

Yellowstone River - Intake Dam Fish Passage and Entrainment Prevention

National Conference on Ecosystem Restoration

Chris Svendsen, PE

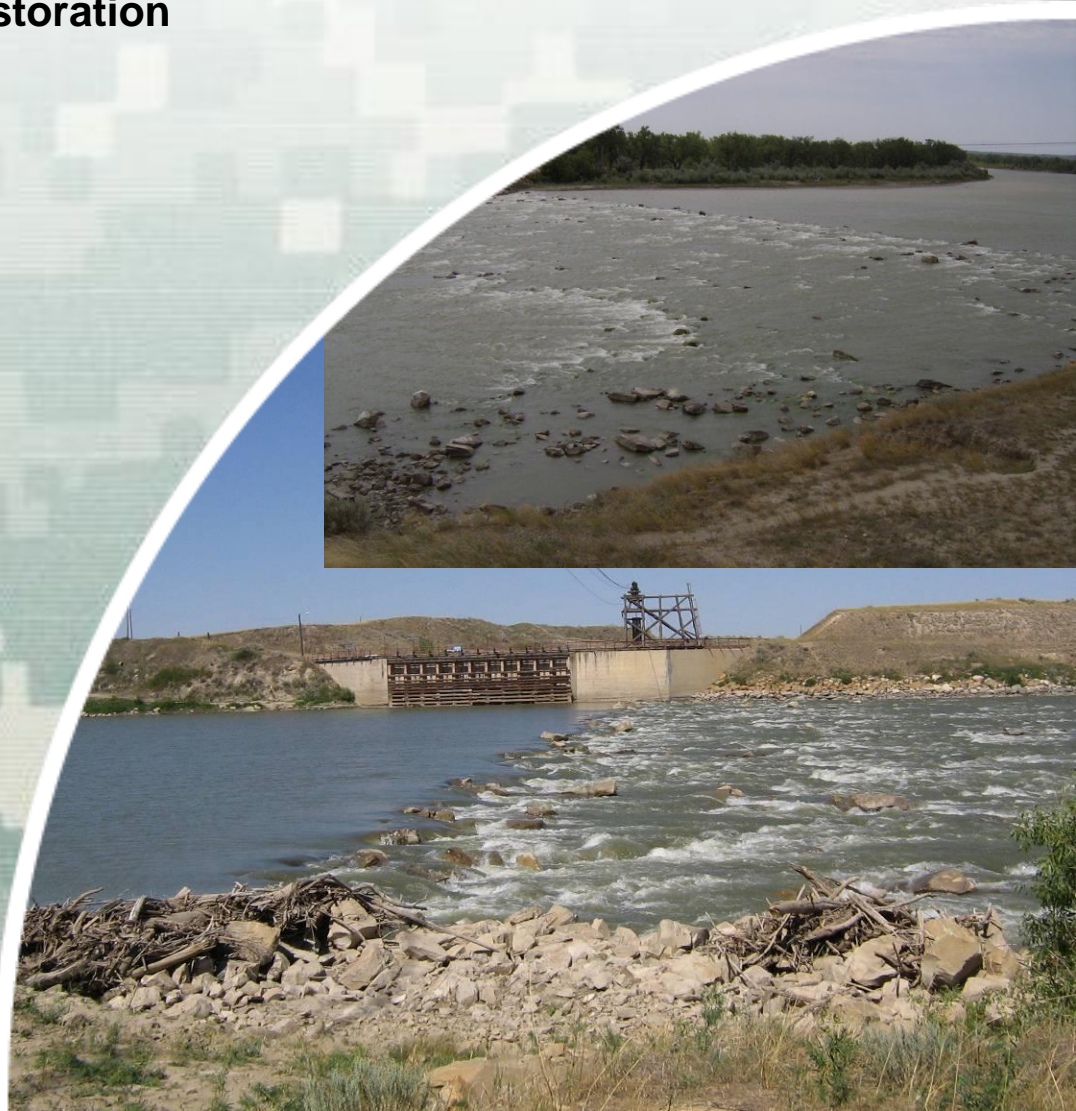
USACE – Omaha District

August 2011



®

US Army Corps of Engineers
BUILDING STRONG®



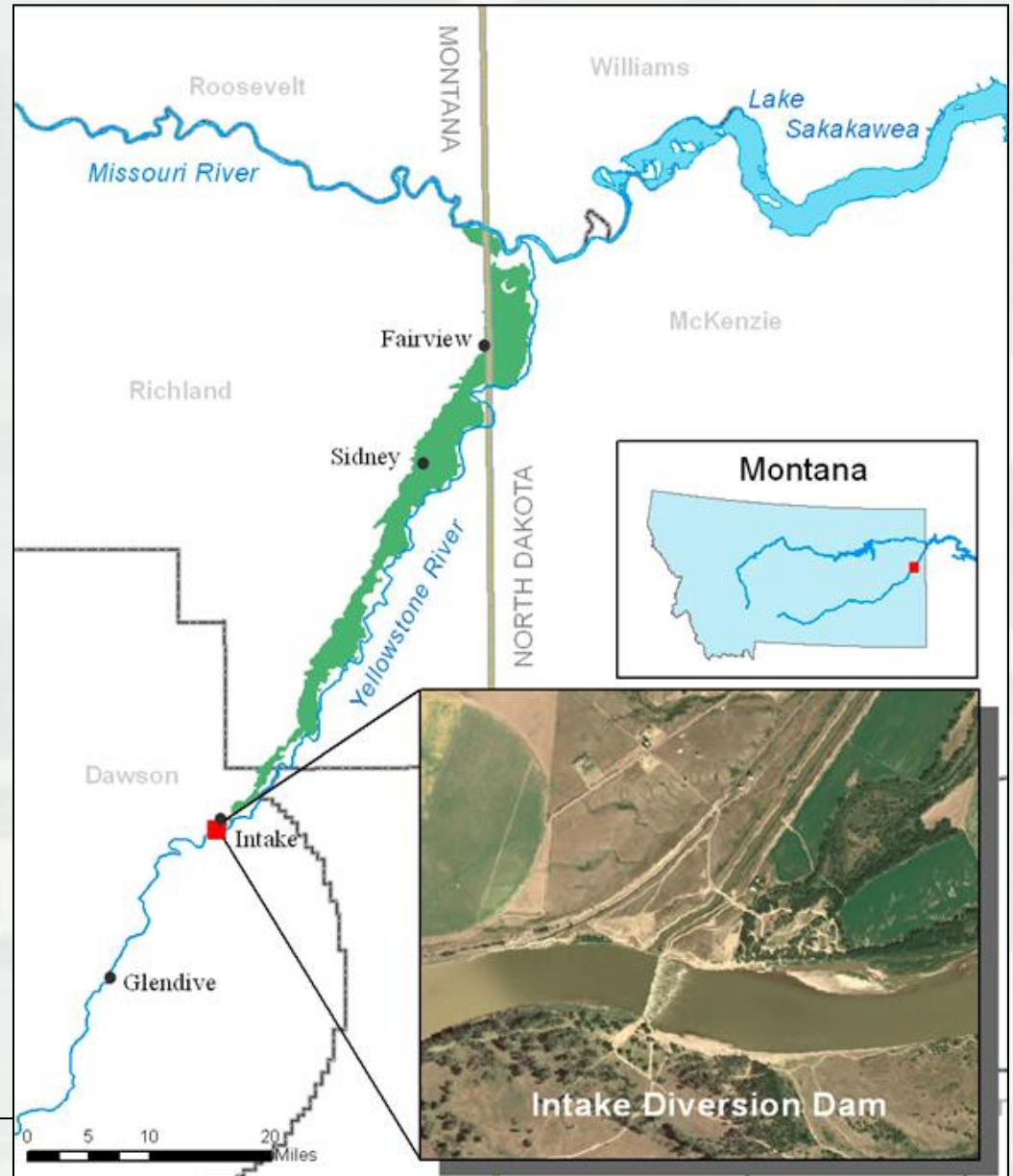
What Are We Proposing to Do?

- 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.



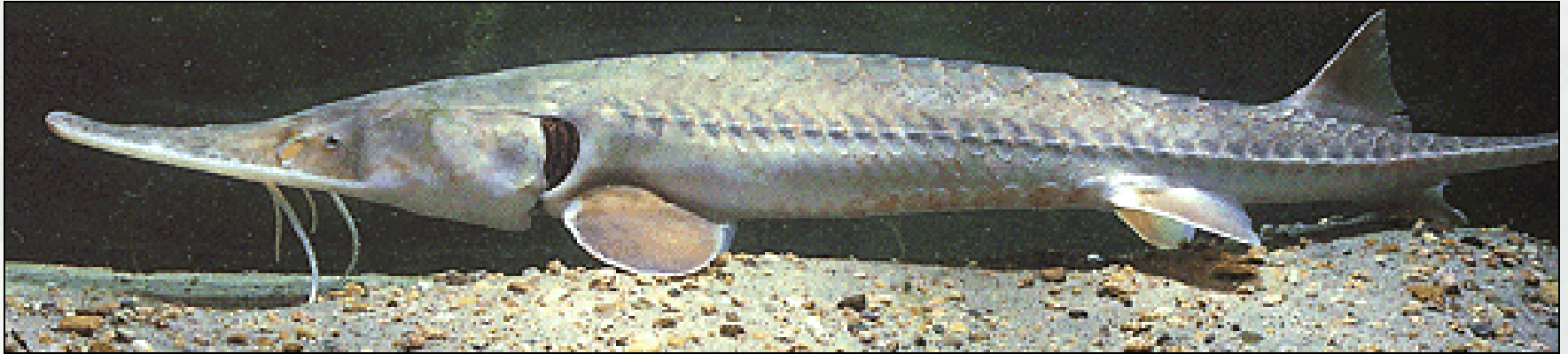
Lower Yellowstone Project Background

- 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





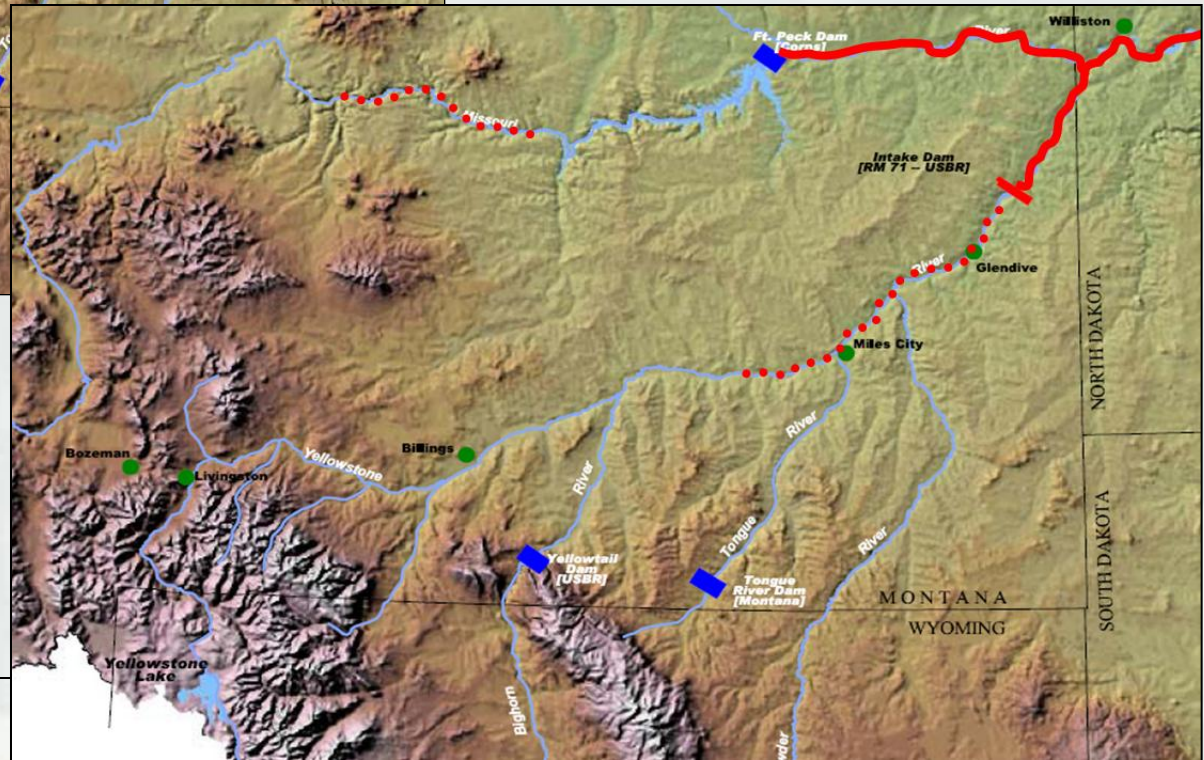
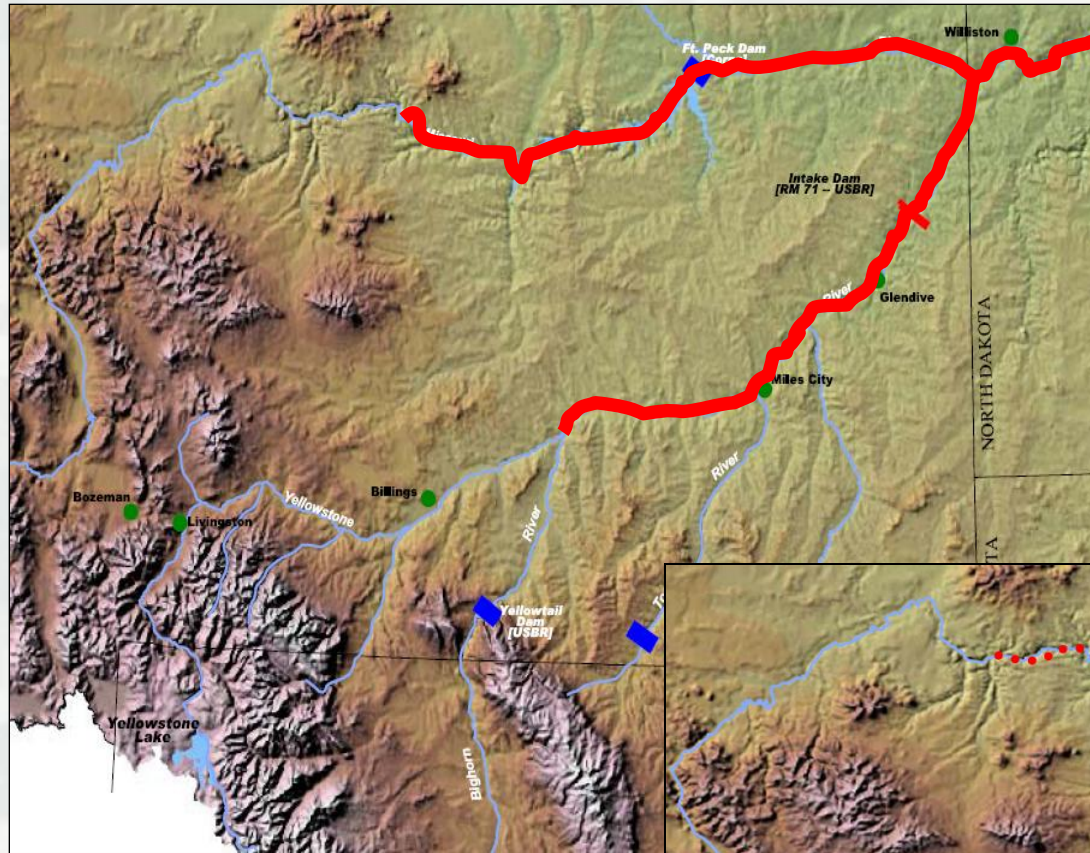
Pallid Sturgeon Recovery in the Missouri River Basin



- 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



BUILDING STRONG®

Continue Operation of Lower Yellowstone Project



BUILDING STRONG®

Minimize Entrainment

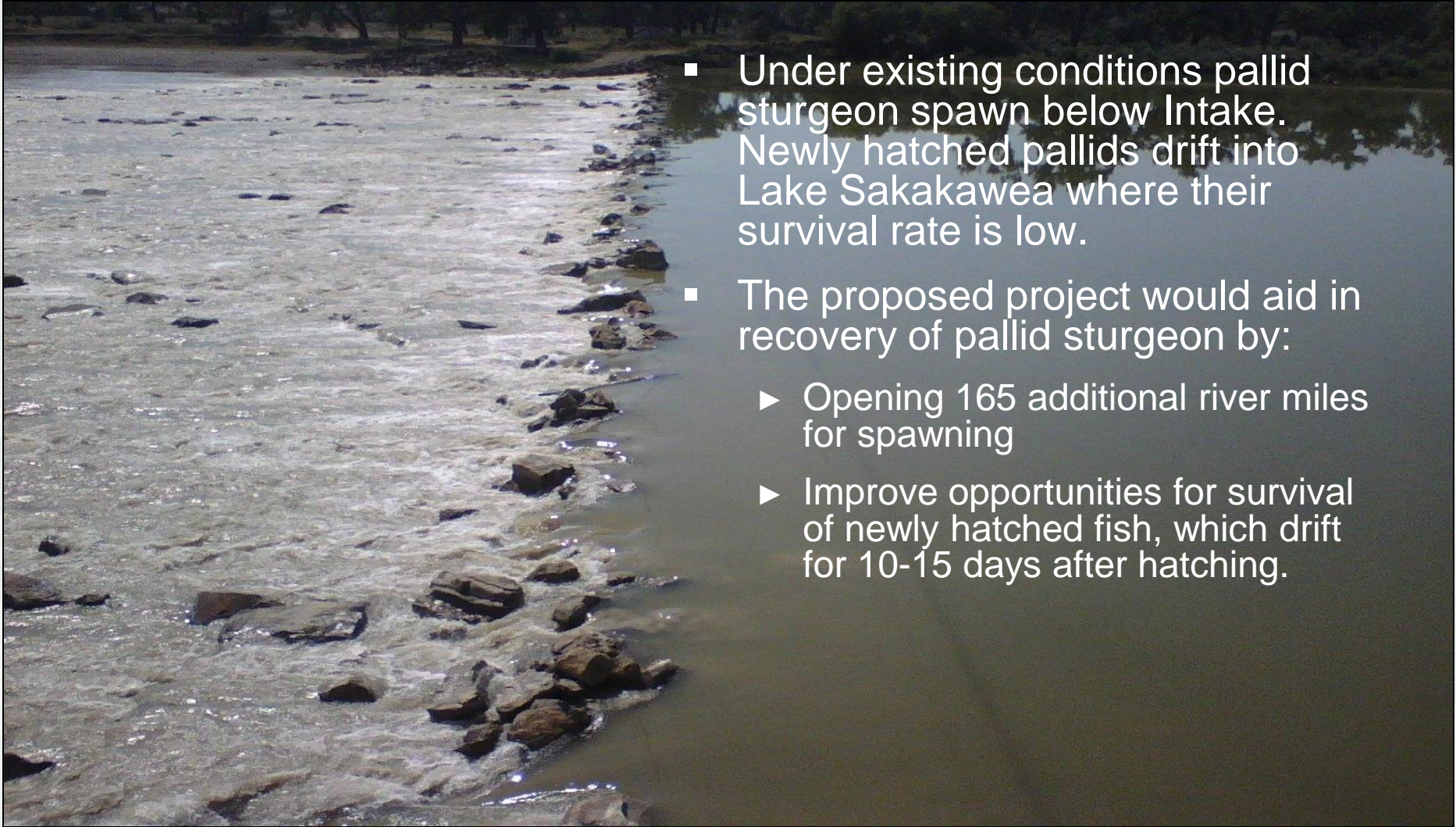


- Research indicates that thousands of native fish are being unintentionally trapped and lost to the irrigation canal.



BUILDING STRONG®

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

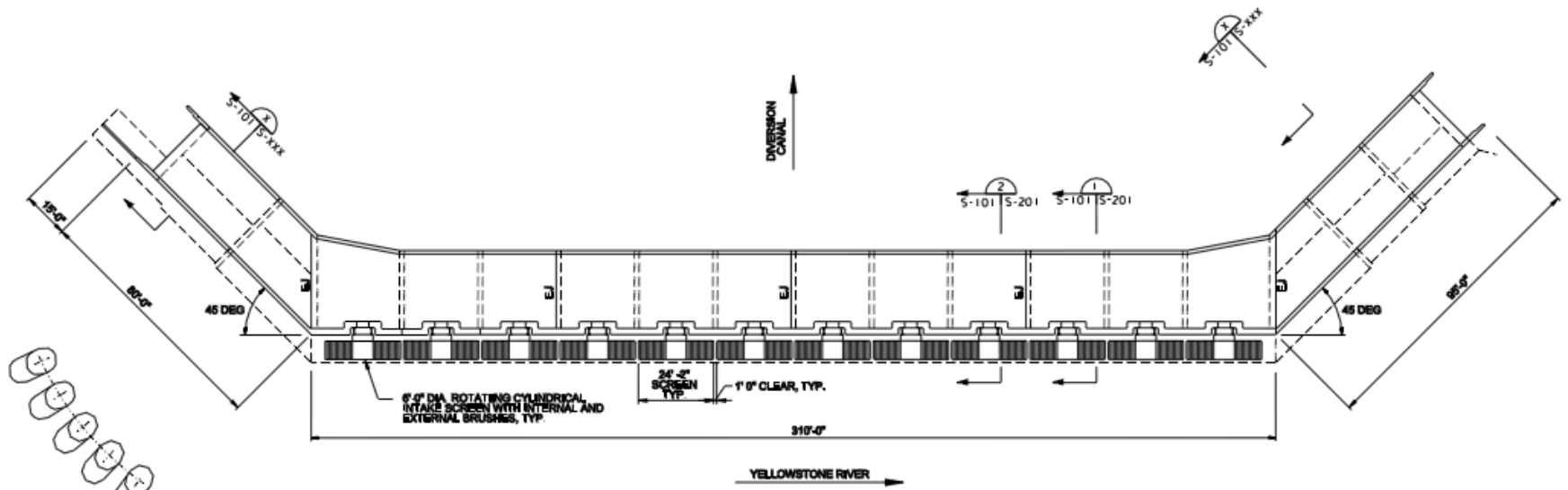


BUILDING STRONG®

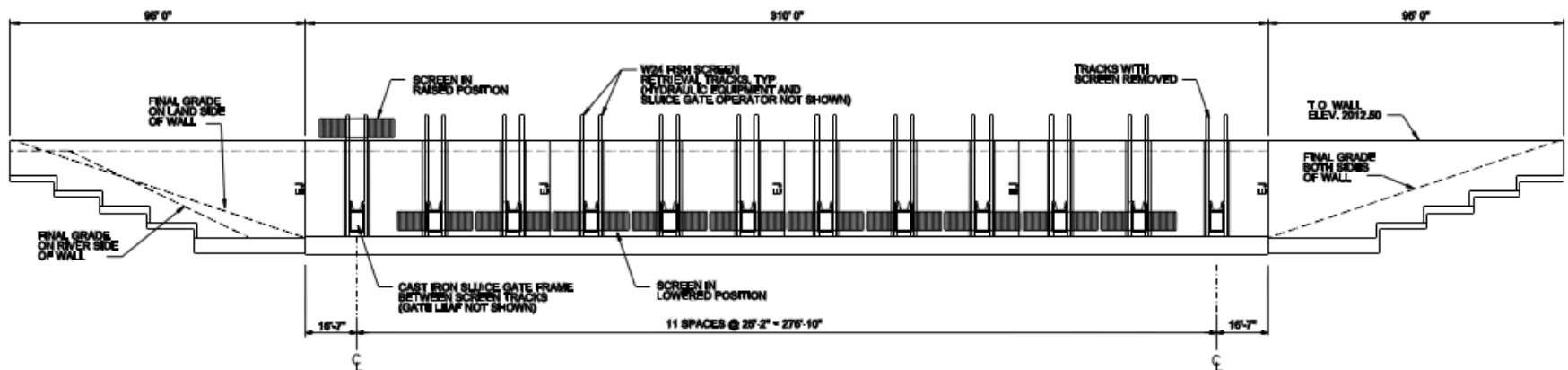
Fish Entrainment Prevention

- 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

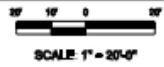




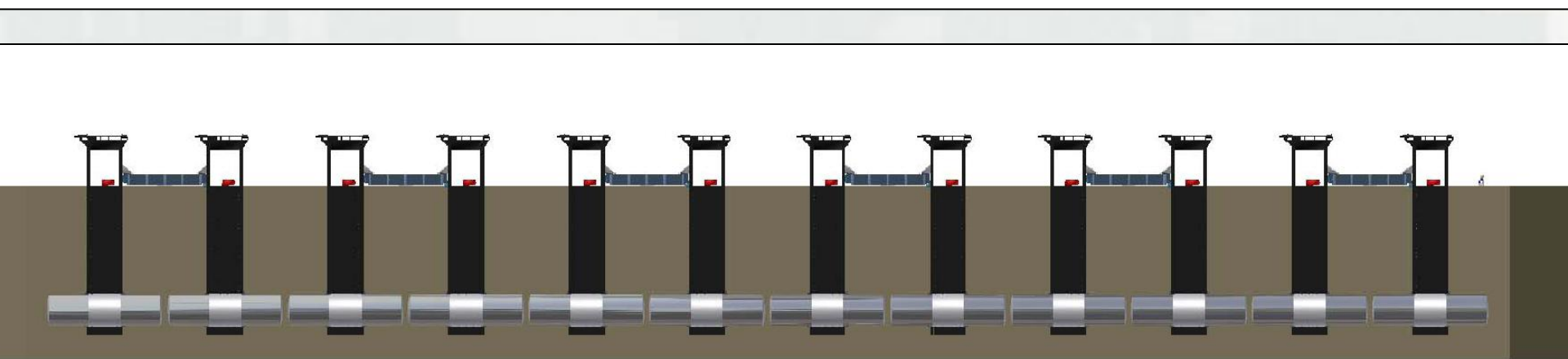
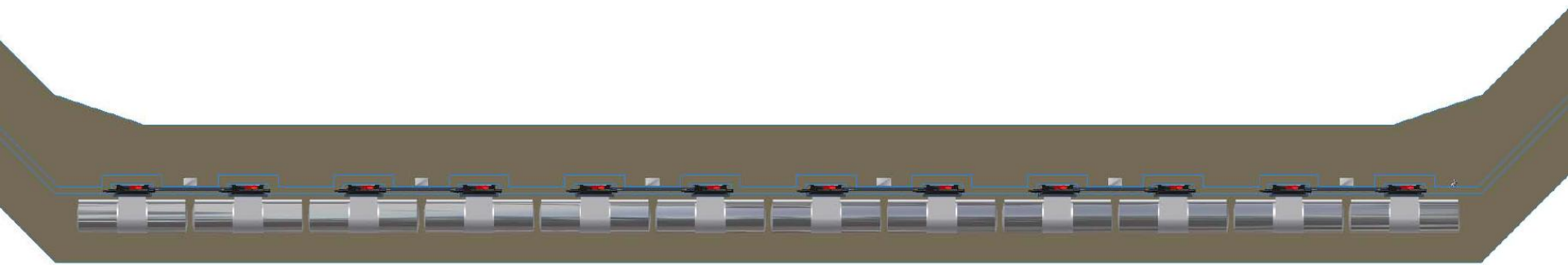
HEADWORKS WITH FISH SCREENS - PLAN



HEADWORKS FRONT WALL ELEVATION

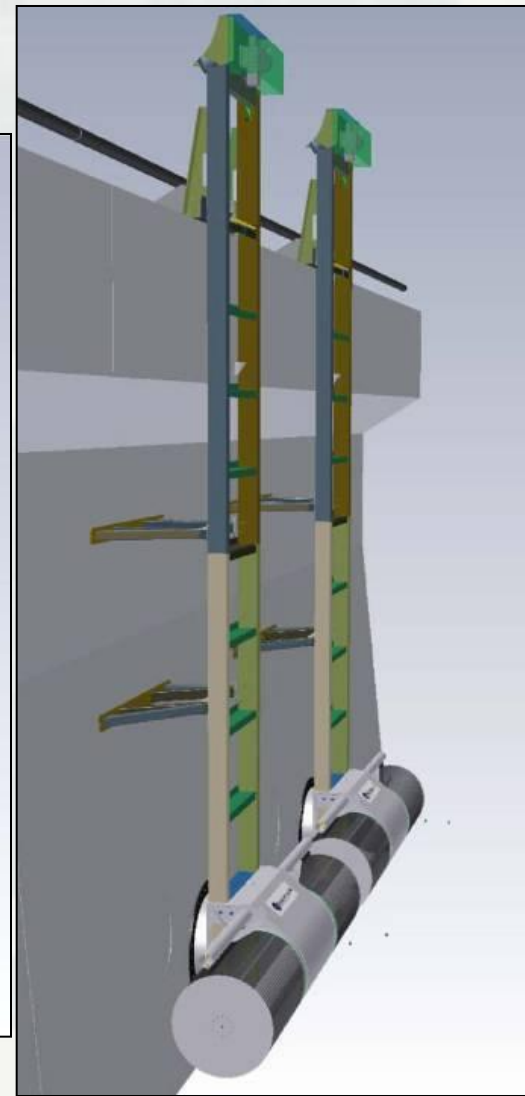
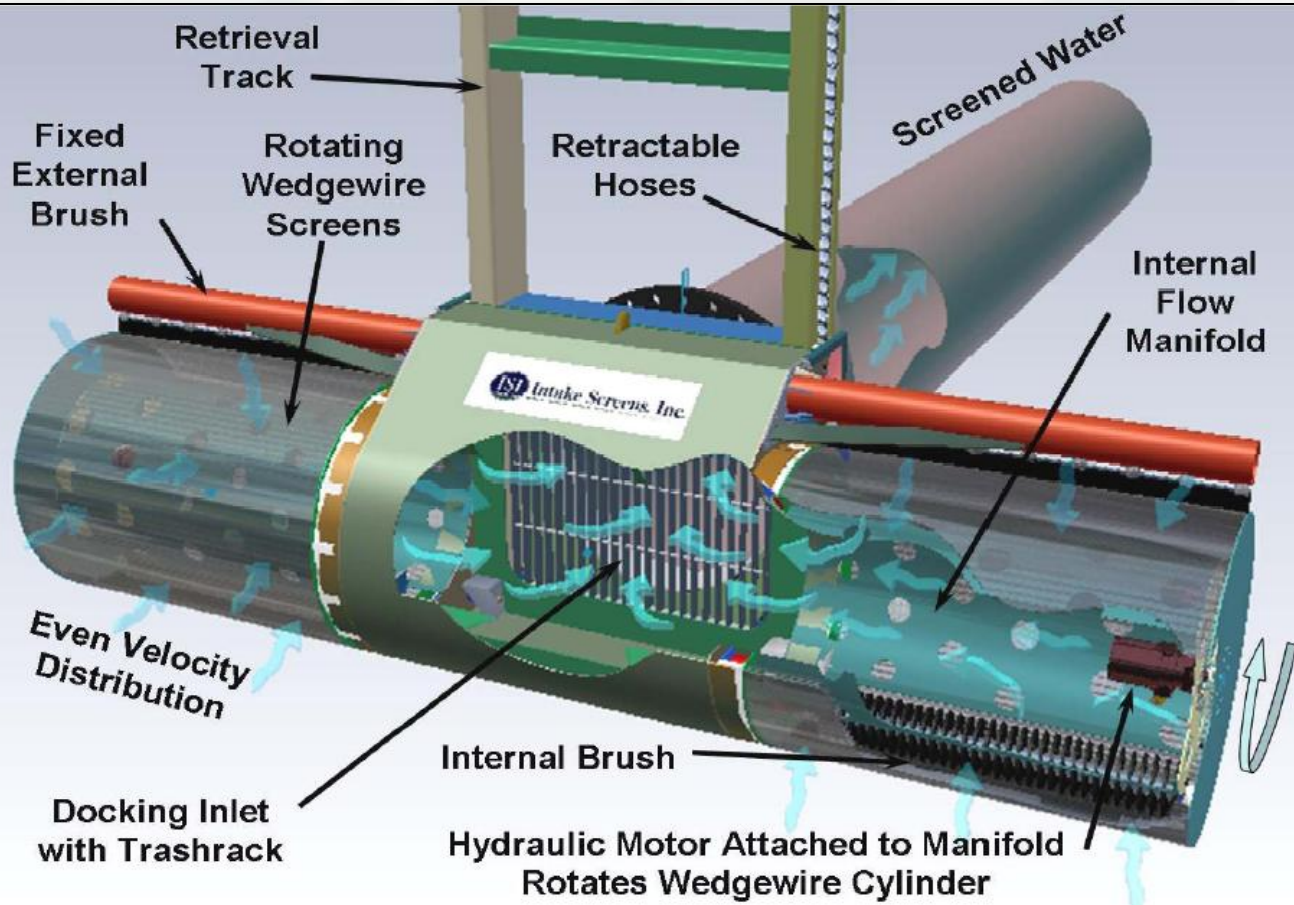


NOTES:

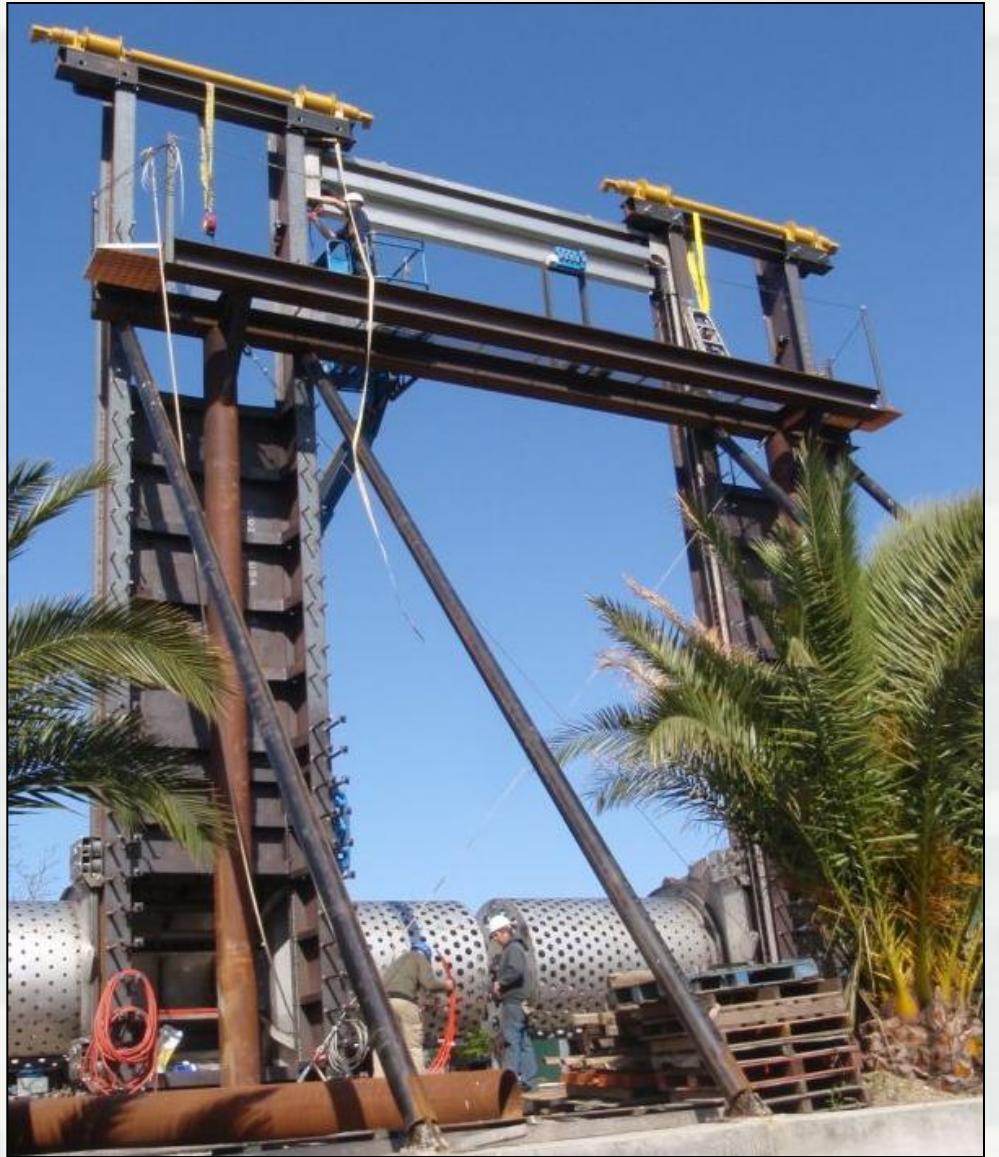
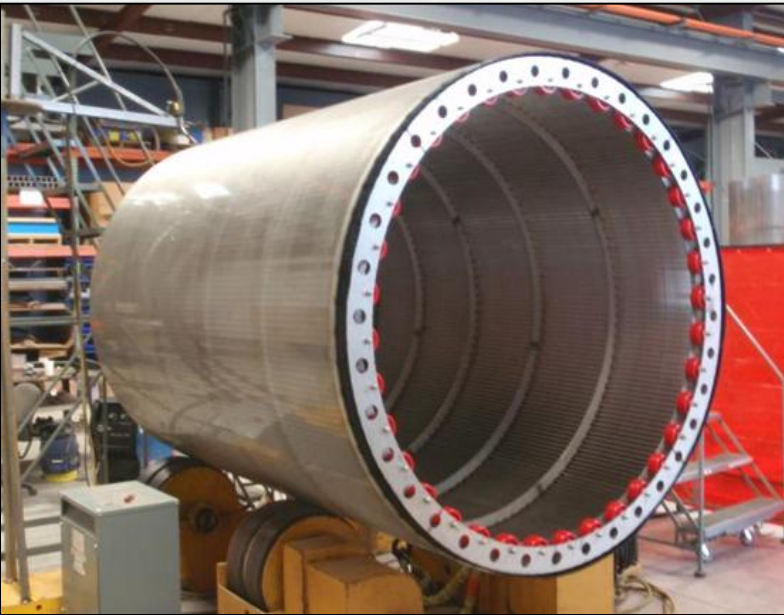


BUILDING STRONG®

Conceptual Screen Configuration



BUILDING STRONG[®]



BUILDING STRONG®



- To be completed and operational late FY12



BUILDING STRONG®

Fish Passage Improvement

Full River Rock Ramp or Diversion Channel



BUILDING STRONG®

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)

Depth Ranges (ft)	Velocity Ranges (fps)
0 to 1.64	0 to 2
1.64 to 3.28	2 to 4
3.28 to 30	4 to 6
	6 to 8
	8 to 12

50% Exceedance by Month
April-8,470
May-14,800
June-30,700
July-17,100
August-7,080
September-6,660 cfs

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)

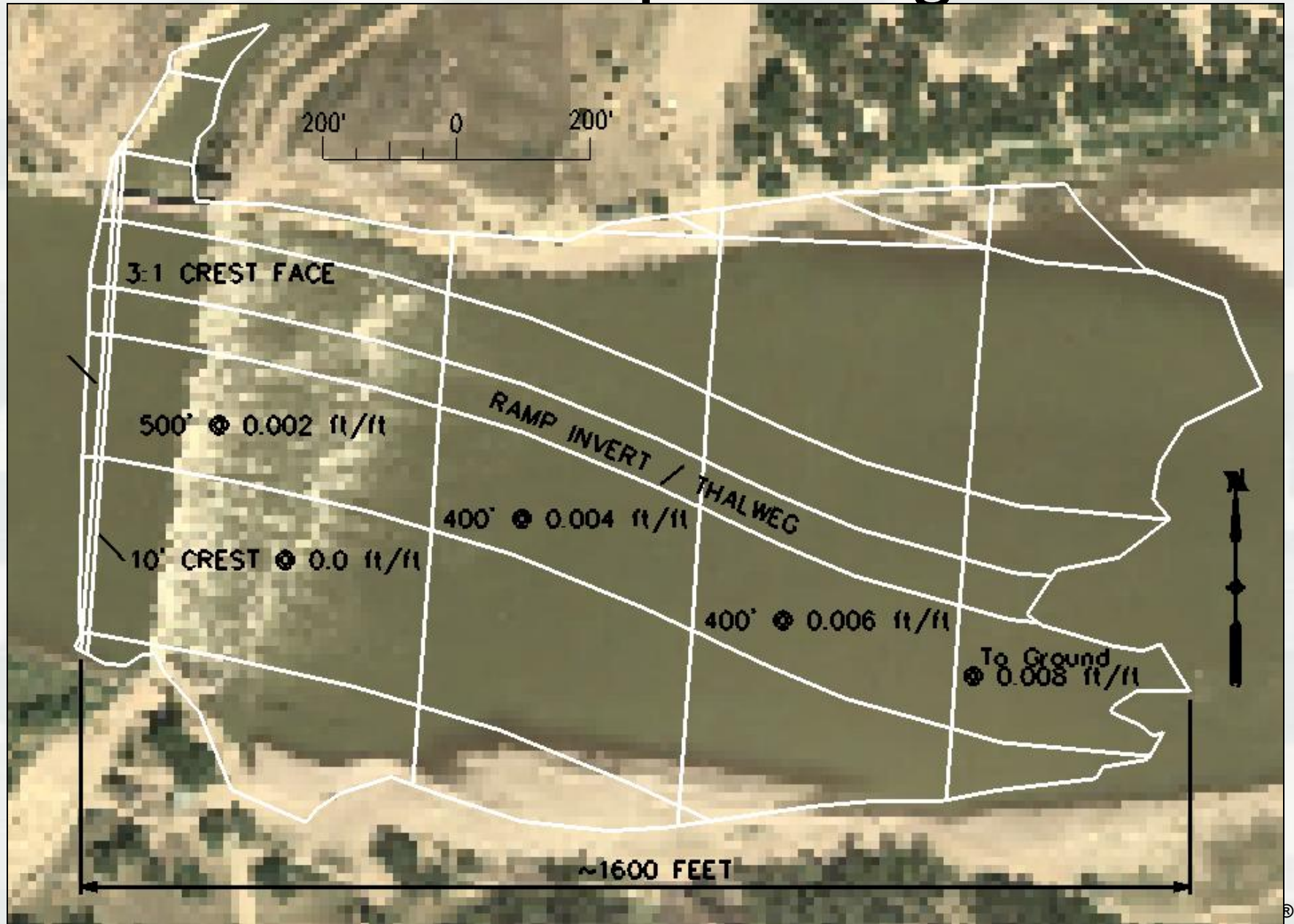


Ramp Analysis

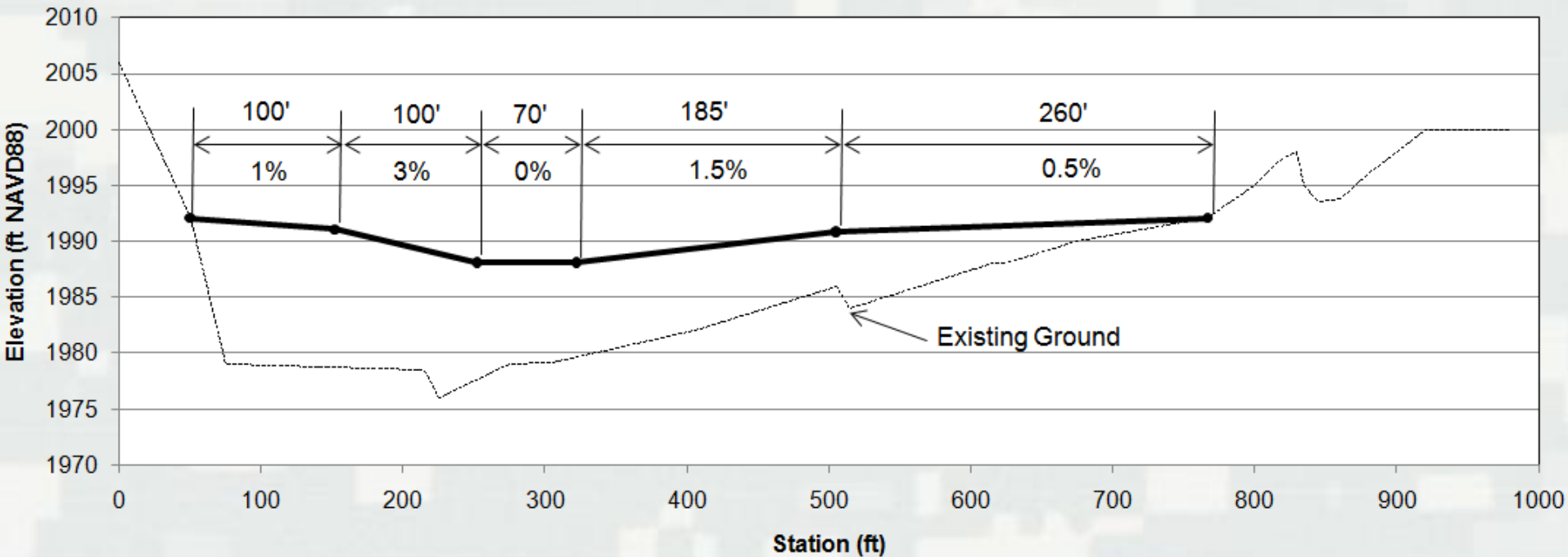
- Preliminary design with RAS 1D
- Extensive 2D modeling with ADH
- Physical model at Reclamation lab at Denver TSC



Crest and Ramp Configuration



Crest and Ramp Configuration

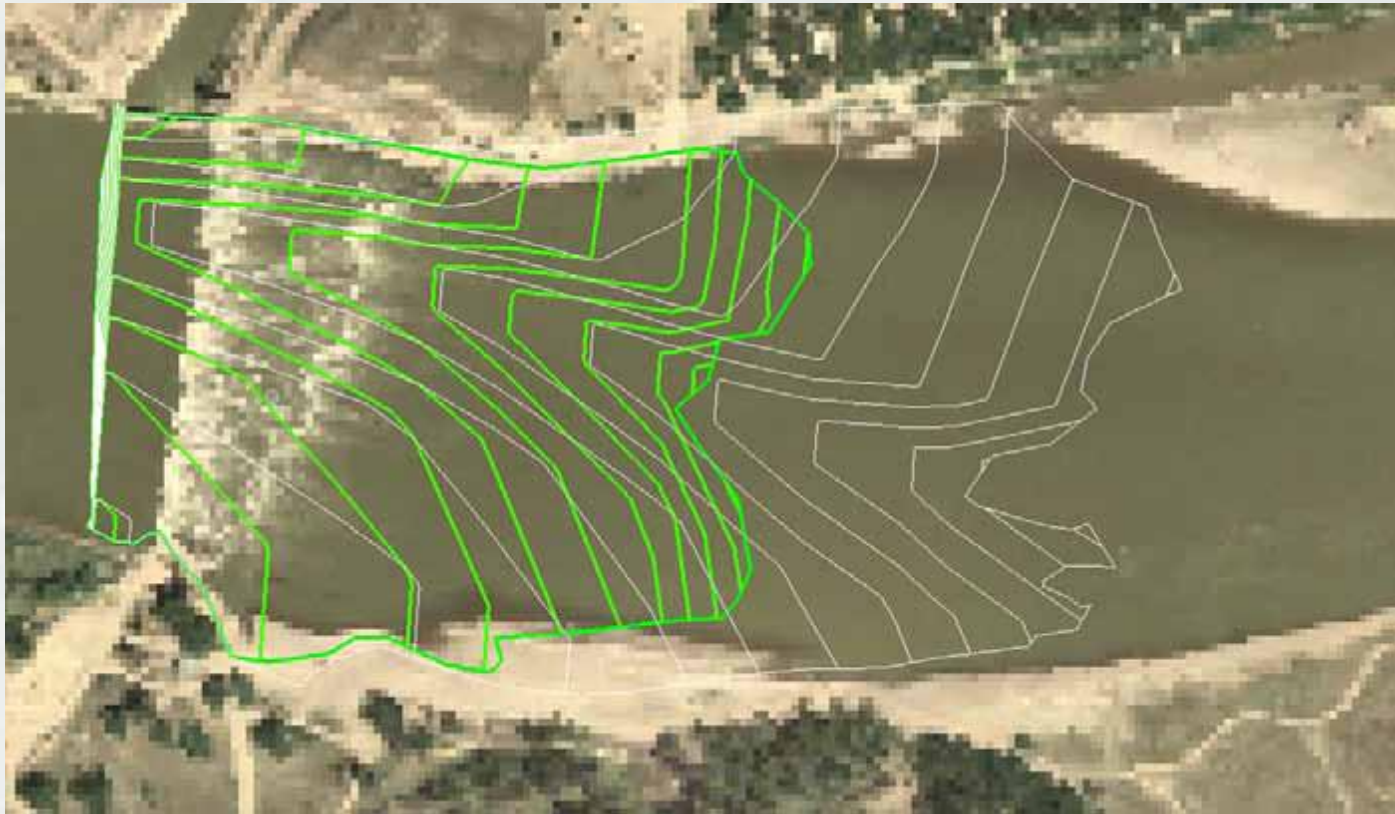


- Variable Slope Crest.
- Designed to maintain minimum 1m depths and maintain head for irrigation at all flows to be encountered.



Crest and Ramp Configuration

Full river width, 0.9% nominal compound slope compared to .4% nominal compound slope



BUILDING STRONG®



7,000 CFS



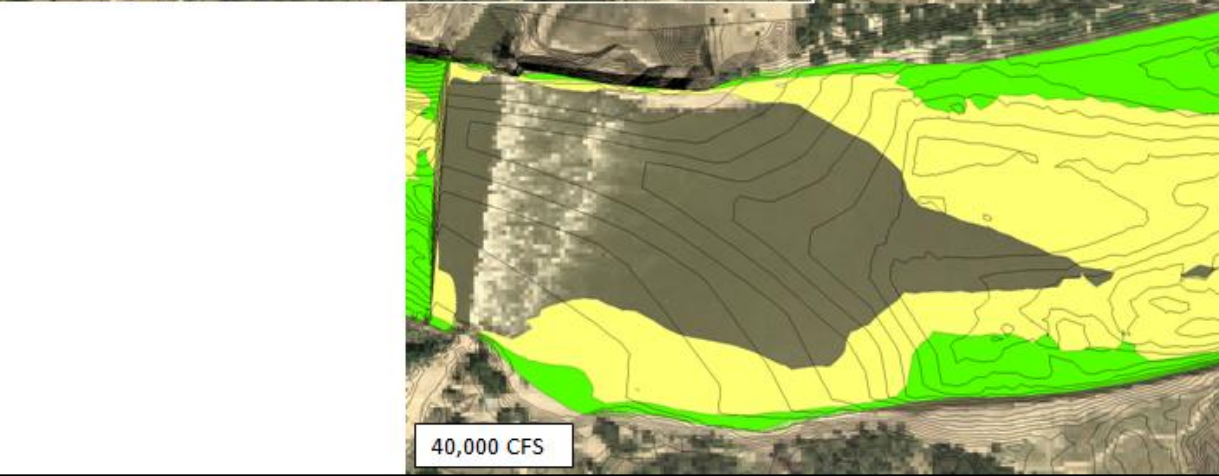
15,000 CFS



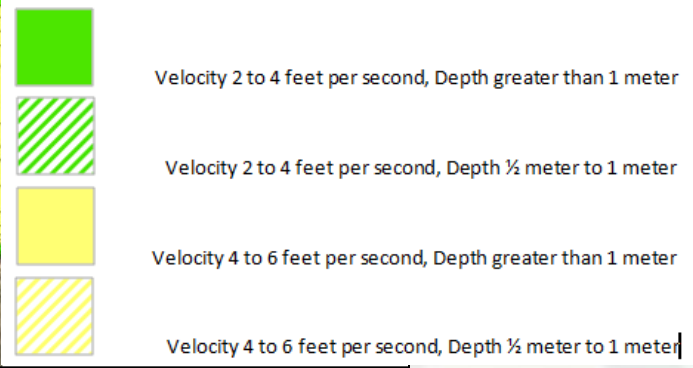
24,000 CFS



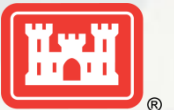
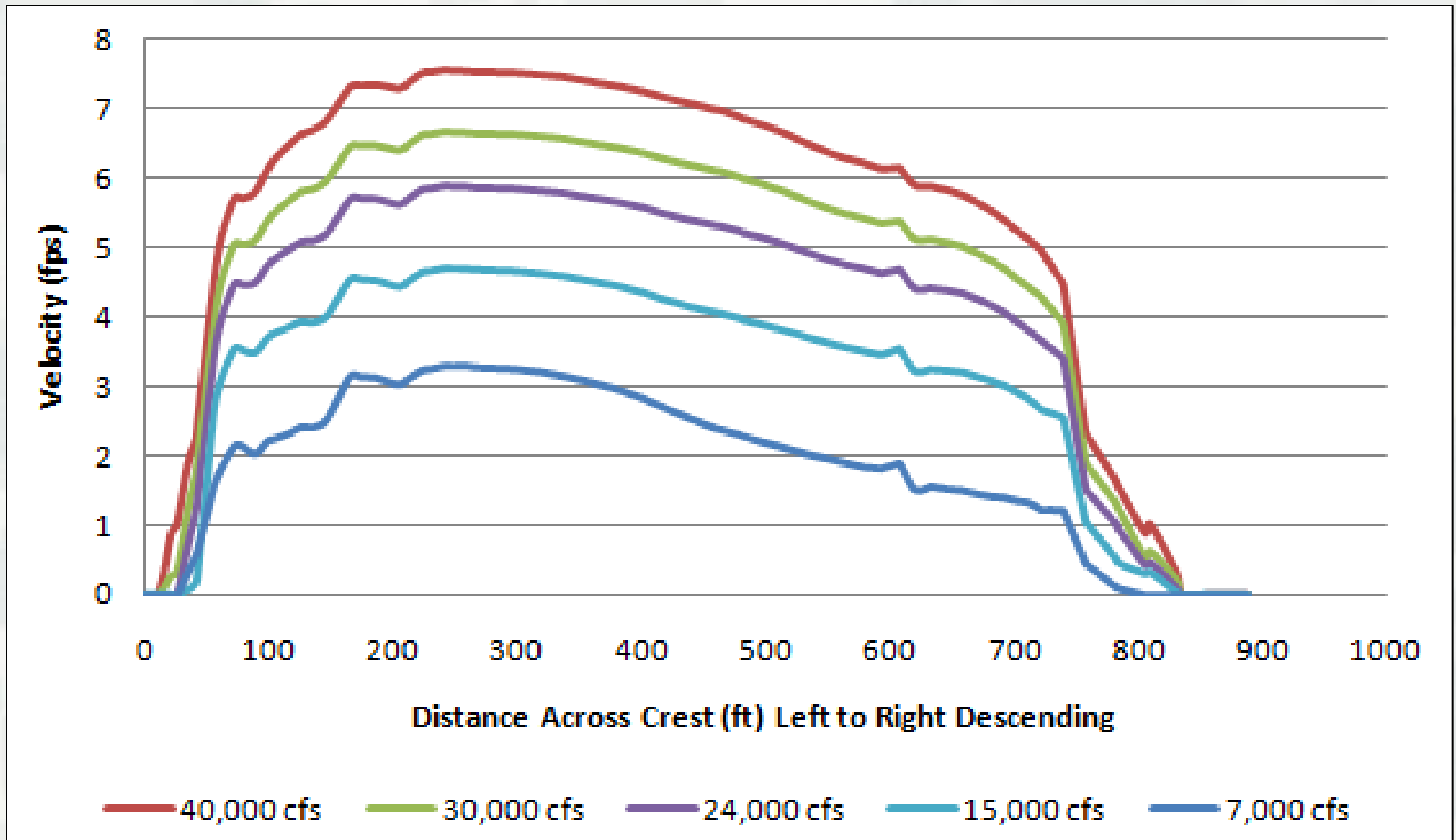
30,000 CFS



40,000 CFS



Ramp Crest Velocities



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

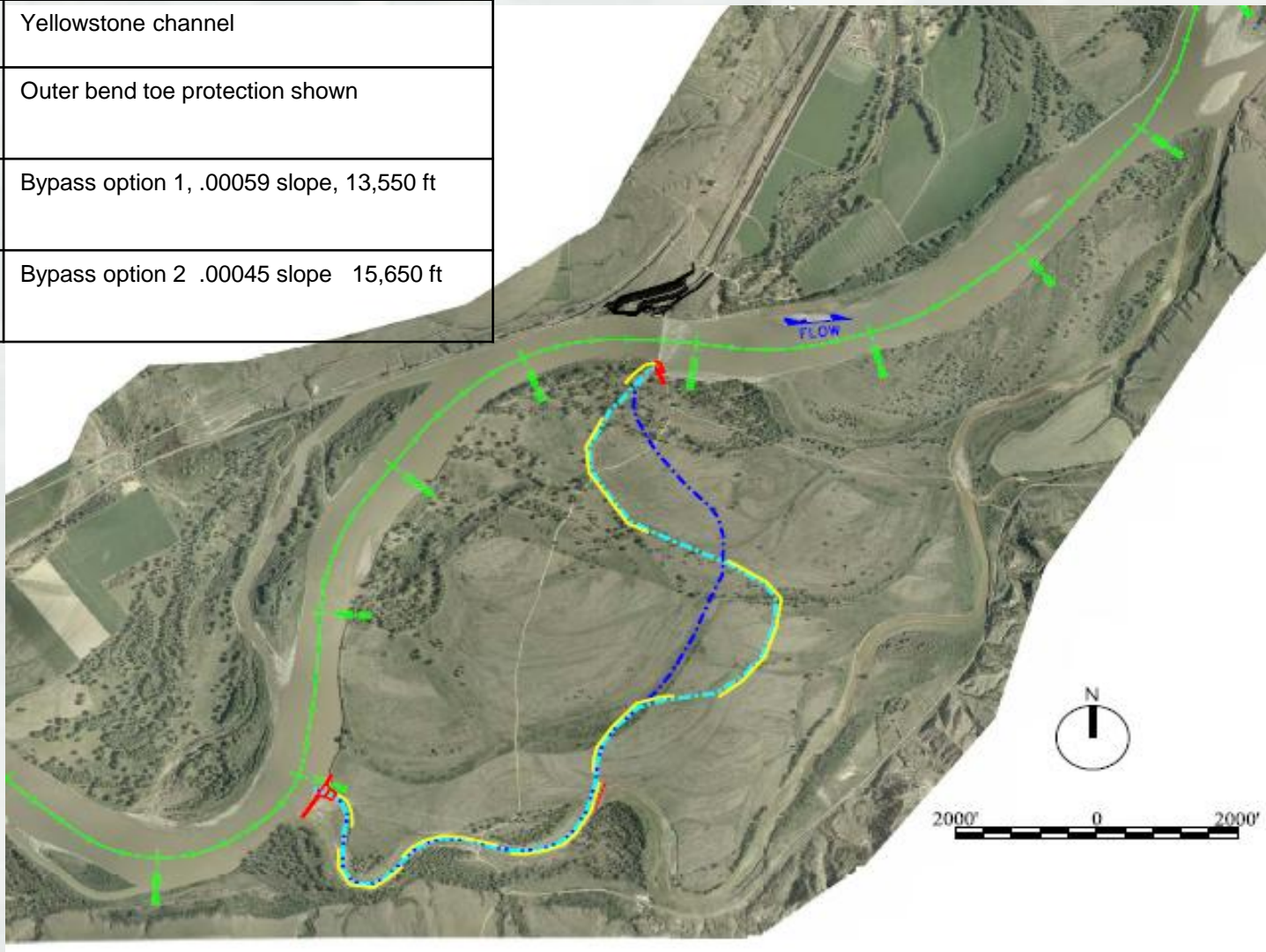
- ▶ 10% diversion questioned because of potentially insufficient Attractive flow

- ▶ 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



Bypass channel Options

	Yellowstone channel
	Outer bend toe protection shown
	Bypass option 1, .00059 slope, 13,550 ft
	Bypass option 2 .00045 slope 15,650 ft



Conceptual Bypass Details

		Flow Splits for Base and Alternatives							
Recurrence interval (annual, post- Yellowtail flows)	Total Yellowstone River discharge	BASE (existing right bank chute assuming new headworks with existing dam)		10% Diversion		15% Diversion		30% Diversion	
		(cfs)	(%)	(cfs)	(%)	(cfs)	(%)	(cfs)	(%)
<2-yr	3000	0	0	210	7	570	19	830	28
<2-yr	7000	0	0	750	11	1260	18	2540	36
<2-yr	15000	0	0	1600	11	2280	15	5280	35
<2-yr	20000	0	0	2120	11	2850	14	6930	35
<2-yr	30000	790	3	3170	11	3990	13	9840	33
5-yr	60600	4050	7	7190	12	7920	13	18540	31
Pertinent Bypass Channel Parameters				10% Diversion		15% Diversion		30% Diversion	
Alignment				2		1		2	
Bypass Channel Length (ft)				13550		15650		13550	
Bypass Channel Longitudinal Slope				0.00059		0.00045		0.00059	
Low Flow Channel Depth (ft)				2		N/A		2	
Low Flow Channel Bottom Width (ft)				10		N/A		10	
Low Flow Channel Side Slopes				1V:3H		N/A		1V:3H	
Main Bypass Channel Bottom Width				50		61		300	
Main Bypass Channel Side Slopes				1V:5H		1V:4H		1V:5H	
Approximate Excavation Quantity (cubic yards)				650,000		950,000		2,460,000	



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

