Yellowstone River - Intake Dam Fish Passage and Entrainment Prevention

National Conference on Ecosystem Restoration
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USACE – Omaha District
August 2011
What Are We Proposing to Do?

- The Bureau of Reclamation and U.S. Army Corps of Engineers propose to modify Intake Diversion Dam and Canal Headworks, a Bureau of Reclamation Project on the Yellowstone River.
Lower Yellowstone Project Background

- Construction of the Lower Yellowstone Project began on July 22, 1905.
- Located 70 miles upstream from mouth of Yellowstone River.
- Irrigates approximately 55,000 acres with 1400 cfs water right.
- Project consists of a diversion dam (Intake Diversion Dam), headworks, main canal, laterals, and drains.
Pallid Sturgeon Recovery in the Missouri River Basin

- Pallid Sturgeon listed as endangered in 1990

- Pallid Sturgeon Recovery Plan (USFWS) identified the historic range of pallid sturgeon includes the Yellowstone River to the mouth of the Bighorn River (~290 miles)

- Intake Dam is known to impede upstream migration of native Yellowstone River fish, notably pallid sturgeon, paddlefish, burbot, etc…

- Fish entrainment studies documented that thousands of native fish are entrained into the canal system and perish annually, including some restocked hatchery raised pallid sturgeon
Historic Range of Pallid Sturgeon on the Yellowstone
Corps of Engineers Involvement
Missouri River Biological Opinion (Corps)

“The value of restoring the Yellowstone River as a natural migratory route for sturgeon, and making the Yellowstone function as the spawning and nursery ground for pallids cannot be overstated. Having a healthy population of pallid sturgeon at any point on the Missouri River brings significant flexibility in the management prerogatives and reduces the risk associated with Adaptive Management experiments.”
[USFWS, 2003 Amended BiOp on Missouri River]

Water Resources Development Act of 2007 (WRDA)

SEC. 3109. LOWER YELLOWSTONE PROJECT, MONTANA.

The Secretary may use funds appropriated to carry out the Missouri River recovery and mitigation program to assist the Bureau of Reclamation in the design and construction of the Lower Yellowstone project of the Bureau, Intake, Montana, for the purpose of ecosystem restoration.
Project Goals
Continue Operation of Lower Yellowstone Project
Minimize Entrainment

- Research indicates that thousands of native fish are being unintentionally trapped and lost to the irrigation canal.
Improve Fish Passage

- Under existing conditions pallid sturgeon spawn below Intake. Newly hatched pallids drift into Lake Sakakawea where their survival rate is low.

- The proposed project would aid in recovery of pallid sturgeon by:
  - Opening 165 additional river miles for spawning
  - Improve opportunities for survival of newly hatched fish, which drift for 10-15 days after hatching.
Selected Improvements
Fish Entrainment Prevention

- New Headworks with Fish Screen
  - Prevent entrainment and allow for continued delivery of water.
  - Designed to NOAA passage criteria for Salmonids
    - 0.4 fps approach velocity
- Cylindrical Screens
  - Concentrate a large amount of surface into a small area
  - Retrievable with winch and track system (ice avoidance)
- 12 screen units
  - Diameter of 78 inches
  - 100 inch length of each screen cylinder
  - 2 screen cylinders per unit
Conceptual Screen Configuration

- Retrieval Track
- Fixed External Brush
- Rotating Wedgewire Screens
- Retractable Hoses
- Screened Water
- Internal Flow Manifold
- Even Velocity Distribution
- Internal Brush
- Docking Inlet with Trashrack
- Hydraulic Motor Attached to Manifold Rotates Wedgewire Cylinder
• To be completed and operational late FY12
Fish Passage Improvement
Full River Rock Ramp or Diversion Channel
Design Goals

• Allow passage under flow conditions to be experienced during spring and summer
• Reduce velocities experienced across crest and throughout ramp
• Maintain depths necessary for passage
• Provide head for diversion at 3000 cfs (August 95% duration flow rate)

<table>
<thead>
<tr>
<th>Depth Ranges (ft)</th>
<th>Velocity Ranges (fps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 1.64</td>
<td>0 to 2</td>
</tr>
<tr>
<td>1.64 to 3.28</td>
<td>2 to 4</td>
</tr>
<tr>
<td>3.28 to 30</td>
<td>4 to 6</td>
</tr>
<tr>
<td></td>
<td>6 to 8</td>
</tr>
<tr>
<td></td>
<td>8 to 12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>50% Exceedance by Month</th>
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<tbody>
<tr>
<td>April-8,470</td>
</tr>
<tr>
<td>May-14,800</td>
</tr>
<tr>
<td>June-30,700</td>
</tr>
<tr>
<td>July-17,100</td>
</tr>
<tr>
<td>August-7,080</td>
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<tr>
<td>September-6,660 cfs</td>
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</tbody>
</table>
Design Tools

• Site **data collection** (surveys, WS elev from several flows, sediment data, velocity data collection)

• **RAS 1D** model
  • Initial ramp configuration
  • Water surface elevation impacts

• **ADH 2D** modeling
  • Sediment transport evaluation
  • Debris protection evaluation
  • Velocity and depth evaluation for passage

• **Physical models** at Reclamation lab at Denver TSC (2 phases for headworks and ramp, include sediment)
Ramp Analysis

- Preliminary design with RAS 1D
- Extensive 2D modeling with ADH
- Physical model at Reclamation lab at Denver TSC
Crest and Ramp Configuration
Crest and Ramp Configuration

- Variable Slope Crest.
- Designed to maintain minimum 1m depths and maintain head for irrigation at all flows to be encountered.
Crest and Ramp Configuration
Full river width, 0.9% nominal compound slope compared to .4% nominal compound slope
Ramp Crest Velocities

Distance Across Crest (ft) Left to Right Descending

- 40,000 cfs
- 30,000 cfs
- 24,000 cfs
- 15,000 cfs
- 7,000 cfs
Bypass Channel Options

- Bypass channel utilizing existing high flow channel

- Three conceptual channel alignments for varied Yellowstone flow diversion
  1. 10% diversion .00059 slope, 13550 ft x 50 ft        630k cy excavation
  2. 15% diversion .00045 slope, 15650 ft x 61 ft        950k cy excavation
  3. 30% diversion .00059 slope, 13550 ft x 300 ft    2,436k cy excavation

  ► Flow meets velocity and depth passage criteria for all scenarios

  ► 10% diversion questioned because of potentially insufficient Attractive flow

  ► Three level of bank protection considered:
    1. Required: channel entrance and exit grade control plus plug in existing high flow channel
    2. #1 plus outer bend toe protection (likely)
    3. #1 plus continual toe protection
<table>
<thead>
<tr>
<th>Channel Type</th>
<th>Slope</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellowstone channel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outer bend toe protection shown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bypass option 1, 0.00059 slope</td>
<td>0.00059</td>
<td>13,550 ft</td>
</tr>
<tr>
<td>Bypass option 2, 0.00045 slope</td>
<td>0.00045</td>
<td>15,650 ft</td>
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</tbody>
</table>

Bypass channel Options
# Conceptual Bypass Details

## Recurrence interval (annual, post-Yellowtail flows) vs. Total Yellowstone River discharge vs. Flow Splits for Base and Alternatives

<table>
<thead>
<tr>
<th>Recurrence interval</th>
<th>Total Yellowstone River discharge</th>
<th>BASE (existing right bank chute assuming new headworks with existing dam)</th>
<th>10% Diversion</th>
<th>15% Diversion</th>
<th>30% Diversion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(cfs) (cfs) (%)</td>
<td>(cfs) (%)</td>
<td>(cfs) (%)</td>
<td>(cfs) (%)</td>
<td>(cfs) (%)</td>
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<tr>
<td>&lt;2-yr</td>
<td>3000 0 0</td>
<td>210 7</td>
<td>570 19</td>
<td>830 28</td>
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<tr>
<td>&lt;2-yr</td>
<td>7000 0 0</td>
<td>750 11</td>
<td>1260 18</td>
<td>2540 36</td>
<td></td>
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<tr>
<td>&lt;2-yr</td>
<td>15000 0 0</td>
<td>1600 11</td>
<td>2280 15</td>
<td>5280 35</td>
<td></td>
</tr>
<tr>
<td>&lt;2-yr</td>
<td>20000 0 0</td>
<td>2120 11</td>
<td>2850 14</td>
<td>6930 35</td>
<td></td>
</tr>
<tr>
<td>&lt;2-yr</td>
<td>30000 790 3</td>
<td>3170 11</td>
<td>3990 13</td>
<td>9840 33</td>
<td></td>
</tr>
<tr>
<td>5-yr</td>
<td>60600 4050 7</td>
<td>7190 12</td>
<td>7920 13</td>
<td>18540 31</td>
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## Pertinent Bypass Channel Parameters

<table>
<thead>
<tr>
<th>Pertinent Bypass Channel Parameters</th>
<th>10% Diversion</th>
<th>15% Diversion</th>
<th>30% Diversion</th>
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<tbody>
<tr>
<td>Alignment</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Bypass Channel Length (ft)</td>
<td>13550</td>
<td>15650</td>
<td>13550</td>
</tr>
<tr>
<td>Bypass Channel Longitudinal Slope</td>
<td>0.00059</td>
<td>0.00045</td>
<td>0.00059</td>
</tr>
<tr>
<td>Low Flow Channel Depth (ft)</td>
<td>2</td>
<td>N/A</td>
<td>2</td>
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<tr>
<td>Low Flow Channel Bottom Width (ft)</td>
<td>10</td>
<td>N/A</td>
<td>10</td>
</tr>
<tr>
<td>Low Flow Channel Side Slopes</td>
<td>1V:3H</td>
<td>N/A</td>
<td>1V:3H</td>
</tr>
<tr>
<td>Main Bypass Channel Bottom Width</td>
<td>50</td>
<td>61</td>
<td>300</td>
</tr>
<tr>
<td>Main Bypass Channel Side Slopes</td>
<td>1V:5H</td>
<td>1V:4H</td>
<td>1V:5H</td>
</tr>
<tr>
<td>Approximate Excavation Quantity (cubic yards)</td>
<td>650,000</td>
<td>950,000</td>
<td>2,460,000</td>
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Bypass Channel Options

- Further analysis later this FY/FY12
  - Sediment sampling in area
  - Further Hydraulic Modeling
  - Optimization of Flow Split
    - Channel Stability
    - Attractive Flow at Outlet
Questions