



University of  
Massachusetts  
Amherst

## North Battle Creek Feeder Fish Screen and Fishway Model

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# RECLAMATION

*Managing Water in the West*

## North Battle Creek Feeder Fish Screen & Fishway Case Study and Physical Modeling

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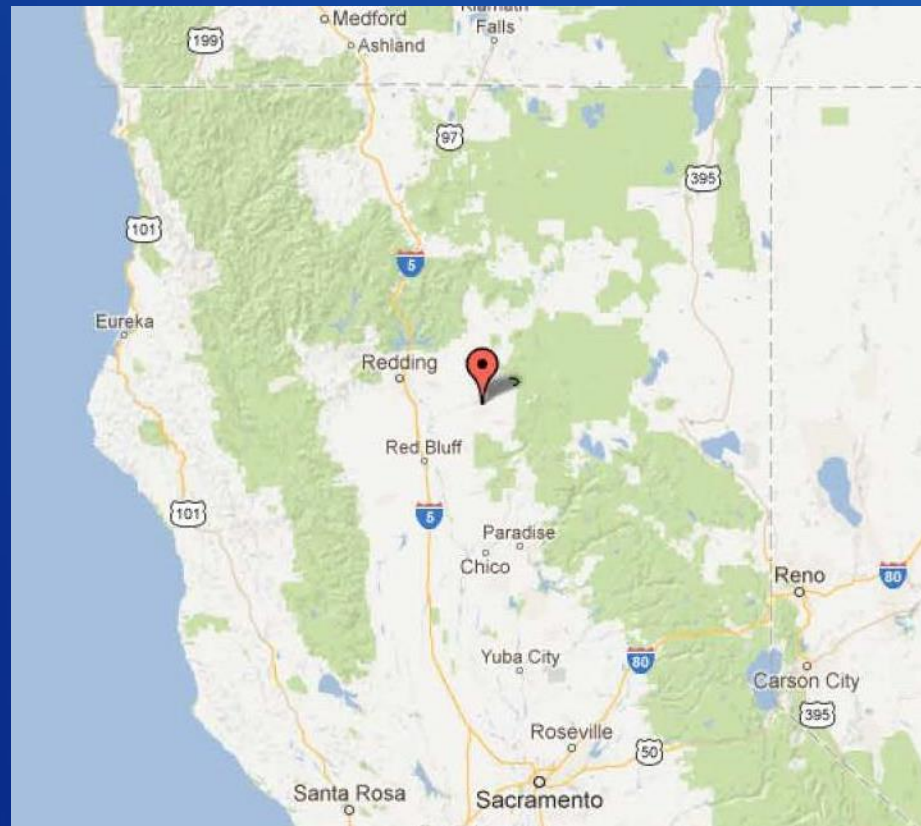
9 June 2014



U.S. Department of the Interior  
Bureau of Reclamation

# North Battle Creek Feeder Diversion

- Near Manton, CA on the North Fork of Battle Creek
- Owned and operated by Pacific Gas And Electric Co.
- 55 cfs diversion for power generation



MATION

# North Battle Creek Feeder

- Original construction ~ 1910
- Re-built in 2011 as part of the Battle Creek Salmon and Steelhead Restoration project
  - 83' Fish screen (55 ft<sup>3</sup>/s diversion)
  - Fishway (8 pools)
  - Overflow portion of dam is original construction (el= 2082.4)





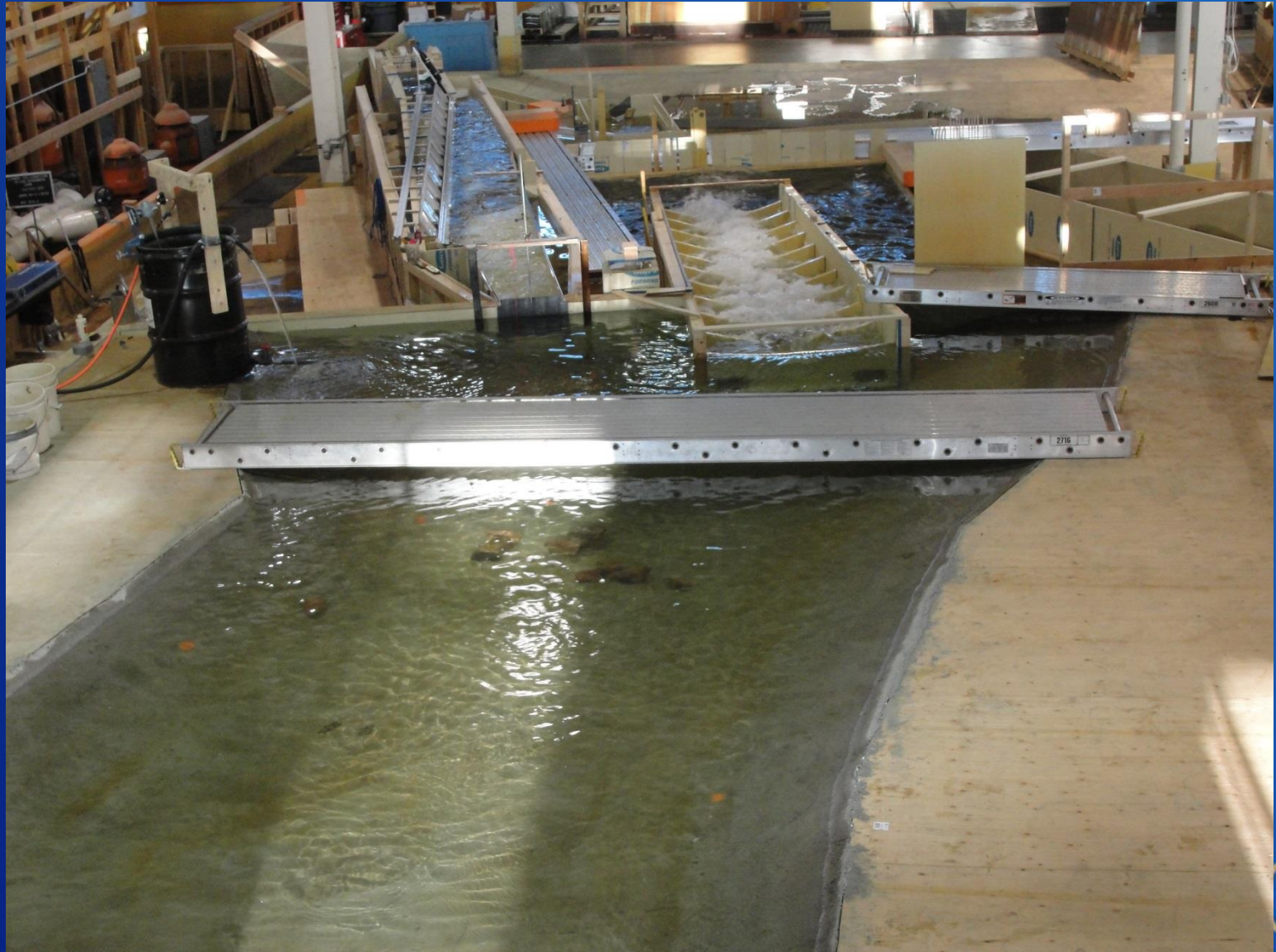
## TESTS OF THE AS-BUILT SCREEN AND DIVERSION CHANNEL SHOWED:

- A diversion flow of  $>\sim 40$  cfs overtopped the screens.
- High approach velocities in screen bays 1-7 and low or reverse flow in bays 20-27.
- Significant large scale turbulence in the diversion channel resulting in highly unsteady approach and sweeping velocities along the upstream 1/3 of the screen.
- The flow capacity of the fishway with exit weir set at elevation 2079 restricted diversion flows to less than 55 cfs unless additional weir boards were added to the fishway.

## **TESTS OF THE AS-BUILT FISHWAY SHOWED:**

- **Tailwater to fishway entrance pool water surface differences exceed 1 ft for all conditions**
- **Exit pool to diversion pool water surface difference can exceed 1 ft.**

**Physical Model was built in Reclamation's Hydraulics laboratory in Denver, CO to evaluate post construction solutions.**

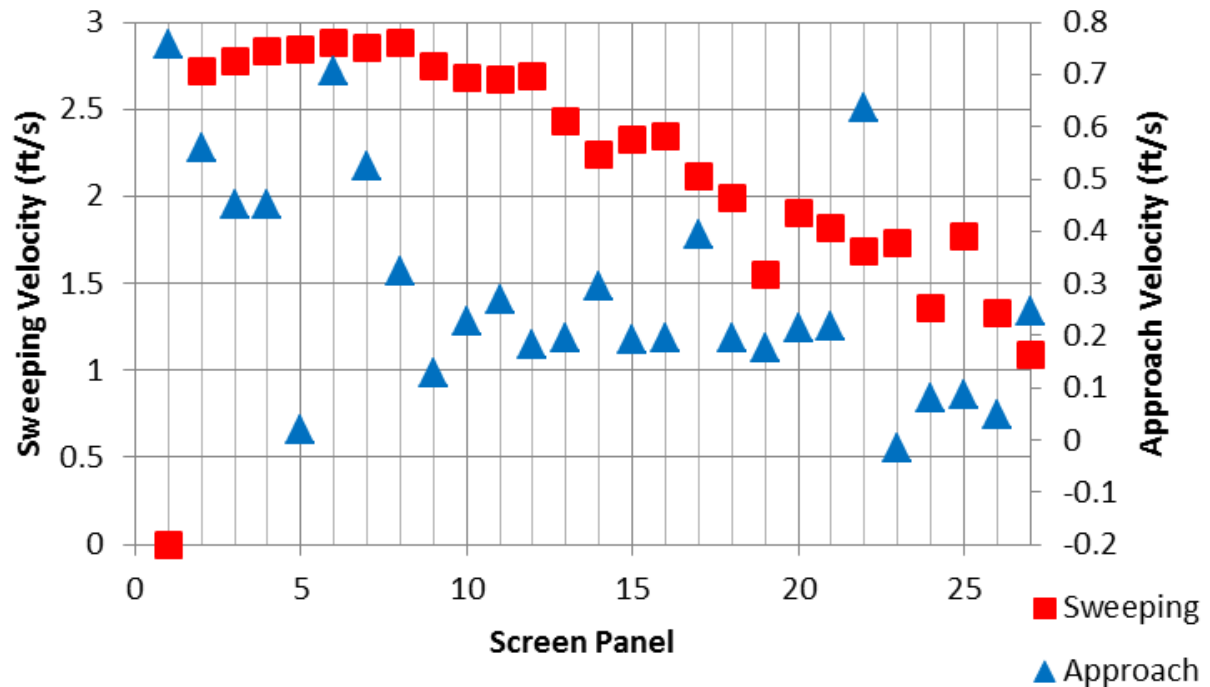
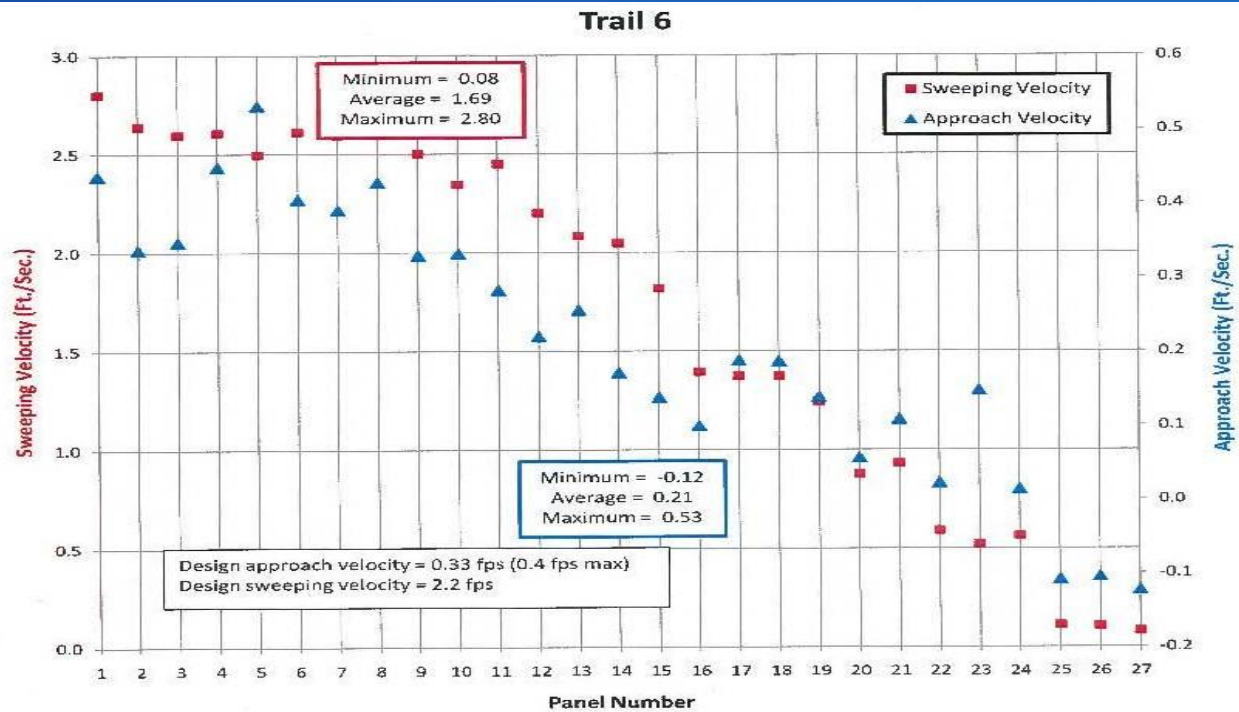


# Worst Case Scenario

- Total river flow= 110 cfs
- Diversion= 55 cfs
- Screen Bypass ~ 5 cfs
- Fishway= ~ 50 cfs

# Screen Evaluation Trial 6 vs Model

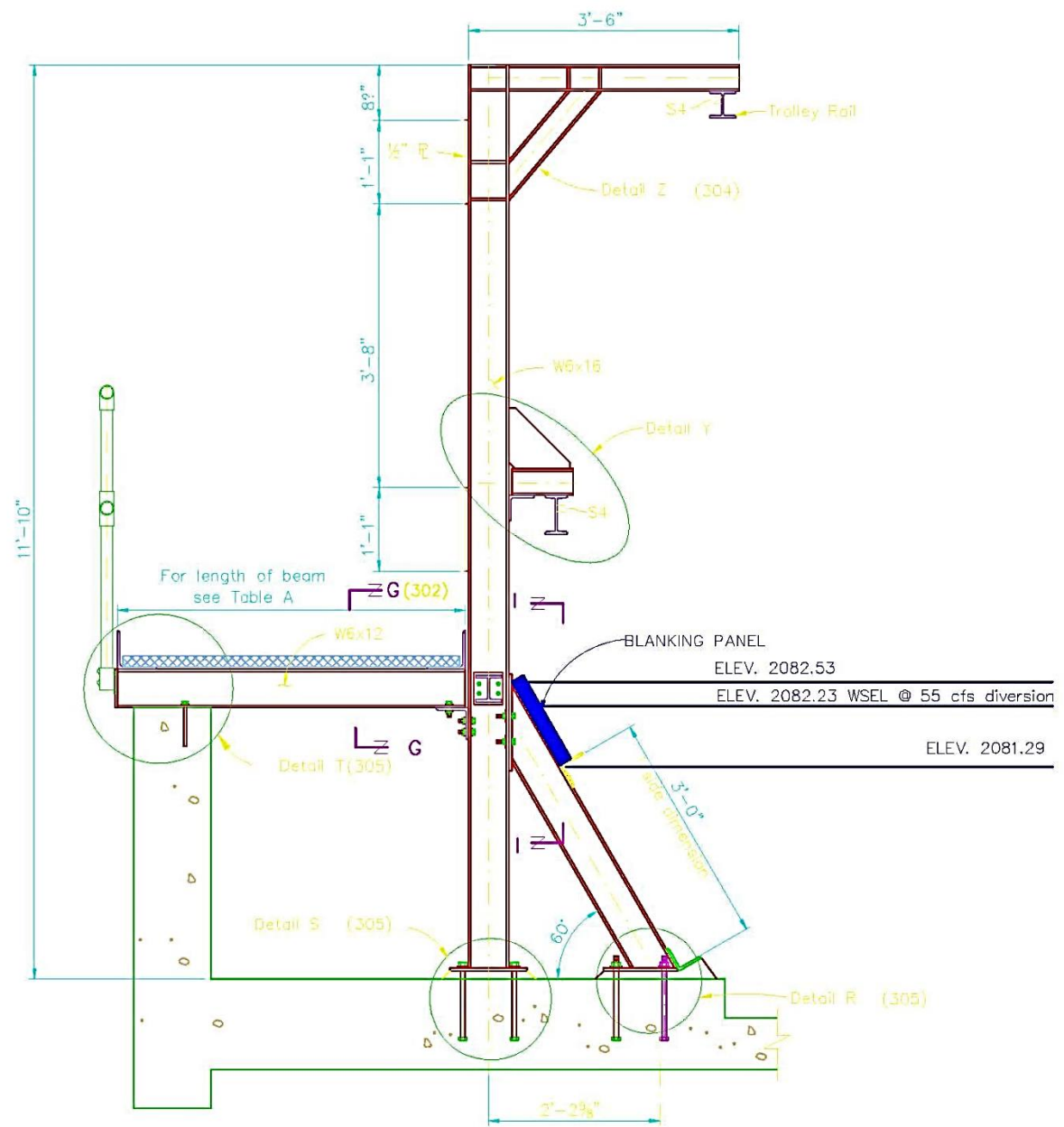
	Trial 6 2011	Model 2
Total Q	64	64
Diversion	44.2	40.7
Bypass	13.2	19.1
Fishway	6.6	4.17
Forebay		2082.02
Tailwater		2069.33
Div. WSEL	2.35	2.09
Headgate	full open	full open
Bypass weir boards		1
Fishway Right Orifice	closed	closed
Fishway Left Orifice	closed	closed
Stop logs		0
Baffle 8 stop logs		5
Baffle 7 stop logs		1



# Screen Modifications

- Added screen blanking panels
- Added 3 guidance veins behind the screen
- Added straightened wall opposite the screen
- Added guide walls to create a gradual expansion downstream of diversion gate
- Added bullnose around diversion entrance

# Blanking Panels



SECTION F-F (297)

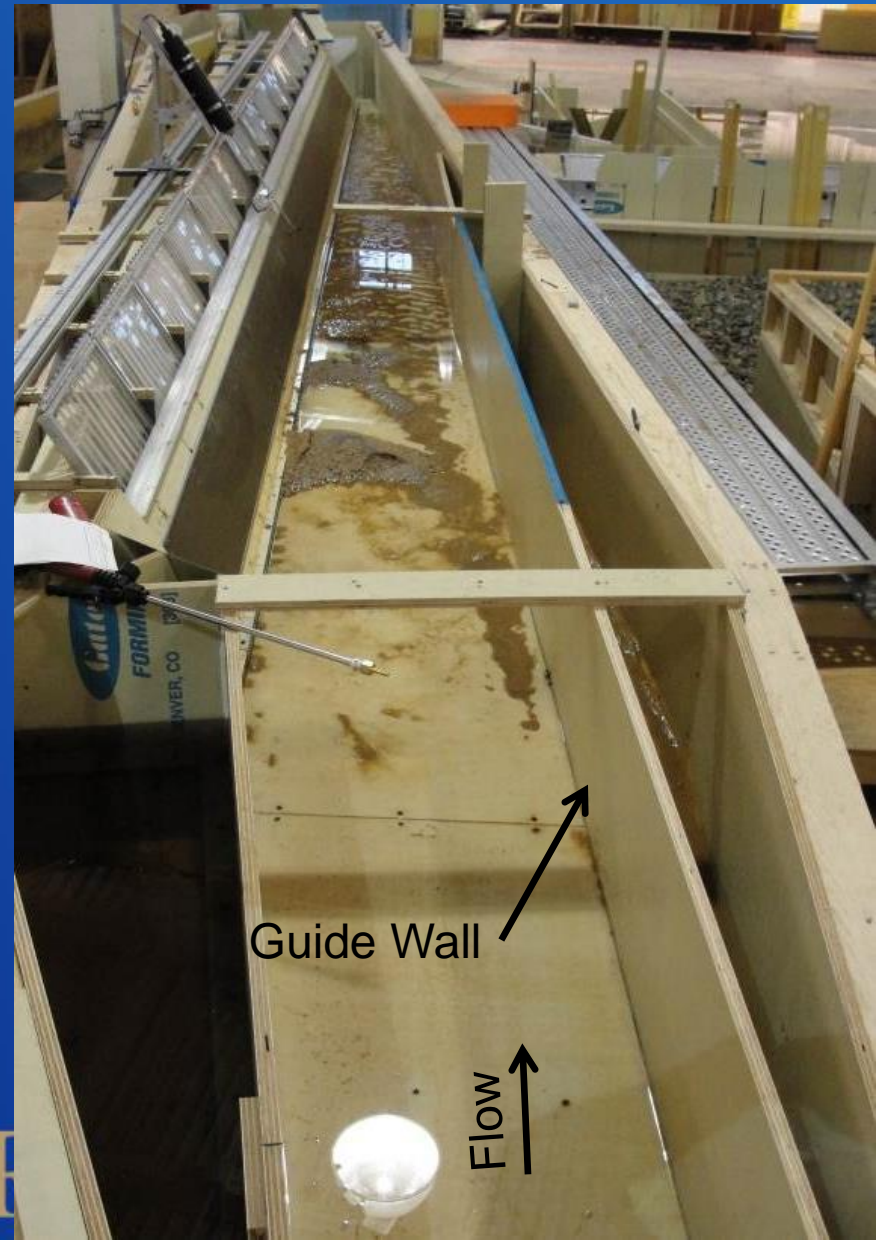
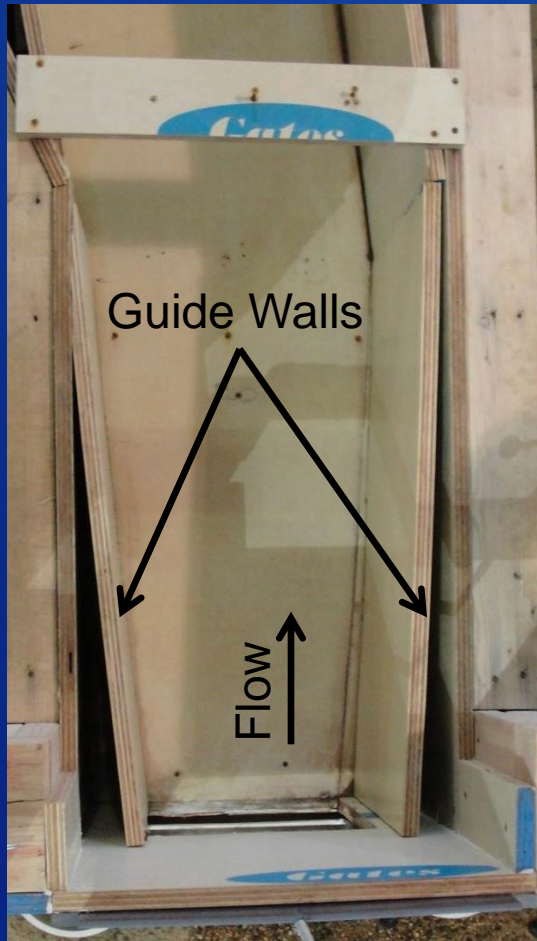
SUPPORTS NO. 6 THRU 20





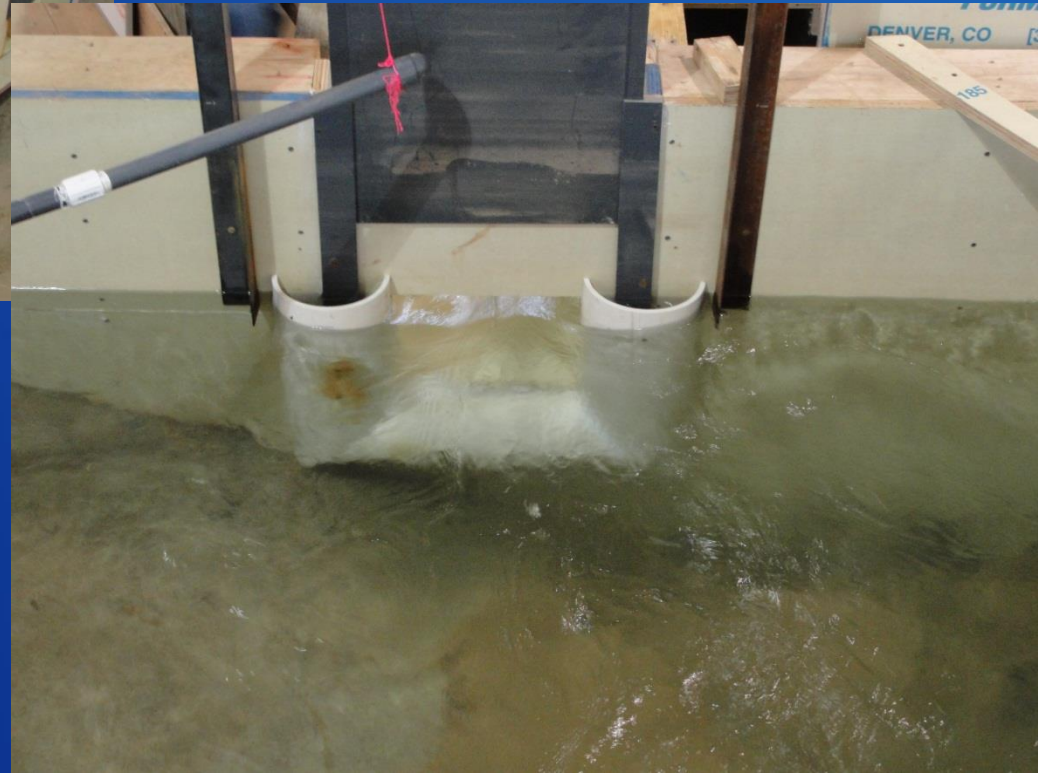
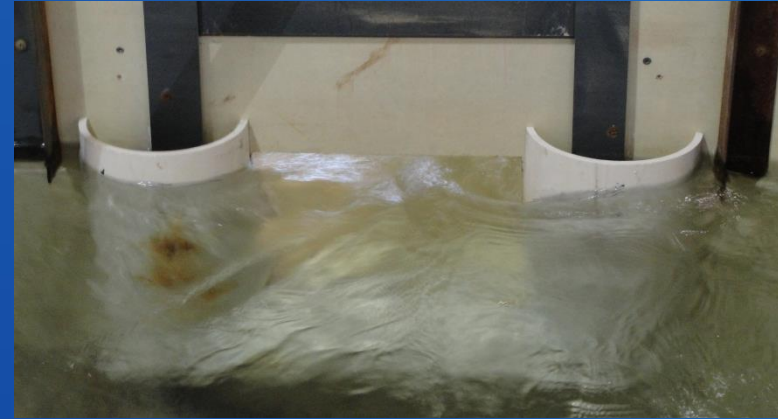
# Guide Walls

- Guide wall opposite the screen
- Gradual expansion



# Diversion Gate Bullnose

- 2' Diameter half pipe



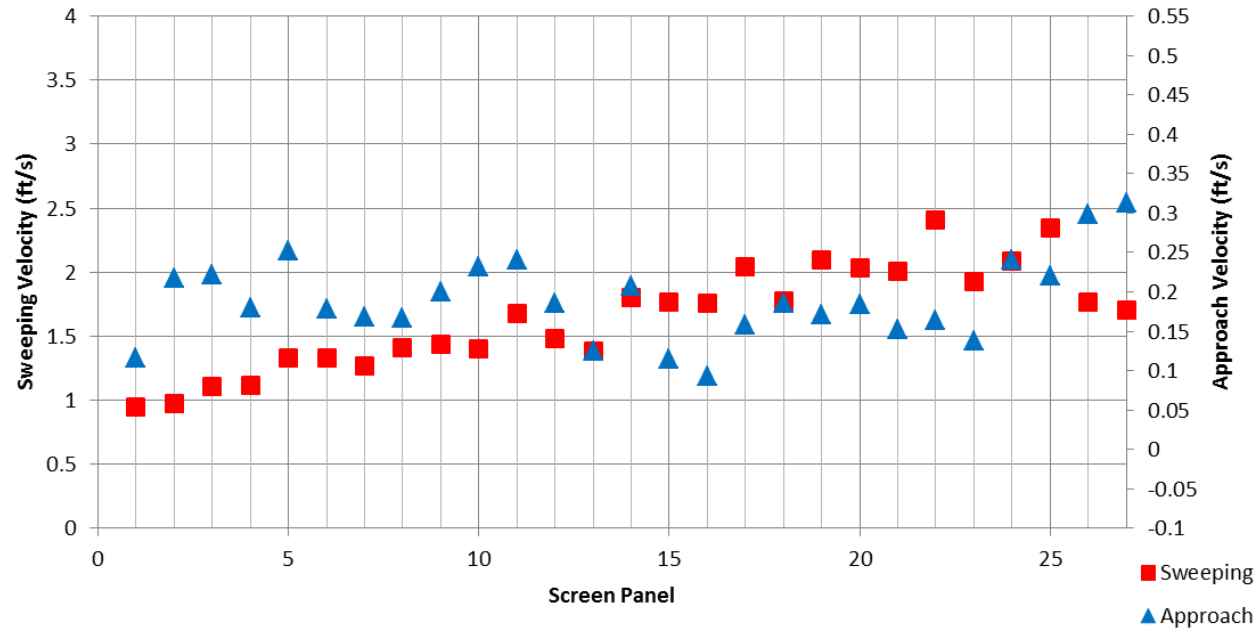
# Screen Performance

- Bull nose

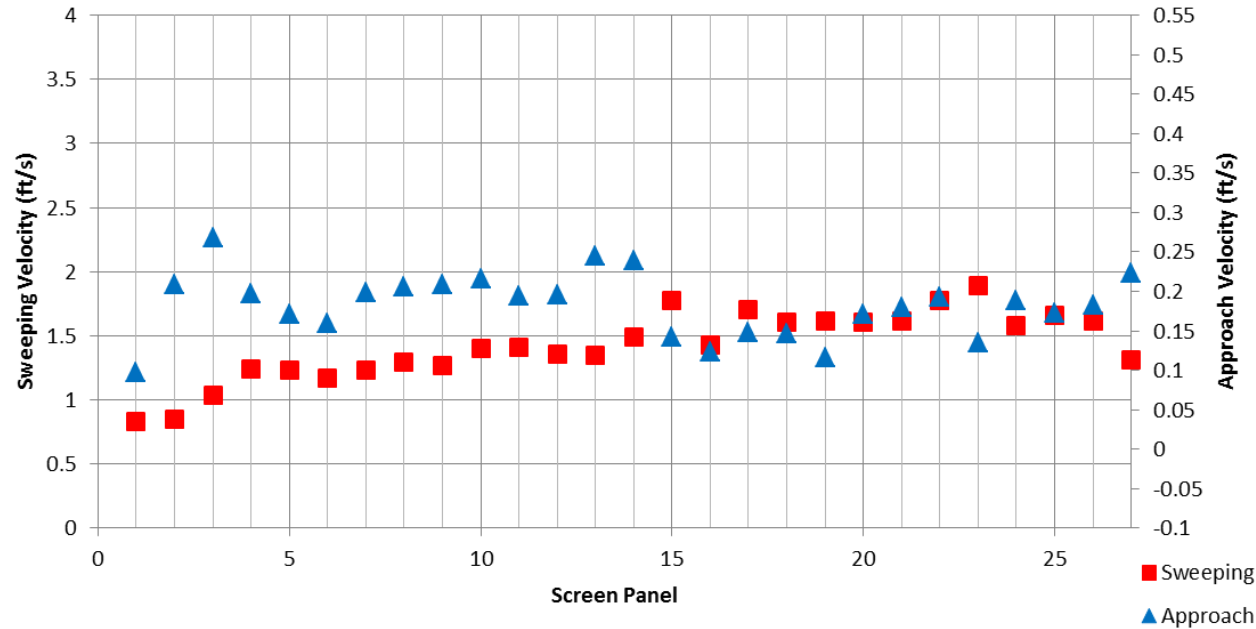


	Run 16	Run 31
Total Q	110.1	110
Diversion	55.2	55.7
Bypass	7.9	5.6
Fishway	47	48.7
Forebay	2082.76	2082.37
Tailwater	2070.64	2071.27
Div. depth	2.27	2.23
Headgate	full open	full open
Bypass weir boards	5	5.5
Fishway right orifice	closed	open small
Fishway left orifice	closed	closed
Stop logs	0	0
Baffle 11 stop logs	2.5	2.25
Baffle 10 stop logs	2	2
Baffle 9 stop logs	1	1
Diversion treatment		bull nose

## Run 16



## Run 31



# Fishway Tests



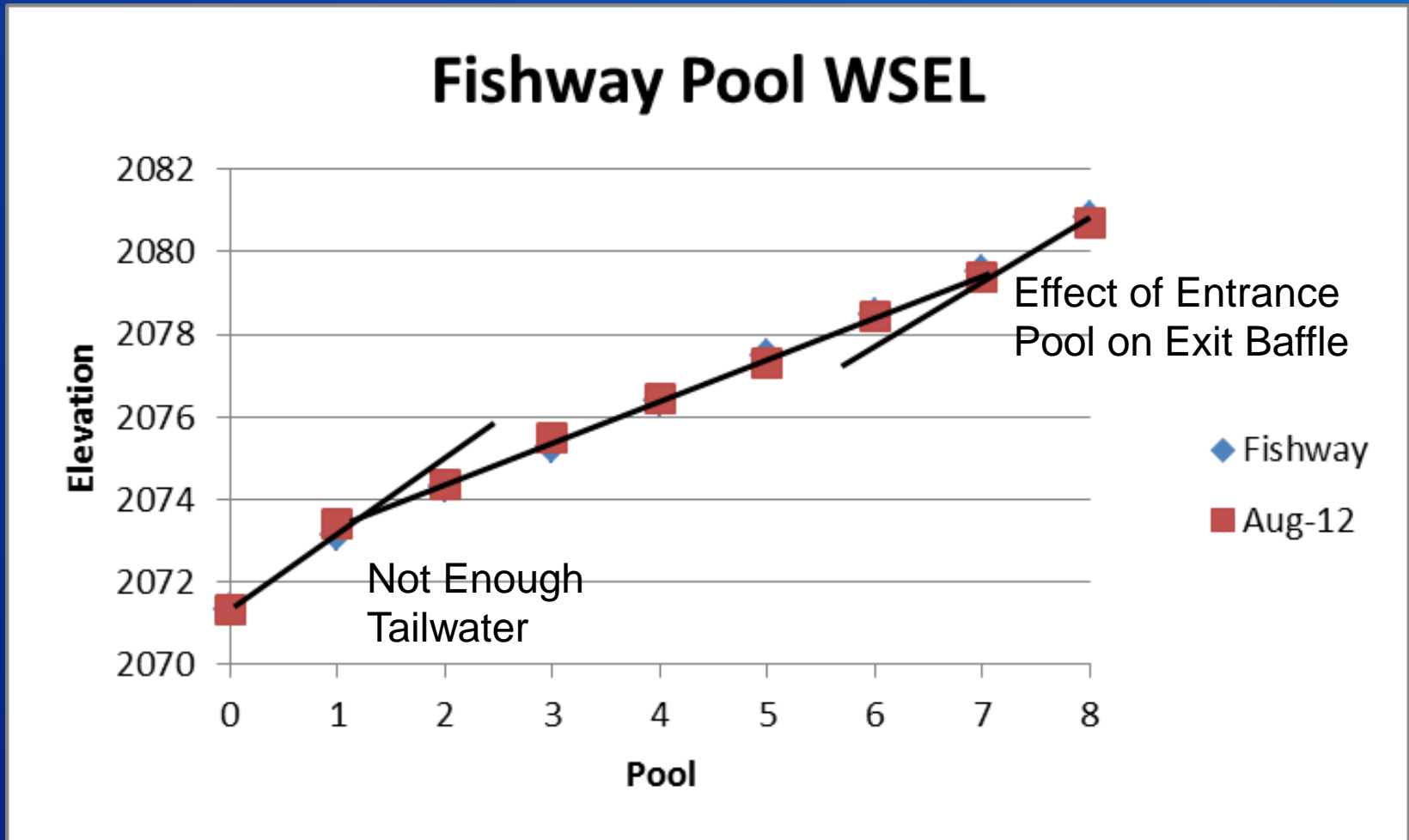
RECLAMATION

# Fishway Modifications

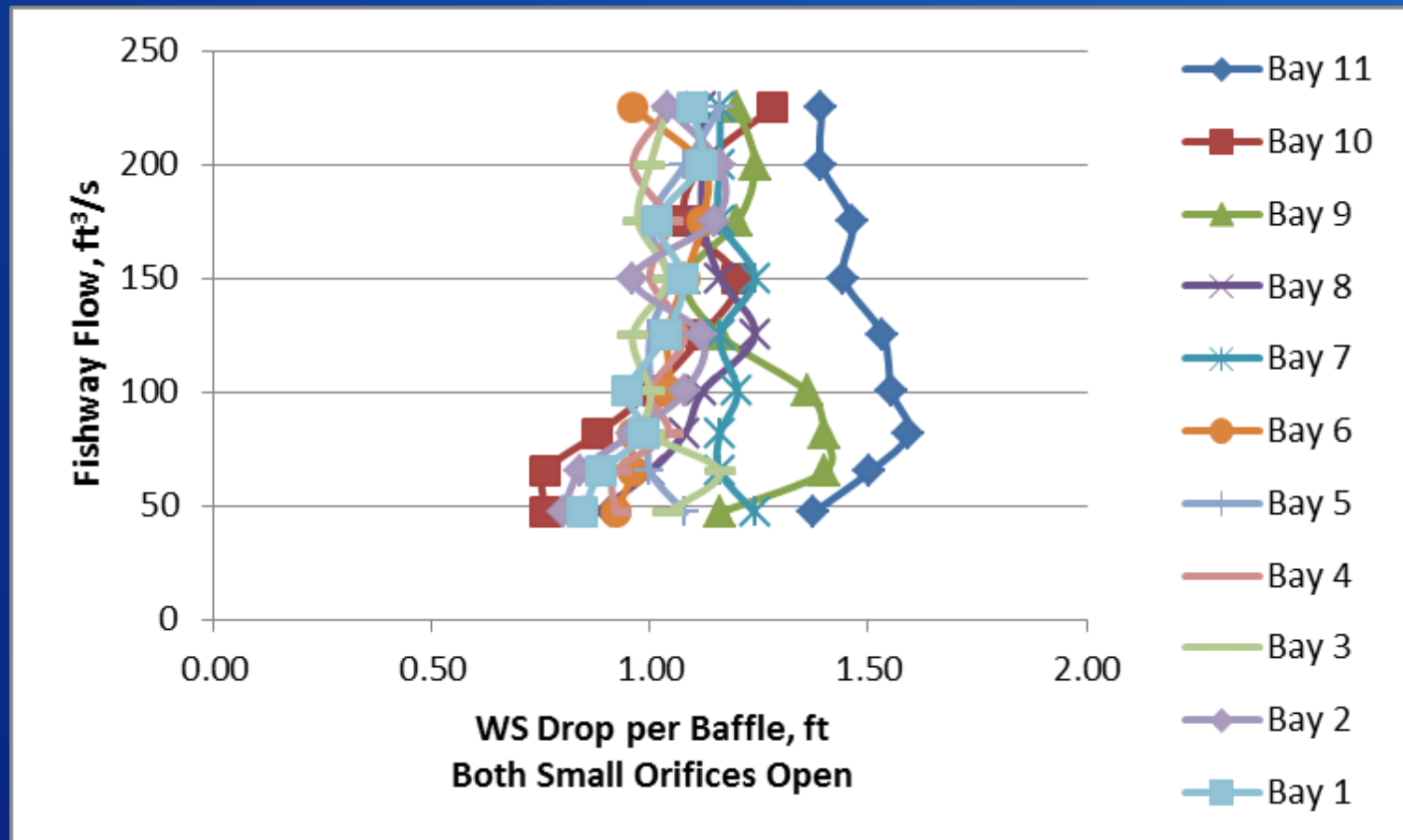
- 2 additional bays downstream
- 1 additional bay upstream
- 15x12 inch orifices



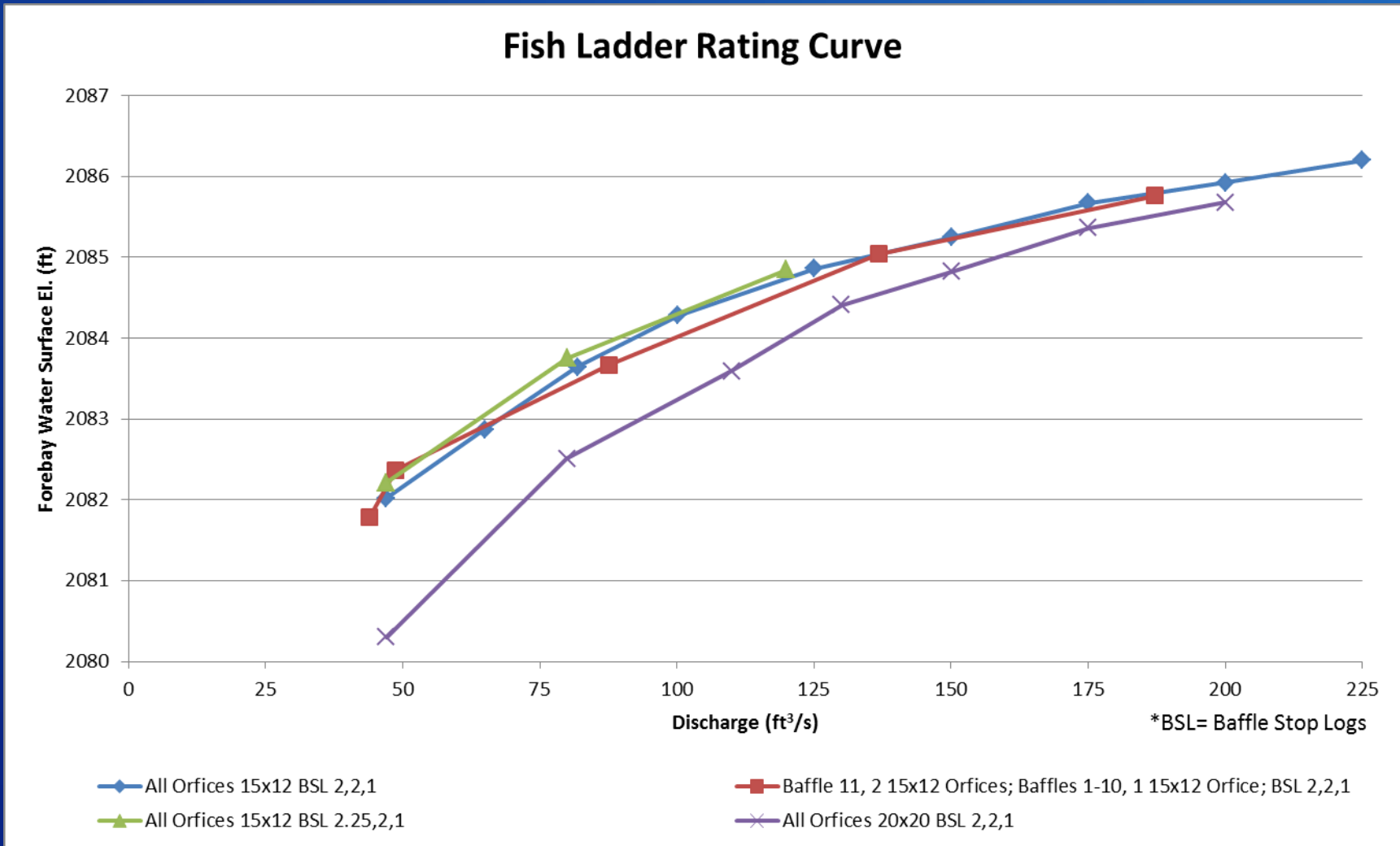
# As-Built Entrance and Exit WS Drop



# Fishway Pool to Pool WS Change with Tailwater adjusted to a 1ft drop for Flows > 100 cfs. Note exit baffle 11 requires more head than downstream baffles.



# Fish Ladder Rating Curve

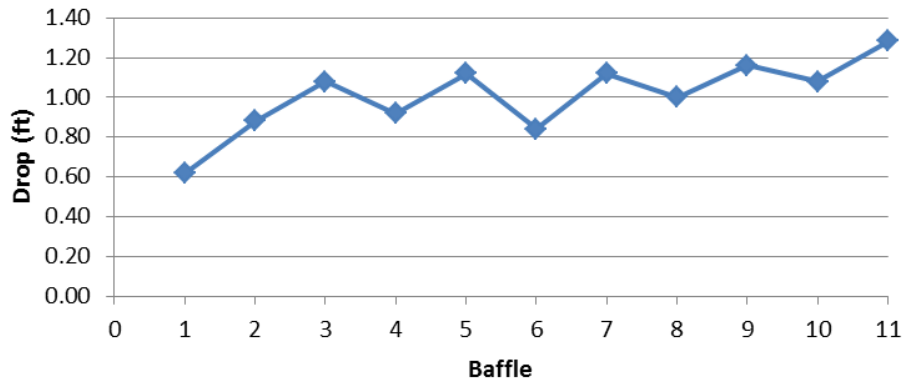


# WS Drop Per Baffle

- Baffle Stop Logs 2.25, 2, 1
- Baffle 11 2 small orifices open
- Baffles 1-10 1 small orifice open

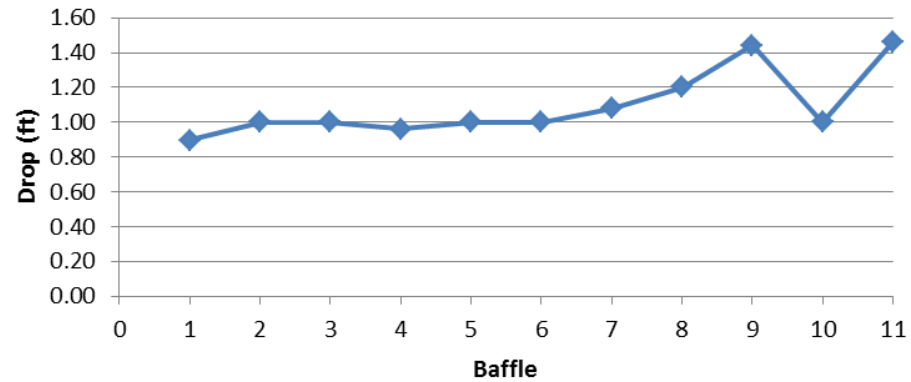
## WS Drop Per Baffle

Baffle Stop Logs 2.25, 2, 1, Ent=2sO, Q= 49 cfs



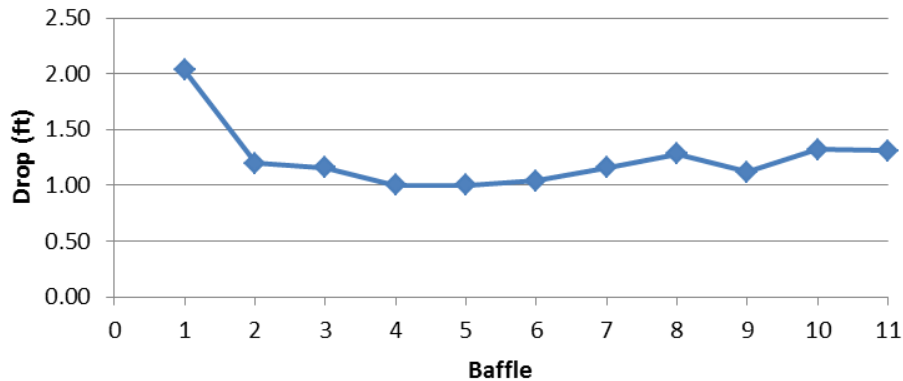
## WS Drop Per Baffle

Baffle Stop Logs 2.25, 2, 1, Ent=2sO, Q= 88 cfs



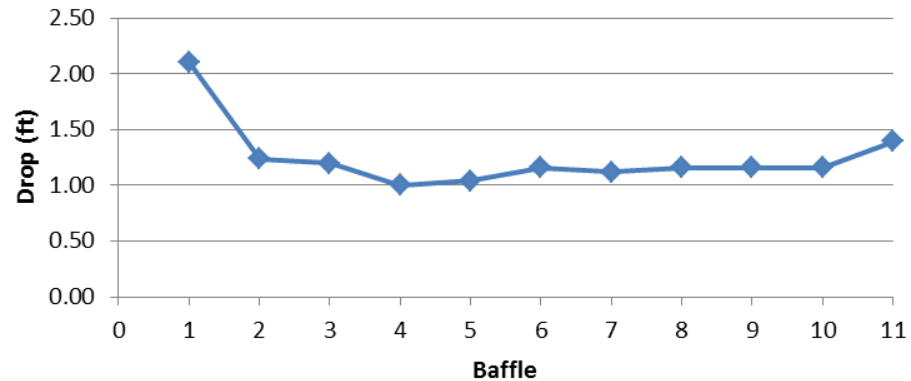
## WS Drop Per Baffle

Baffle Stop Logs 2.25, 2, 1, Ent=2sO, Q= 137 cfs



## WS Drop Per Baffle

Baffle Stop Logs 2.25, 2, 1, Ent=2sO, Q= 187 cfs



# Fish Screen Findings

Diverting 55 cfs requires a pool elevation  $> \sim 2082.4$  and a diversion channel WSE of  $\sim 2082.25$  (top of screens=2081.46)

Uniformity of screen approach velocity can be significantly improved by using guide vanes behind the screen, louvers, a right-bank guide wall, entrance bullnose, and a gradual expansion DS of gate.

# Fishway Findings

- Adding two bays on the entrance and one on the exit helps but does not fully meet the desired 1 ft drop per baffle target
- Operating the fishway with 2 small orifices open in baffle 11 and one small orifice open in baffles 1-10 allows diversion flows to be achieved at 110 cfs with forebay WSE of 2082.4.
- As-built orifices pass ~ 25-35 cfs per orifice for a 1 ft drop across the baffles
- A 12" by 15" orifice passes about 12-17cfs for a 1 ft drop across the baffles
- The exit baffle is less efficient than downstream baffles due to difference in approach flow. This results in a greater WS drop at the exit.
- No large scale flow instability has been seen for fishway flows <250 cfs (tested range).

# Wrap-up

- The initial design is very similar to a previous successful fish screen and fishway at another location
  - Site conditions
  - Poor approach conditions
- Proposed fixes are in final design and will be implemented next year
- Perform modeling before construction.
- [http://www.usbr.gov/pmts/hydraulics\\_lab/pubs/HL/HL-2013-04.pdf](http://www.usbr.gov/pmts/hydraulics_lab/pubs/HL/HL-2013-04.pdf)
- <http://www.usbr.gov/mp/battlecreek/about.html>