwater?**
Response: This specific location and purpose of the bollards has not been considered. Creation of a backwater may not be a desirable objective with high sediment loading in the Yellowstone River, likely resulting in downstream sedimentation of the boat ramp.

***Comment*: What or is there a plan for mitigation for long-term flooding that may occur as a result of changes to the Intake project?**
Response: This evaluation is underway. Increased river stages are only anticipated in the actual ramp vicinity, from the ramp toe upstream to the diversion dam crest. Project grading and inclusion of features such as low levees to contain flow are potential ways to mitigate higher flow levels in the ramp impacted area.

***Comment*: Are the O&M costs estimates included in the draft EA up to date?**
Response: The O&M cost estimate for the no action was developed by the Lower Yellowstone Irrigation District and is considered the best available information based on past expenditures and future forecasting. Cost estimates for O&M of the alternatives were developed by the Corps based on cost data for similar O&M activities. O&M costs were calculated for planning and alternative evaluation purposes only. The estimated O&M costs are not the total additional O&M costs; therefore, the estimates need to be adjusted for existing O&M activities that would no longer be necessary.

***Comment*: Have we considered the impacts and issues that could result from the silts and debris during spring flooding?**
Response: Silt and sediment impacts and issues are currently being evaluated as part of the physical model. The rotating drum screens will be raised out of the river during periods of ice flow. Most floating debris will be present during high flow events and will pass above the screens near the river surface. Also, the proposed structure would be longer than the current structure and designed for much lower intake velocities, resulting in less debris attraction.

***Comment*: Is the construction schedule realistic?**
Response: The construction schedule has been reviewed by the Corps and Reclamation's construction divisions and is considered realistic. Following Reclamation and the Corps issuance of a FONSI, construction of a cofferdam would likely begin late in this summer or early fall. This would be followed by the construction of the new headworks structure.

***Comment*: Do local contractors have priority when contracts are available?**
Response: Federal procurement regulations will be followed in the issuance of all contracts for this project. The project will be advertised free and open and can be bid on by any contractor with the ability to perform the work and meet the schedule.

***Comment*: Why isn't a power generation feature being considered as part of the project?**
Response: Power generation is considered to be outside the scope of the proposed project.

***Comment*: Who is paying for construction of the project and could this funding be used for O&M purposes?**
Response: The Corps is authorized to construct this project using appropriated funds provided through the Missouri River Recovery and Mitigation Program as discussed in chapter 1. Funding provided through the Missouri River Recovery and Mitigation Program is limited to construction activities and cannot be used for operation and maintenance activities.

***Comment*: Will the current design of the rock ramp alternative be able to deliver the full volume of irrigation water during low flow?**
Response: The rock ramp alternative is designed to reliably deliver the District's water right during river flows as low as 3000 cfs. More information on the short-term impacts associated with the reliability of water delivery during construction of the rock ramp alternative is available in the Lower Yellowstone Irrigation Project section of chapter 4.

***Comment*: As part of the O&M of a new rock ramp, will rock need to be added?**
Response: Future O&M activities for the rock ramp could include the addition of rock. The O&M cost estimates in the EA account for this possibility.

***Comment*: What acreage does the rock ramp cover in the river bed? Language within the EA is not consistent in identifying the area of the river bed covered by the rock ramp.**
Response: Additional information is included in the Geomorphology section of chapter 4 to clarify the specific area covered by the proposed rock ramp is 32 acres.

***Comment*: Who is responsible for repairing the rock ramp if it is damaged by ice flows?**
Response: If the rock ramp is damaged during construction the Corps will be responsible for the necessary repairs. After the rock ramp is constructed and has been officially turned over to Reclamation, the project will be considered in the O&M stage; therefore, activities and costs associated with any repairs will be the responsibility of Reclamation and/or the Lower Yellowstone Irrigation District as determined in the operation and maintenance agreement to be developed between these two parties. A Memorandum of Agreement between the Corps and Reclamation regarding the construction stage and O&M stage is under development.

***Comment:* What is the cost of the screens and how reliable are they?**
Response: Cost of each screen is approximately $575,000. The screens have been in production since 1995 and are utilized in several rivers across the country, particularly the West and Northwest. To date, they have proven to be very reliable.

***Comment*: What are the O&M requirements for the new headworks and rock ramp that are causing the increase in O&M costs?**
Response: O&M estimates for the rock ramp include some rock replacement as well as one major repair of the weir over a 50 year period.

***Comment*: Recommend that future O&M contracts include provisions that would avoid creating conditions that would impair pallid sturgeon passage. It is recommended that O&M activities be carefully planned and carried out in coordination with lead agencies for this project, as well as with the U.S. Fish and Wildlife Service and Montana Department of Fish, Wildlife, and Parks.**
Response: Reclamation is consulting with the Service on future O&M of the Lower Yellowstone Project. Future O&M of the proposed modifications will be in accordance with the Lower Yellowstone Project O&M biological opinion issued by the Service. It is anticipated the biological opinion would include provisions to maintain proper conditions for pallid sturgeon passage.

***Comment*: Appropriate O&M measures to address the issue of damaging effects of ice on the rock ramp should be considered by Reclamation, the Corps, and the Board of Control and identified in the final EA.**
Response: The concrete weir and rock ramp are described in Chapter 2. The concrete weir is being designed to withstand damage from blocks of ice and to withstand ice jams. An adaptive management plan, developed in accordance with the adaptive management strategy included in appendix J, will include provisions for O&M of the rock ramp if required. Long term O&M

activities will be completed in accordance with the Lower Yellowstone Project O&M biological opinion to be issued by the Service.

***Comment*: Is the discussion regarding sediment deposition on page 3-11 consistent with the discussion of sediment deposition and infiltration gallery backflushing in Appendix A.1? Would an infiltration gallery placed along the North Bank of the river, where there is active erosion, require as much back-flushing as suggested in Appendix A.1?**
Response: Sediment in the Yellowstone River is very fine. Pumping water induces a flow gradient toward the screen which results in accumulation and plugging of the gravel filter. The discussion on page 3-11 has been modified to clarify the issue of sediment deposition.

***Comment*: Were impacts to local bridges and roads (load restrictions) considered during the planning for this project?**
*Response***:** The existing bridge across the canal has no load restrictions other than usual highway legal weight. The Corps will include terms in the construction contract for the selected alternative to protect local roads and bridges from damage during construction activities. If damage would occur due to construction activities it would be repaired.

***Comment*: How do the proposed screens handle algae?**
*Response***:** The nylon brush cleaning system was selected because it is more effective in cleaning algae and other debris from the screens than an air burst cleaning system. The screens will be cleaned at preset time intervals, but if sensors detect clogging, that will trigger an additional cleaning cycle.

***Comment*: How or will the proposed screens ability to remove sediment benefit the farmer?**
*Response***:** Although not designed to remove sediment, the screens have been designed to have low approach and sweep velocities to prevent the impingement of native fish species from the Yellowstone River. These designed velocities should minimize the amount of sediment that is passed into the main canal. Possible ancillary benefits for the irrigator may include lower O&M costs in the canal as: 1) sediment removal by the District would be minimized over historic practices and 2) lower sediment loading would minimize pump maintenance in areas where pumping occurs from the canal.

***Comment*: The EA is inconsistent in terms of the amount of rock that will be required for the rock ramp. Is it 119,000 tons or 400,000 tons?**
Response: Approximately 119,000 tons of rock would be required during the construction of the rock ramp. The Final EA has been updated to provide consistency in these numbers.

***Comment*: Recommended that a clearer more detailed description of the proposed rock ramp be provided to include information on rock ramp rock sizes on each segment, rock placement, configuration and description of ramp low flow channels, etc.**
*Response***:** A physical model of the rock ramp is being developed by Reclamation's Technical Service Center to allow a better understanding of what the rock ramp will require to function appropriately for native fish passage. At this time it would be premature to provide this information until modeling and designs are closer to completion. In addition, these designs may change slightly due to recommendations from the Service's Biological Review Team or the Intake Adaptive Management Team.

***Comment*: Provide an explanation of why if the Upper Missouri River and Yellowstone River area are genetically distinct from other parts of the species range, this population is not considered a distinct population segment by the U.S. Fish and Wildlife Service under the Endangered Species Act.**
*Response***:** At the time the pallid sturgeon was listed through ESA, there was insufficient genetics data to make that determination and there was not a Distinct Population Policy (DPS). There are several criteria that need to be considered in designating a DPS; genetic differences are just one of these criteria. In addition, the Service needs to consider the value of designating a DPS. If the population is endangered range-wide, DPS designation does not offer additional protection, but could offer flexibility in terms of eventual delisting or downlisting. The concept of looking at DPS is being discussed as the Pallid Sturgeon Recovery Team works toward updating and revising the Pallid Sturgeon Recovery Plan.

Adaptive Management

***Comment:* The 8-year monitoring period discussed in the Adaptive Management section may be inadequate to determine whether or not the project is successful and contributes to natural recruitment of pallid sturgeon. Who would pay for any modifications to the rock ramp and fish screens after the 8-year monitoring period?**
Response: The 8-year monitoring period is based on success criteria developed by the Service and the Corps. This is documented in an October 23, 2009 letter from the Service's Regional Director to the Northwest Division of the Corps of Engineers. Reclamation and the Corps as the lead agencies believe this will be sufficient to determine if constructed features operate as planned (i.e. provide passage and minimize entrainment). At the same time, the lead agencies agree that monitoring beyond 8 years may be needed to document recruitment of pallid sturgeon. An Adaptive Management Plan is being developed, based on the Adaptive Management Strategy included in appendix J. When completed, the plan will provide more detailed description of the monitoring program. The Adaptive Management Plan, monitoring results, and any proposed changes will be posted to Reclamation's MTAO website at http://www.usbr.gov/gp/mtao/loweryellowstone/.

Modifications to the design of the rock ramp or fish screens both during and after the 8-year monitoring period would be funded by the Corps or Reclamation per the Memorandum of Agreement that is currently under development between the two agencies. Routine O&M (e.g., replacing rocks moved by ice action) would be performed by the irrigation districts and funded in accordance with the terms of the O&M agreement between Reclamation and the irrigation districts.

Geomorphology

Comment: **The bank stabilization required to tie the proposed Rock Ramp structure wasn't included in the Channel Migration Zone or the Cumulative Effect analyses in the Geomorphology section in Chapter 4, indicating there was a decrease in the amount of bank stabilization for the Rock Ramp Alternative.**
Response: A refined drawing of the Rock Ramp was used to update the Channel Migration Zone and Cumulative Effects analyses in the Geomorphology section of chapter 4. Additional information on the bank stabilization needed for the rock ramp structure has been included in chapter 4 along with a new figure to further illustrate this information.

Comment: **Bank stabilization features associated with No Action Alternative (Existing Conditions) were not identified in Figure 3.5 nor were the approximate acreages associated with those features.**
Response: Figure 3.5 was updated to show existing features that contribute to bank stabilization and additional explanation was included in the Geomorphology section of chapter 3 to disclose how many acres in the channel migration zone are affected currently.

Comment: **Recommend the EA explicitly state that impacts such as loss of natural channel migration and river access to the floodplain, and impacts to wetlands and other potential aquatic impacts will be monitored, evaluated, and unavoidable impacts mitigated.**
Response: The Corps is currently working with EPA and MT DEQ to resolve the issue of mitigation on an ecosystem restoration project.

Surface Water Quality

Comment: **The water quality sampling and testing protocols involved mixing sediment with river water and then analyzing the water after sediment settled, which is not standard sampling and analysis protocol for water quality assessment and comparison to State Water Quality Standards. Therefore, the significance of the results is unclear.**
Response: The purpose of the elutriate sampling was to assess whether sediments disturbed by construction contain any contamination that may be a concern. This is fundamentally different than sampling the water column for comparison to State Water Quality Standards. To address this unknown, soil/sediment in the projected scour area upstream and in selected areas downstream of Intake Dam were sampled and analyzed for contamination. Representative samples were collected and elutriate analysis conducted in accordance with the "Evaluation of Dredged Material Proposed for Discharge in Waters of the U.S. – Testing Manual: Inland Testing Manual" (EPA/USACE, 1998). In general, concentrations of nutrients and metals in the prepared sediment samples were similar to the ambient water, so no significant water quality impacts due to disturbance of contaminated sediments are anticipated. The full report "Results of elutriate sampling conducted along the Yellowstone River at Intake Dam, Montana on April 29-30, 2009" (Corps 2009) is included as a supporting document to the Final EA. Water quality will be monitored during construction to ensure that State Water Quality Standards are not violated.

Aquatic Communities

Comment: **Over time, deposition of river sediment and bedload on the low gradient low velocity rock ramp would likely result in a rock ramp bottom that resembled native bed materials more so than large stone. Therefore, improved macroinvertebrate habitat may not occur.**
Response: The rock ramp will function as a constructed riffle, and although some filling of interstitial spaces may occur over time, the rock ramp will likely never resemble the adjacent river bed. As a result, Reclamation and the Corps believe that the ramp will provide increased habitat complexity that will benefit macroinvertebrates over the long term.

Federally-Listed Species and State Species of Special Concern

Comment: **Why is fish protection and passage necessary for pallid sturgeon and was the best science used to make these determinations?**
Response: Fish passage and protection has been determined to be necessary to allow migrating adults access to historical spawning habitats and to protect adults and juveniles from being entrained into the main canal. These actions are necessary to avoid jeopardizing the continued existence of the species and ensure compliance with the ESA. As required by the ESA, the best available scientific and commercial data were used in making these determinations. As part of the NEPA process, the Missouri River Recovery Implementation Committee submitted an extensive list of questions regarding the science, including the entrainment study. These questions were answered by the interdisciplinary team preparing the EA. The extensive body of knowledge that was compiled and used in the EA and BA, as well as the MRRIC questions and answers, were then subjected to a review by a panel of independent experts. This review concluded that the determinations were logical conclusions supported by sound science. Specifically, the review concluded that:

1. The project will provide passage and enhance upstream migration for adult pallid sturgeon,
2. Suitable spawning habitat exists upstream of the project,
3. Conditions at the potential upstream spawning sites are suitable for the development and survival of pallid sturgeon eggs,
4. There is sufficient downstream drift distance for larval development for at least a portion of the larvae in some years for some level of natural recruitment to occur,
5. Proposed fish screens will effectively decrease entrainment of adult, juvenile, larval, and embryonic pallid sturgeon and other fish species, and
6. Conditions in the Yellowstone and connected section of the Missouri River are suitable conditions to support completion of the pallid sturgeon life cycle.

The list of MRRIC questions and answers and the entire review of the science is available in Appendixes L and M, respectively.

Comment: **Why does the project affect pallid sturgeon passage more than other species, why can't they migrate through the side channel around Joe's island or through the canal system?**
Response: Pallid sturgeon are more affected by the existing project than other species due to velocity and physical barriers as described in the Federally-Listed Species and State Species of Special Concern in chapter 3. Pallid sturgeon have not been able to use the side channel that is active at some river flows because they can't locate the entrance to the channel. Further, pallid sturgeon larvae require longer drift times than the shovelnose sturgeon and need to be farther upstream during spawning, which allows better opportunities for successful recruitment of the species.

Comment: **Are there less expensive alternatives to meet pallid sturgeon objectives such as building a hatchery in Glendive, stocking fish, or releasing water out of Ft. Peck reservoir to improve spawning conditions on the Missouri River? If they are stocked upstream of Intake anyway, why is it necessary to provide passage?**
Response: Reclamation is required under the Endangered Species Act to consult on the effects of the Lower Yellowstone Project on listed species. Other alternatives, as suggested in the comment, are outside of the scope of Reclamation's authority and this project. Some of the suggestions are items being addressed through other venues, but that does not alleviate Reclamation's responsibility to consult on the Lower Yellowstone project. Specifically, Ft. Peck water release options are being evaluated, there is already an adequate hatchery system in place for rearing pallid sturgeon for a conservation stocking program, and stocking of juvenile hatchery-raised pallid sturgeon in the Yellowstone River does occur. The stocking program, however, is only a short-term solution to prevent extinction of the species until habitat issues, such as fish passage and entrainment, can be addressed for long-term viability.

Comment: **Are we thinking ahead to ensure this project would meet the needs of any other species that may be listed in the future?**
Response: Yes, the project is being designed as an ecosystem restoration project to meet the needs of all native fish, including several species of concern in the vicinity of the project. Effects to all current species of special concern identified by the State of Montana have been evaluated in chapter 4.

Lower Yellowstone Irrigation District

Comment: **How will individuals be compensated for loss of farm income?**
Response: Reclamation will not provide compensation for increased operation and maintenance costs that are the responsibility of the Lower Yellowstone Project Board of Control. Also, there will not be compensation for any loss of farm income. An agreement covering long term operation and maintenance responsibilities of the proposed facilities will be negotiated between Reclamation and the Board of Control. Actual operation and maintenance expenses covered by the Board of Control will likely not be known until the Board is operating under the agreement.

***Comment:* Why don't the farmers on the Missouri River system where the impacts are occurring compensate the Intake Irrigation District for the increase in their O&M costs?**
Response: It has been determined that the operation of the Lower Yellowstone Project is having an adverse effect on the pallid sturgeon and other native fish, as discussed in the ESA Consultation History section of chapter 1. Also, as stated in chapter 2, Reclamation is obligated to continue consultation with the Service on continued project operations if this proposed action does not happen. The likely outcome of Section 7 consultation on the continued operation of the Lower Yellowstone Project would result in requirements for Reclamation to minimize entrainment and provide suitable upstream and downstream passage for larval, juvenile, and adult pallid sturgeon at Intake (Louis Hanebury, personal communication, 2009).

Recreation

***Comment:* Does environmental justice apply to those who are affected if there are changes to the paddlefish caviar industry such as the community of Glendive and others, contractors that are hired during the paddlefish season, or nearby business? Will their losses be mitigated?**
Response: Based upon Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations", and the result of analyses conducted in the EA, it has been determined that environmental justice policies do not apply to potential or perceived project related financial impacts (loss of income due to reduced visitation or loss of grant monies) to local businesses or communities or for the Chamber of Commerce hired contractors that assist in the collection and processing of paddlefish roe into caviar. As such, potential or perceived losses of revenues, income or grant monies will not be compensated.

***Comment*: What impacts will the construction phase of the project have on paddlefish fishing opportunities and roe collection? Will there be provisions during the construction process to reduce impacts to the paddlefish season?**
Response: The construction phase of the project could have some temporary and minor impacts to paddlefish fishing and roe collection, such as: limited access, limited parking, increased noise and dust, construction activities in portions of the river, etc. Fewer anglers during the typically short paddlefish season at the Intake FAS could result in reduced donations of paddlefish roe. Please see the Recreation section of chapter 4. As noted in "Actions to Minimize Effects" section, there are a number of proposed actions identified to reduce impacts to paddlefish fishing and potentially roe collection. One of the identified actions includes the following provision: "To the extent possible, construction activities will cease during the paddlefish season or until the paddlefish season is closed at Intake FAS."

***Comment:* Will boaters still have access to the channel around Joe's Island during high water levels?**
Response: Temporary culverts and/or low water crossing will be placed or constructed in the side channel to provide improved vehicle access to Joe's Island during project construction. If culverts are used, boat access around the Island would be restricted. Once the culverts are removed access through the channel would be the same as it is now.

Comment: **Will the road improvements to access Joe's Island be temporary or permanent?**
Response: As stated in the previous response to the comment about boaters accessing the channel around Joe's Island, low water crossings or temporary culverts will be used during construction. If low water crossing are used they would provide improved access to Joe's Island during and after construction.

Comment: **Are there plans for a temporary boat launching area during construction?**
Response: The existing boat launch ramp should be operational while construction activities are occurring on the Joe's Island side of the river. However, once construction activities begin on the Intake FAS side of the river the boat launch ramp will eventually be closed. As noted on page 4-48, one of the identified "Actions to Minimize Effects" includes the following provision: "The FWP will designate access corridors through the existing Intake FAS campground and picnic/day use area that could be used to access the river by foot or to launch boats under "primitive" conditions." A formal, temporary boat launch ramp is not planned; however, the rocky/gravely river bed should offer limited launching opportunities for smaller boats. Assessments would have to be made to determine areas where the slope and water depth are sufficient to launch and recover a boat. Another action includes the placement of signs with information regarding boat launching facilities at other FASs.

Comment: **Will boaters be allowed to portage through the construction site?**
Response: As noted on page 4-48, one of the identified "Actions to Minimize Effects" includes the following provision: "The construction contractor, Reclamation and FWP will identify a "portage" route around or through the construction zone to allow boaters to hand-carry or drag their boats past the construction zone."

Comment: **How will boaters navigate the new rock ramp?**
Response: A limited number of boaters navigate over the existing diversion dam structure, but usually only during high water levels. The proposed new rock ramp and dam would be constructed with a gentler slope; during high water levels it is anticipated that boats will be able to navigate over the ramp and dam. However, because large rocks will be placed on the rock ramps, boating over these obstacles will always present a potential risk to the boater.

Comment: **During construction, will the current parking area, day use and campgrounds at Intake FAS be affected?**
Response: Construction activities on the Joe's Island side of the river will impact the limited recreation opportunities on the island but should not overly impact the recreational opportunities on the Intake FAS side of the river. Once construction activities begin on the Intake FAS side of the river, there will be temporary and minor impacts to the recreational opportunities such as dust, noise, the presence of heavy equipment, reduced parking area, etc. There may be some instances when access to the Intake FAS is closed. Chapter 4, Environmental Impacts, discusses potential impacts to a number of recreational opportunities and facilities. The section "Actions to Minimize Effects," page 4-47 and 4-48, discusses a number of activities that are meant to minimize potential impacts due to construction activities.

Social and Economic Conditions

***Comment:* Expenses for the irrigators have increased more than the information presented in the draft EA. These numbers should be updated to reflect more current costs.**
Response: The agricultural economic analysis is intended to be representative of the costs and revenues of production for the local agricultural economy. At the time the analysis was completed the most current published data were used. It is recognized that both expenses and prices received can fluctuate considerably over a relatively short period of time. However, the intent of the analysis is to be representative of conditions over the long term, accepting that there will be times when revenues and expenses are higher and lower. No changes were made in this analysis.

Lands and Vegetation

***Comment:* The EA is inconsistent in the discussion of potential impacts the Rock Ramp Alternative will have on wetlands.**
Response: The identification of vegetated wetlands and riverine wetlands affected by the ramp are not inconsistent. Riverine wetlands, although impacted by the project construction, will continue to function and not be reduced with the placement of the ramp alternative. This is explained in the Lands and Vegetation section of chapter 4.

There also seemed to be confusion between the terms “rock ramp” verses “rock ramp alternative”. In the text, when acres are identified for “rock ramp”, it means just the ramp structure itself. When the text referred to the “rock ramp alternative”, it meant the entire construction area which includes all structures for this alternative. Revisions were made in chapter 4 clarify this.

There has also been confusion in reference to wetlands and comparisons made to the discussion of “channel migration zones”. These are two different resource areas and were evaluated using different methodologies in order to determine the potential impacts of the alternatives. See chapter 3 for the definitions of terms and methodologies used in the evaluation of these resources. The acres used in the channel migration discussions and the wetland discussions cannot be directly compared.

***Comment:* The purpose of stockpiling of wetland soils is not discussed in the EA.**
Response: Revisions were made to the wetlands section in chapter 4 to clarify that wetland soils will only be stockpiled if wetland mitigation is necessary.

Comment: **Efforts should be made to compensate for any unavoidable impacts to wetlands in accordance with the April 10, 2008 Mitigation Rule (40 CFR Part 230, Subpart J).**
Response: The mitigation rule referenced in the comment applies to the issuance of Department of the Army permits under the Clean Water Act. While the Corps does not issue itself a permit under 404 of the Clean Water Act, Appendix B of the EA demonstrates the project is in full compliance with 404(b)1. In the Actions to Minimize Effects discussion in the Lands and Vegetation section of chapter 4 it states "The Environmental Review Team will play a role in oversight of actions to ensure compliance with Section 404 of the Clean Water Act and will suggest actions to minimize effects to wetlands."

Historic Properties

Comment: **Can archeology work be coordinated with the Glendive School for education benefits?**
Response: Most of the archeology work will be completed during the late spring and summer months when school is not in session. This timeline would make it difficult to coordinate such activities.

Comment : **How will the historic properties at Intake be affected?**
Response: As explained in the Historic Properties section of chapter 4, seven historic properties have been identified in the area of potential effects of the Intake Project. Table 4.17 compares the potential effects each of the alternatives on these historic properties. The adverse effects of the Rock Ramp Alternative on historic properties and proposed mitigation measures are also discussed in chapter 4.

Other Topics

Comment: **Are the authorized funds sufficient to complete the entire project?**
Response: The project is funded through the Missouri River Recovery and Mitigation Program which receives a yearly appropriation in the tens of millions of dollars. In fiscal year 2010, $18 million are allocated to complete construction of the new canal headworks and removable rotating drum screens. Due to the high priority level of this project within the Missouri River Recovery Program, it is anticipated that remaining funding needs will be made available in the fiscal year 2011 and 2012 budgets.

Comment: **Have other Missouri River projects been put on hold in order for the Intake project to move forward?**
Response: Due to limited resources, there are other projects within the Missouri River Recovery Program such as construction of shallow water habitat for pallid sturgeon that have been deferred while the Intake project is under development and construction.

Comment: **How will the public know and be kept informed about what is going on?**
Response: As requested during the public meetings, video clips of the physical model being tested at Reclamation's technical center have been posted on the website (www.usbr.gov/gp/mtao.loweryellowstone). Reclamation is also committed to working with FWP to develop a public notification plan by which the public will be kept informed as discussed in the Recreation section of chapter 4.

Comment**: When the river get really low who gets the water right?**
Response: Water rights are administered by the State of Montana. Currently, the water rights on the Yellowstone River are being adjudicated. Once adjudication is complete, it would be the responsibility of the Montana Department of Natural Resources and Conservation to administer the water rights on the Yellowstone River.

Comment**: Do Yellowtail winter releases affect or are they operated to influence ice flows in the spring?**
Response: A steady winter release from Yellowtail Dam is based upon water storage in Bighorn Lake and forecasted inflows into Bighorn Lake. This is not believed to significantly affect ice flows in the Yellowstone River, nor is Yellowtail Dam operated to influence ice flows on the Yellowstone River in the spring.

Comment**: Who is the decision-maker for this process?**
Response: The Regional Director of the Great Plains Region will sign the decision document for Reclamation. The Northwestern Division Commander will sign the decision document for the Corps.