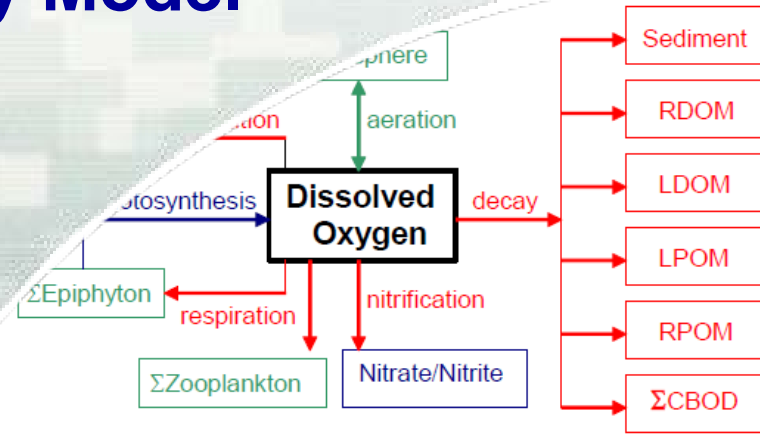


Water Quality Monitoring to Assess the Occurrence of Coldwater Fishery Habitat in Lake Sakakawea and Facilitate Application of the CE-QUAL-W2 Hydrodynamic and Water Quality Model

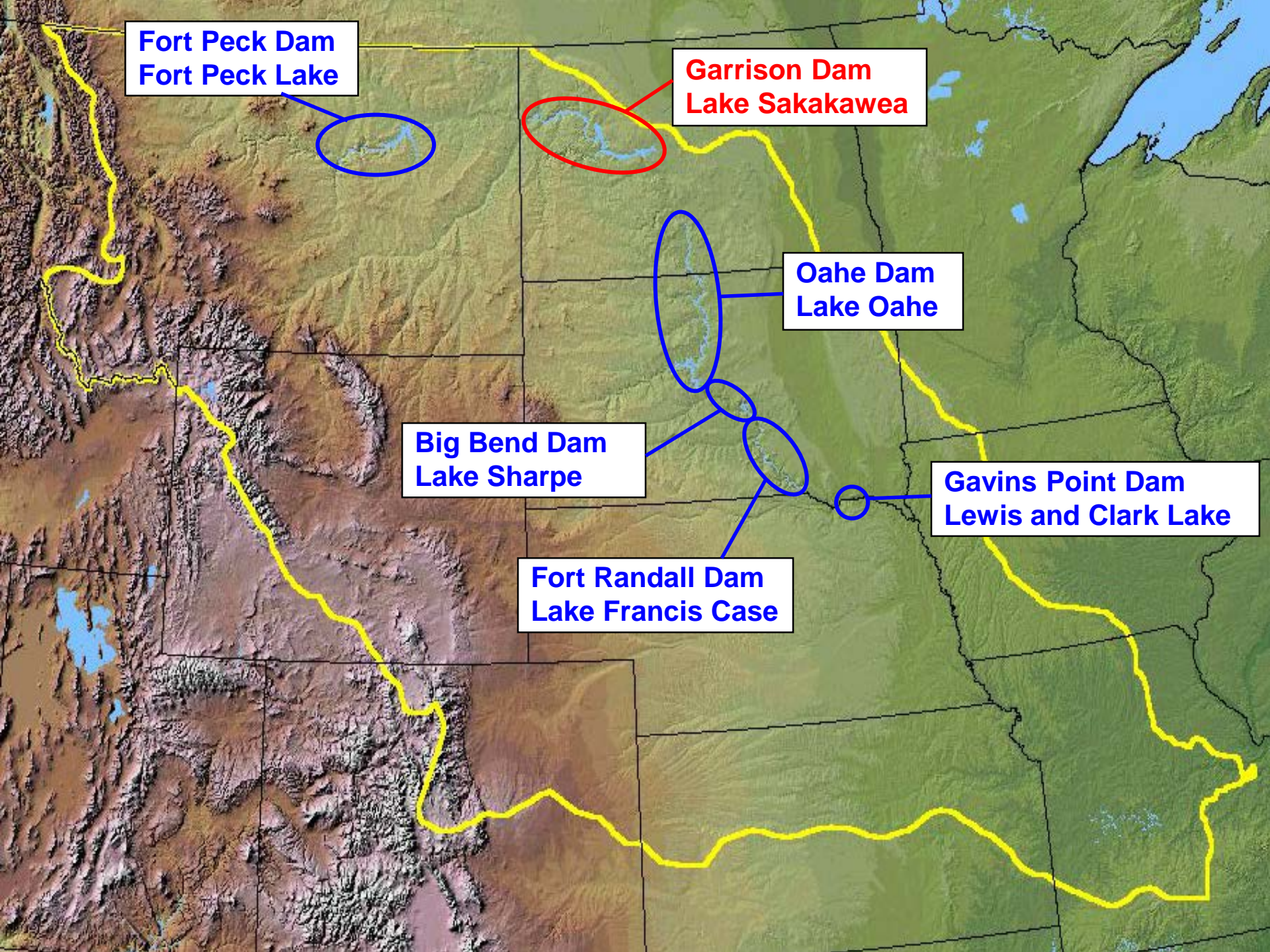
Dave Jensen
Biological Sciences – Water Quality Specialist
Omaha District
4 March 2016



U.S. ARMY



US Army Corps of Engineers
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**Fort Peck Dam
Fort Peck Lake**

**Garrison Dam
Lake Sakakawea**

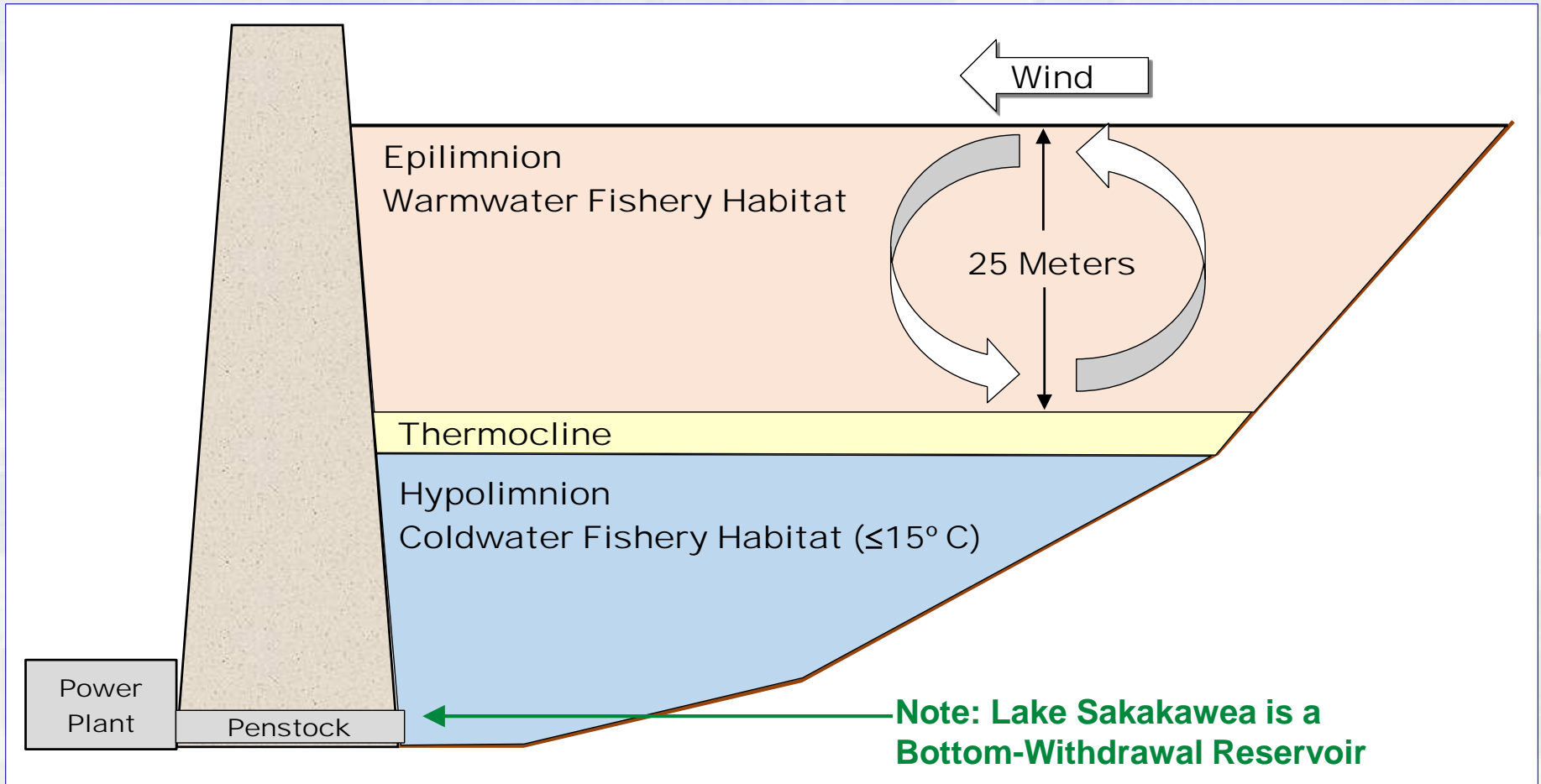
**Oahe Dam
Lake Oahe**

**Big Bend Dam
Lake Sharpe**

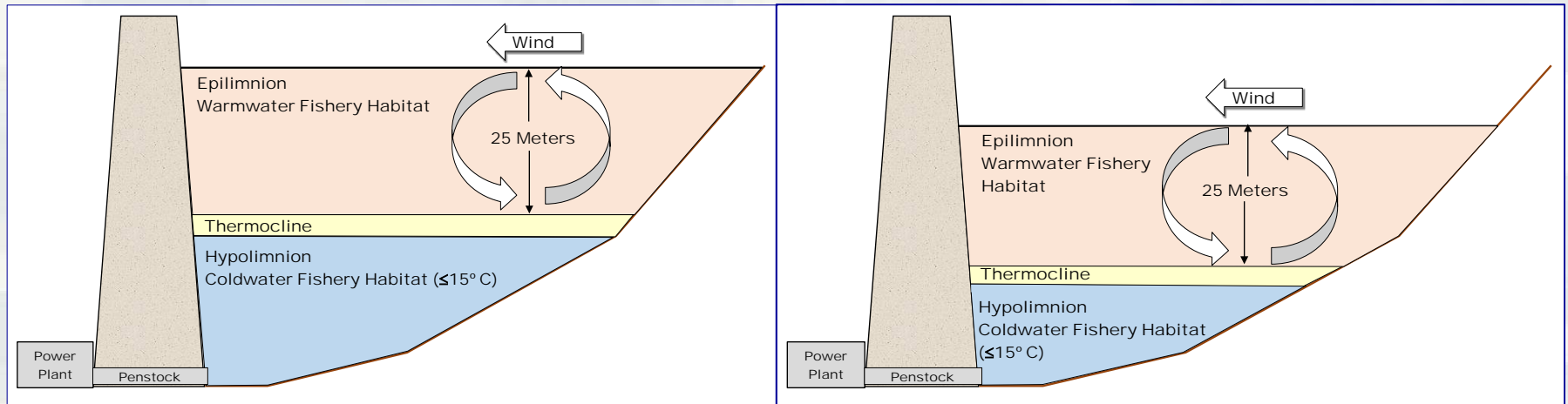
**Gavins Point Dam
Lewis and Clark Lake**

**Fort Randall Dam
Lake Francis Case**

Lake Sakakawea Supports Two-Story Fishery Due to Thermal Stratification of the Reservoir during the Summer



Concerns Expressed during the 2003-2008 Drought that Lowering the Pool Elevations in Lake Sakakawea Could Adversely Impact Coldwater Fishery Habitat



As pool levels drop the depth to the thermocline is maintained. This results in a decrease in the hypolimnetic volume and a reduction in coldwater fishery habitat.

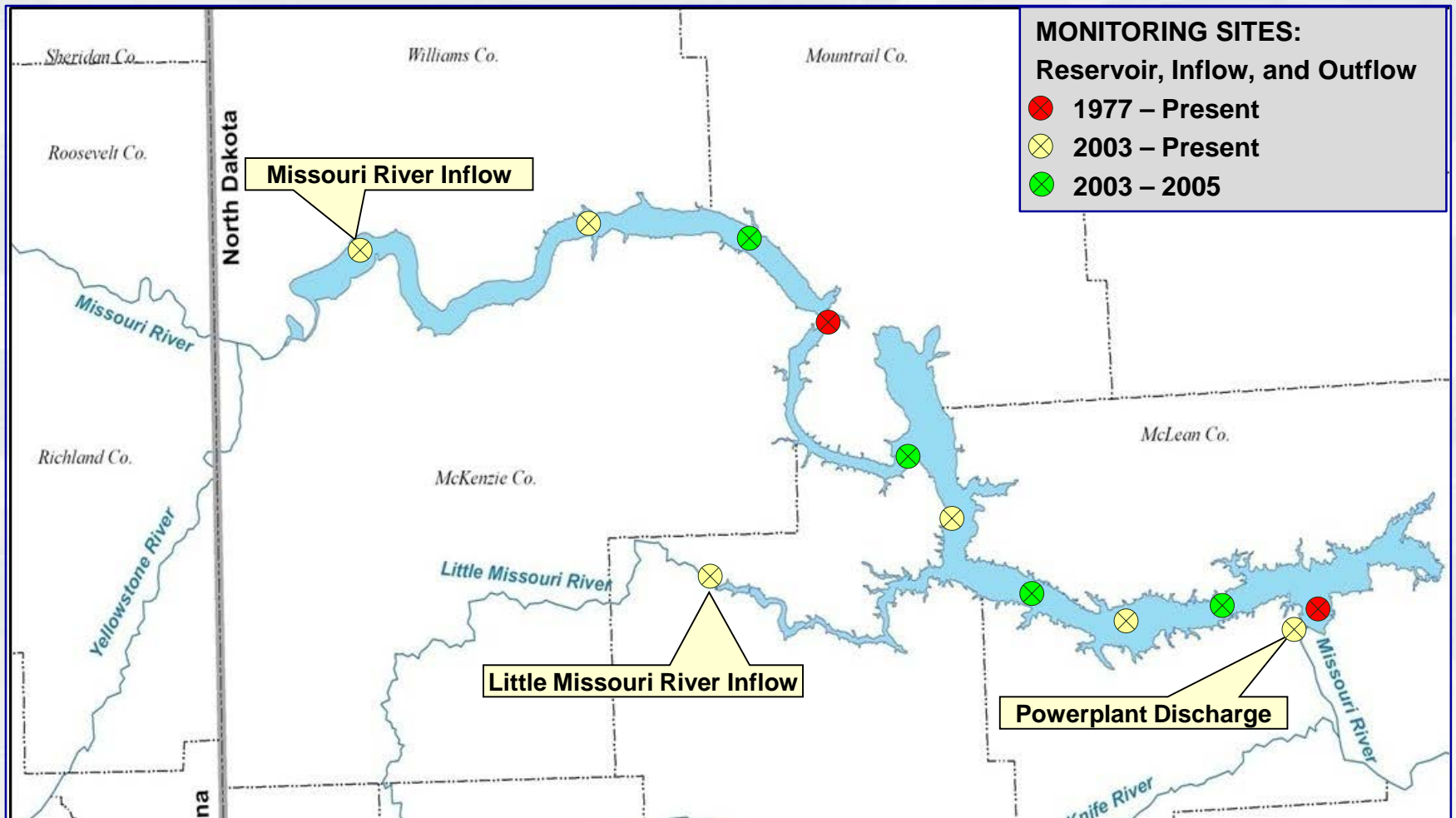


In 2010 North Dakota amended the State's Water Quality Standards to add a provision to protect the coldwater fishery use of Lake Sakakawea

Lake Sakakawea must maintain a minimum volume of water of 500,000 acre-feet that has a temperature of 15° C or less and a dissolved oxygen concentration of not less than 5 mg/L

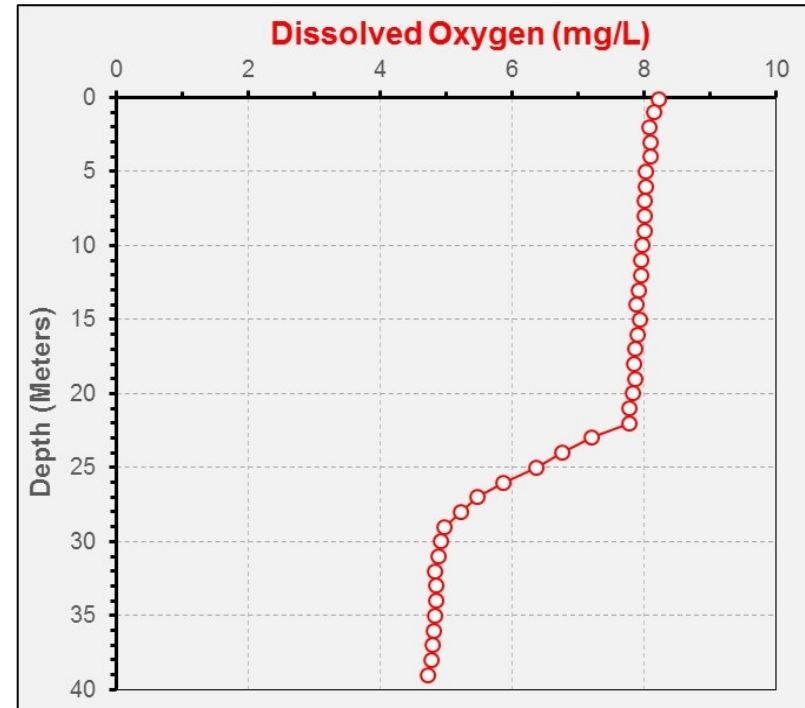
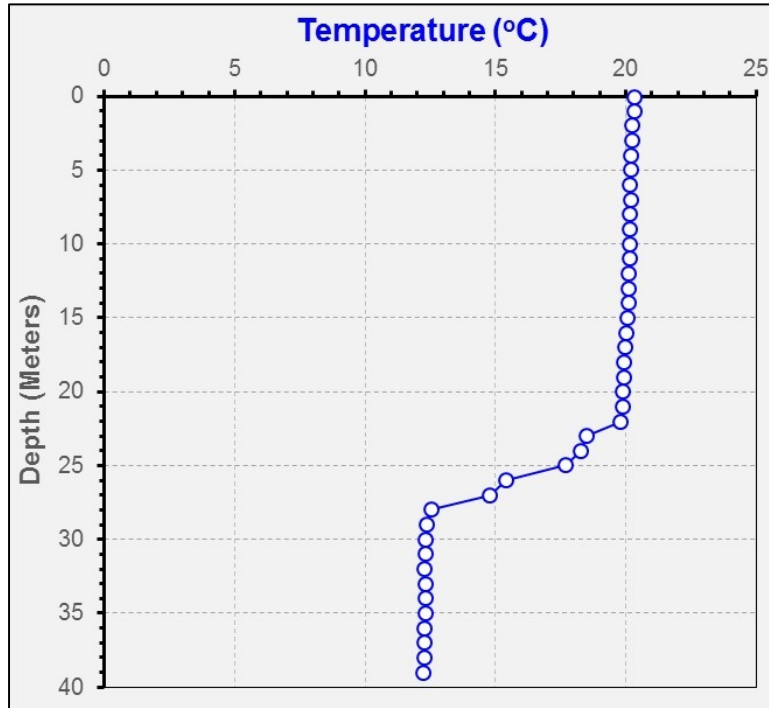


Corps Water Quality Monitoring at the Garrison Project Includes Reservoir, Inflow, and Outflow Sites



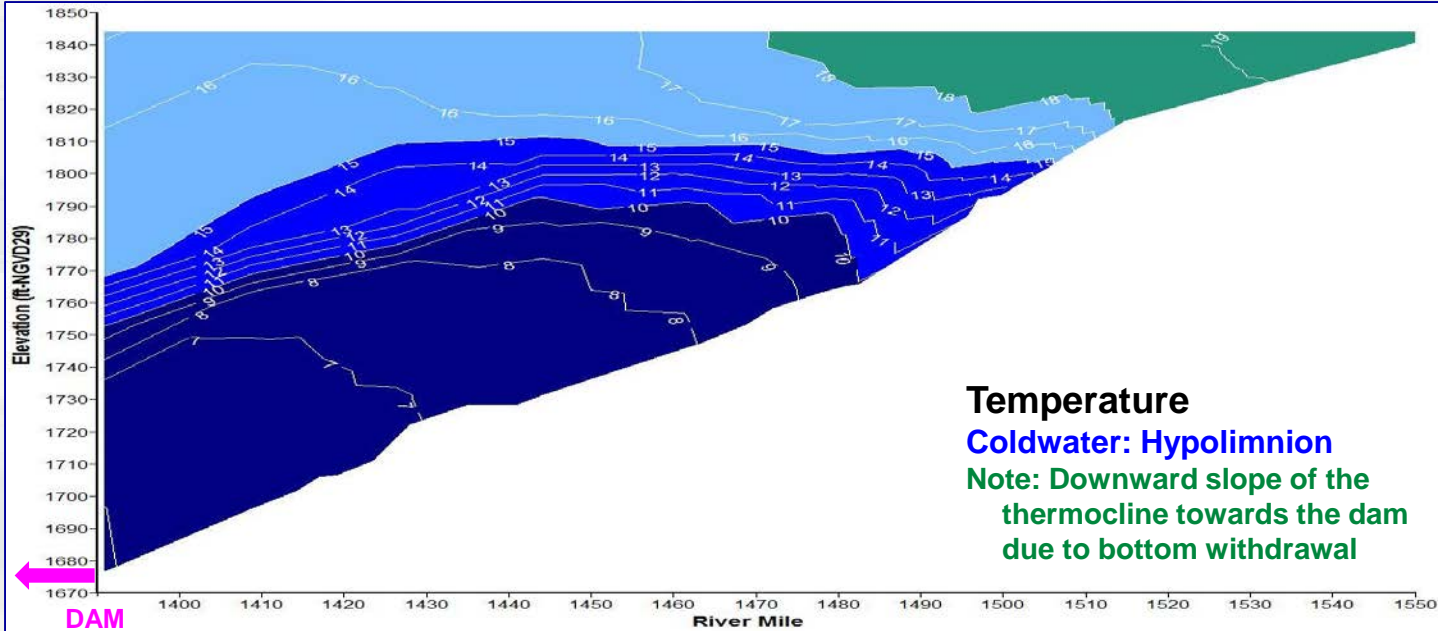
Water Quality Monitoring at Reservoir Sites

- Includes Depth-Profile Measurements in 1-Meter Increments

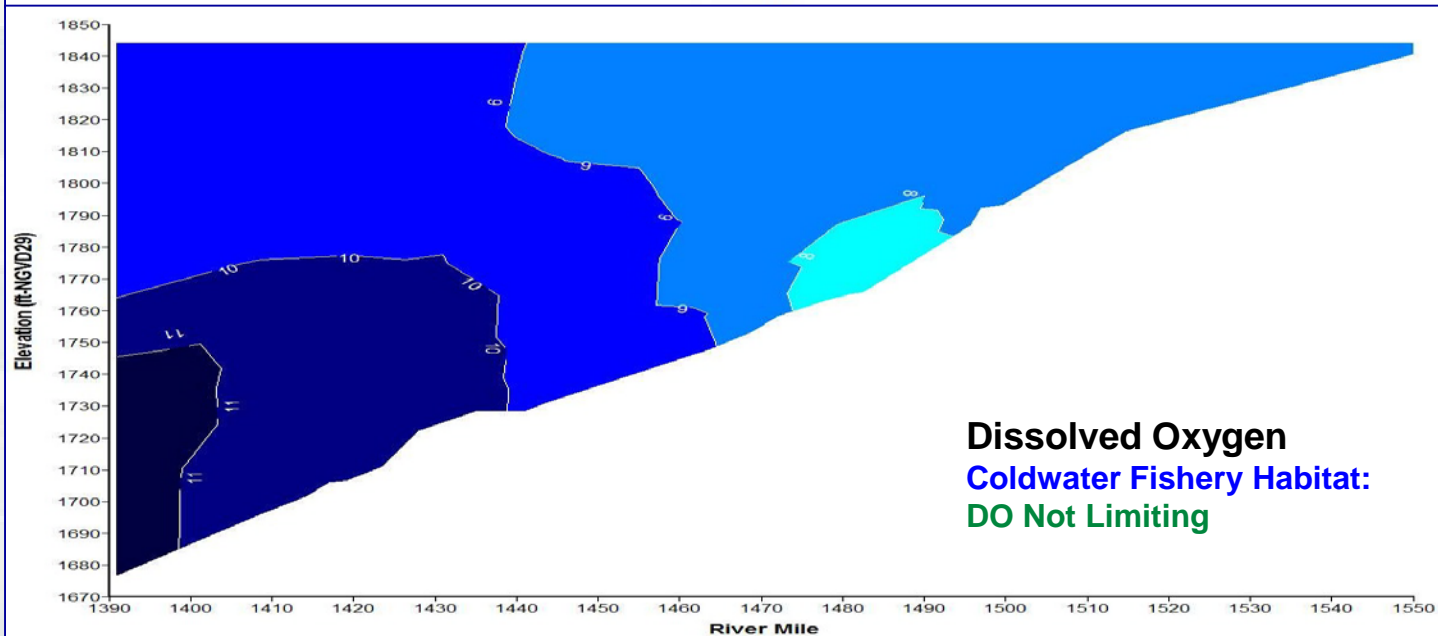


- The Depth-Profile Measurements are used to Construct Longitudinal Contour Plots to Display Temperature and Dissolved Oxygen Conditions in Lake Sakakawea

Lake Sakakawea – 2014 (23-June)

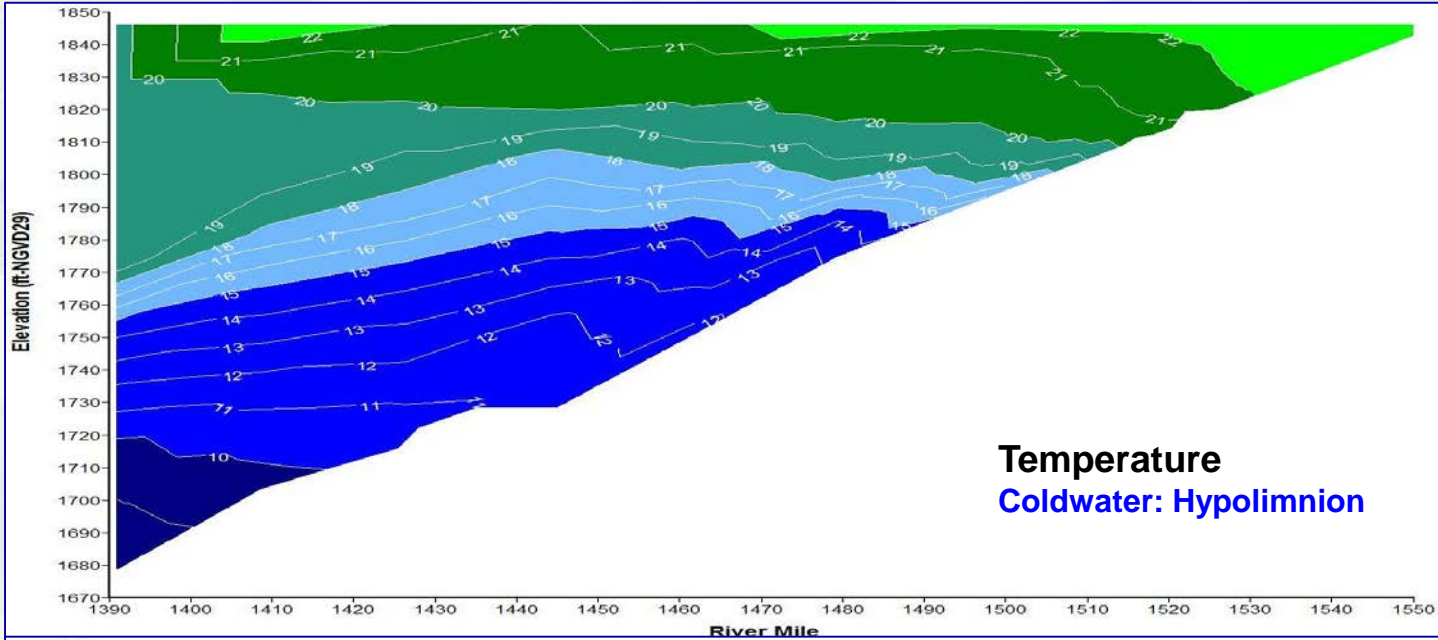


Legend (°C)	
	0 to 10
	10 to 15
	15 to 18
	18 to 20
	20 to 22
	22 to 24
	24 to 26
	26 to 28
	28 to 30
	≥ 30

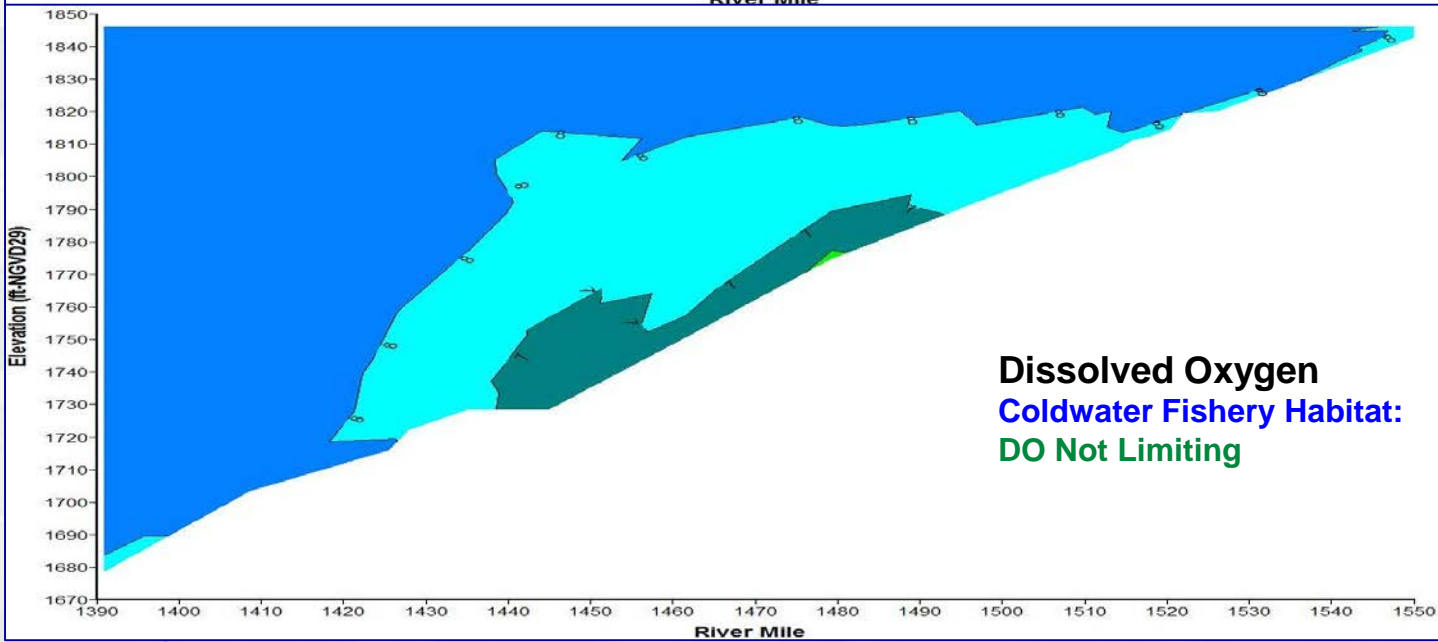


Legend (mg/L)	
	0 to 1
	1 to 2
	2 to 3
	3 to 4
	4 to 5
	5 to 6
	6 to 7
	7 to 8
	8 to 9
	9 to 10
	10 to 11
	> 11

Lake Sakakawea – 2014 (29-July)

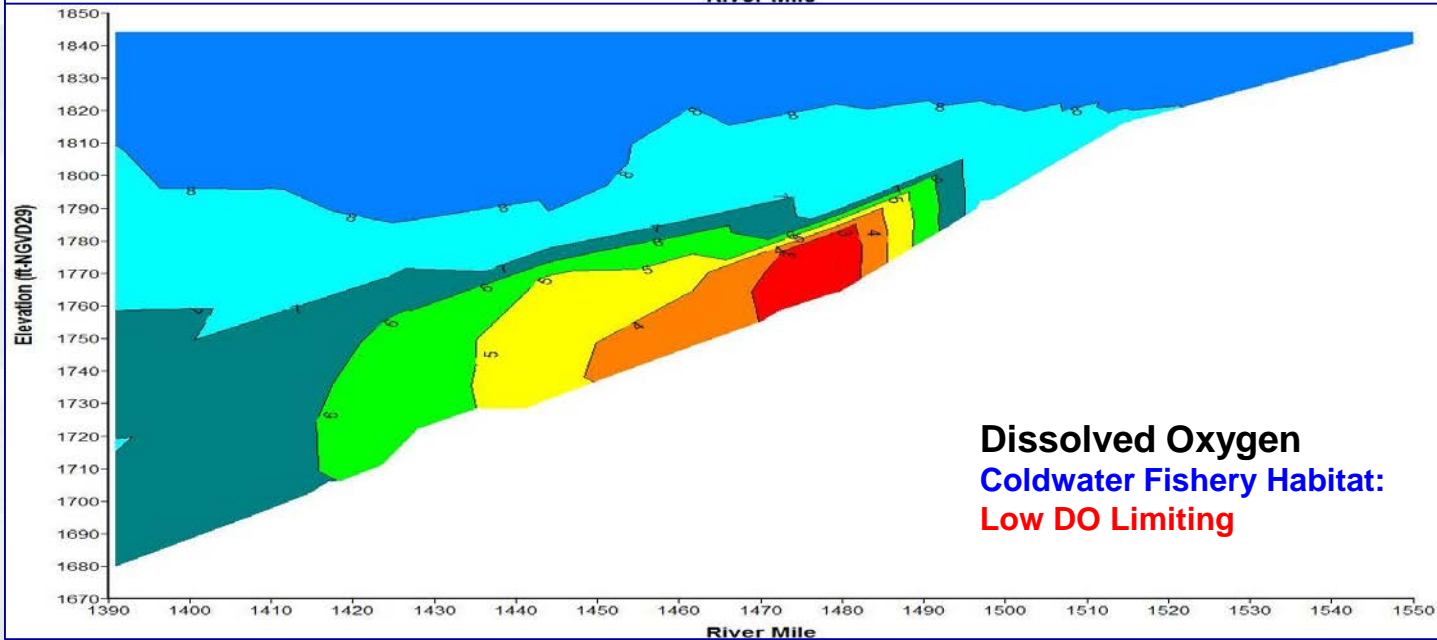
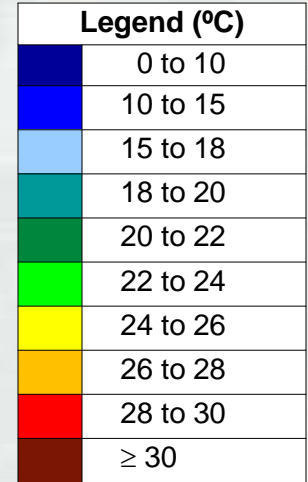
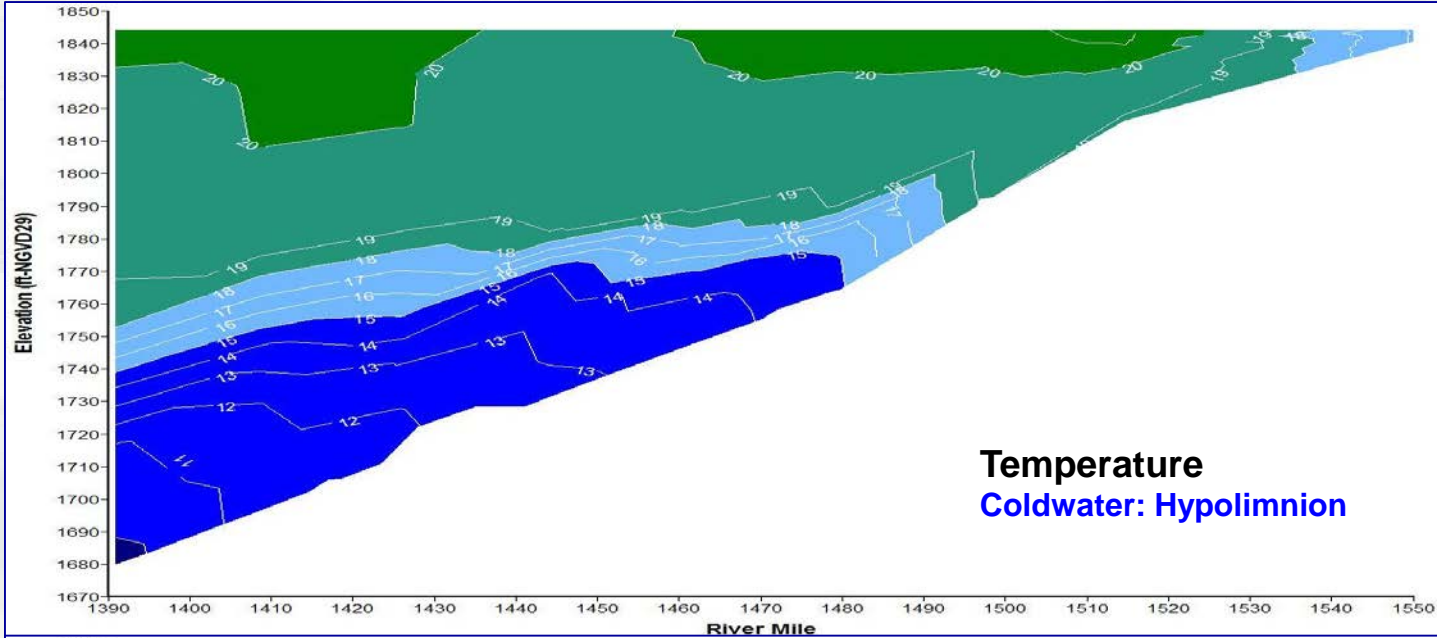


Legend (°C)	
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	10 to 15
	15 to 18
	18 to 20
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	24 to 26
	26 to 28
	28 to 30
	≥ 30

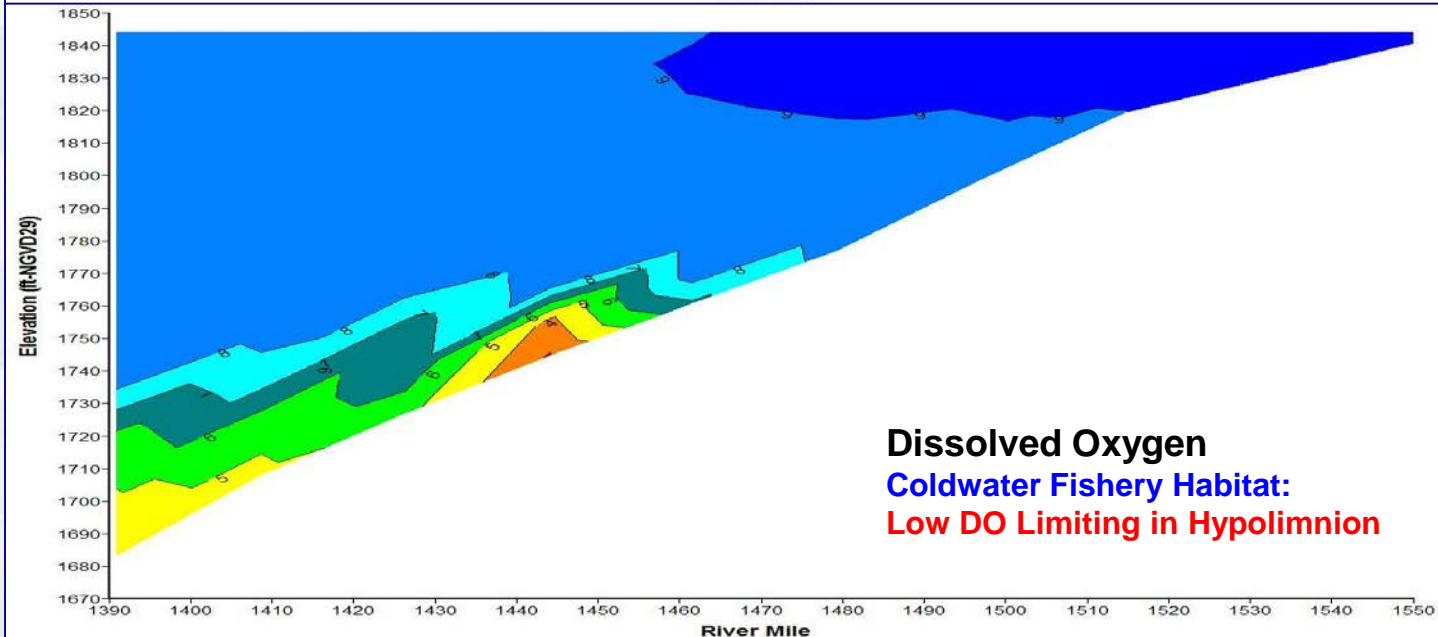
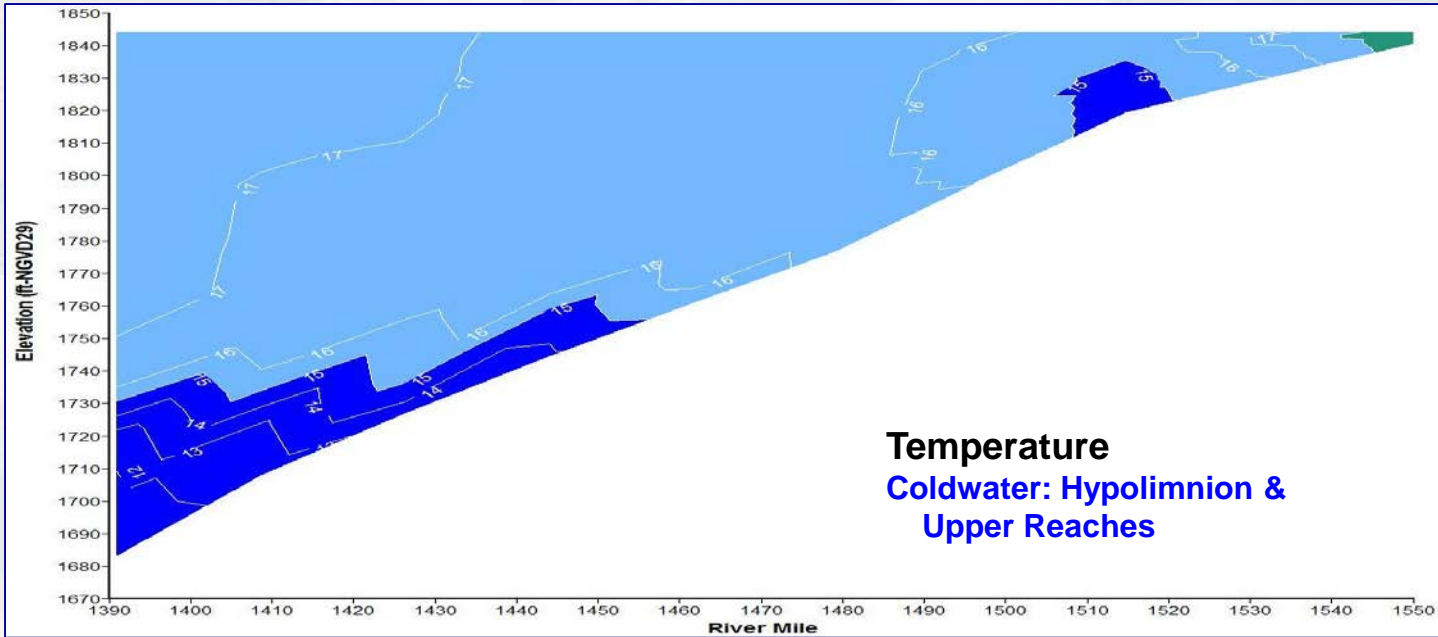


Legend (mg/L)	
	0 to 1
	1 to 2
	2 to 3
	3 to 4
	4 to 5
	5 to 6
	6 to 7
	7 to 8
	8 to 9
	9 to 10
	10 to 11
	> 11

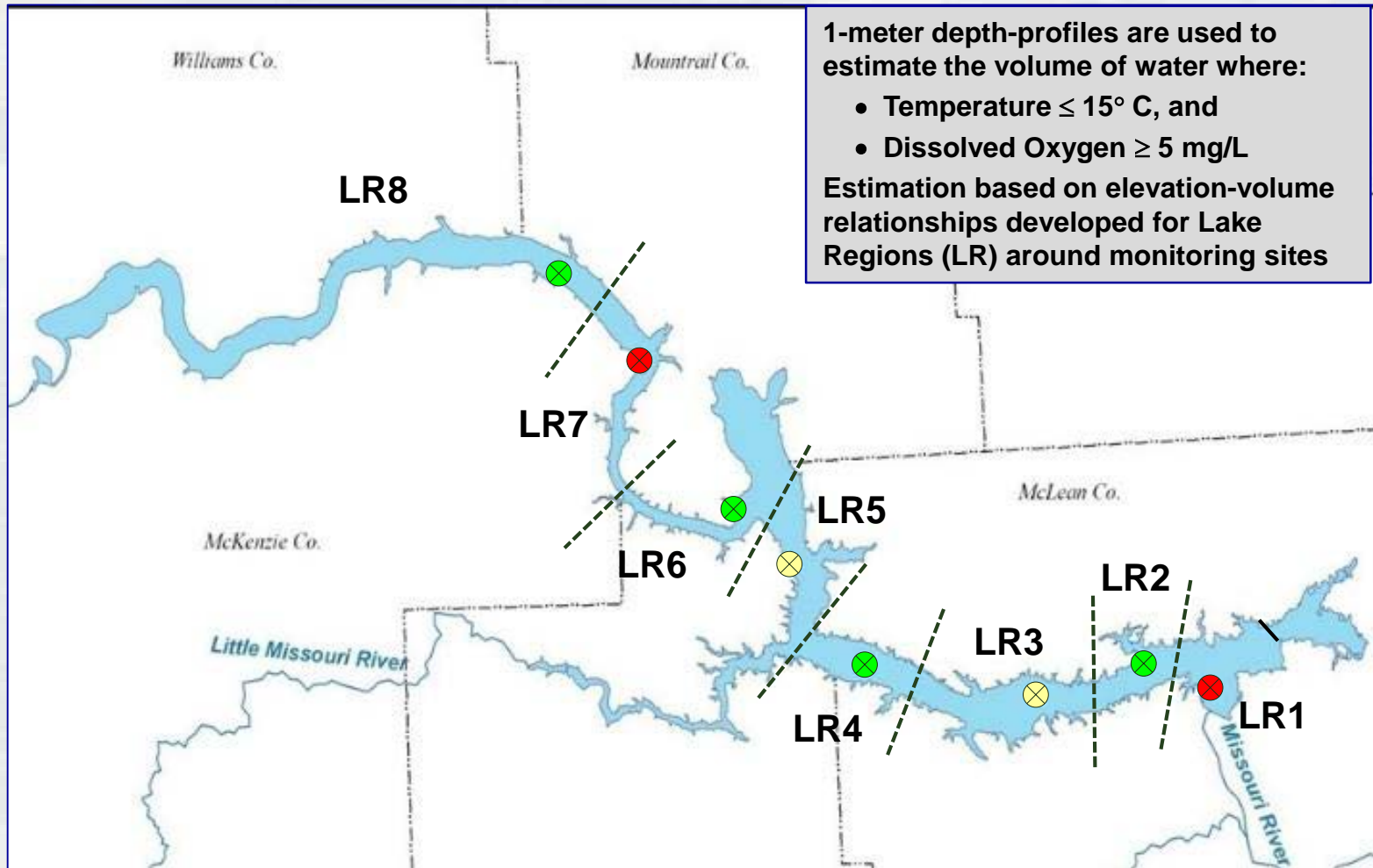
Lake Sakakawea – 2014 (28-August)



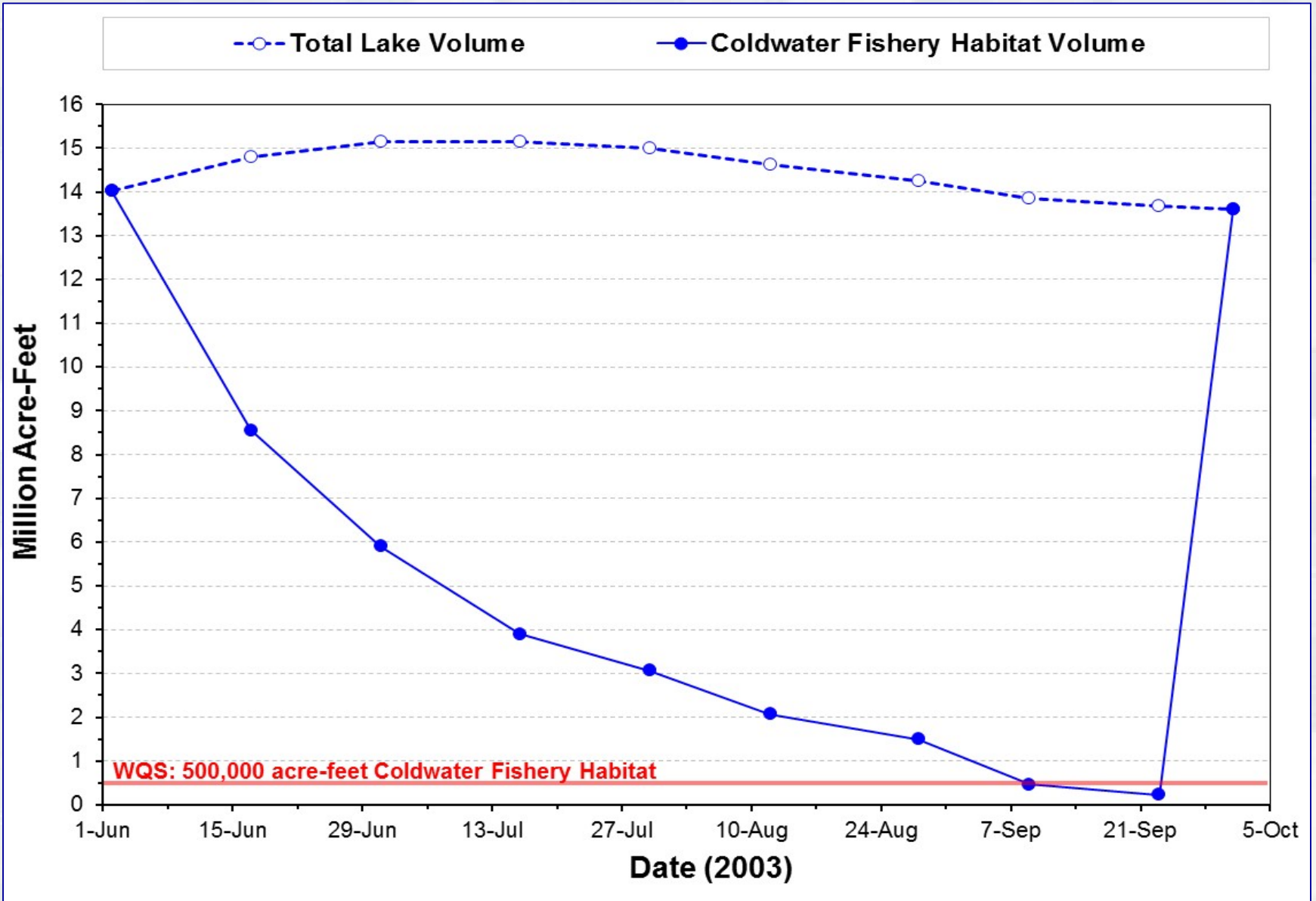
Lake Sakakawea – 2014 (23-September)



The Volume of Coldwater Fishery Habitat Present in Lake Sakakawea is Estimated from Depth-Profile Measurements



Coldwater Fishery Habitat Estimated to Have Occurred in Lake Sakakawea during 2003 Based on Depth-Profile Measurements



The Corps is Utilizing the CE-QUAL-W2 Hydrodynamic and Water Quality Model (W2) to Model Water Quality in Lake Sakakawea

Version 3.7 of W2 is Currently Being Applied to Lake Sakakawea to Assess:

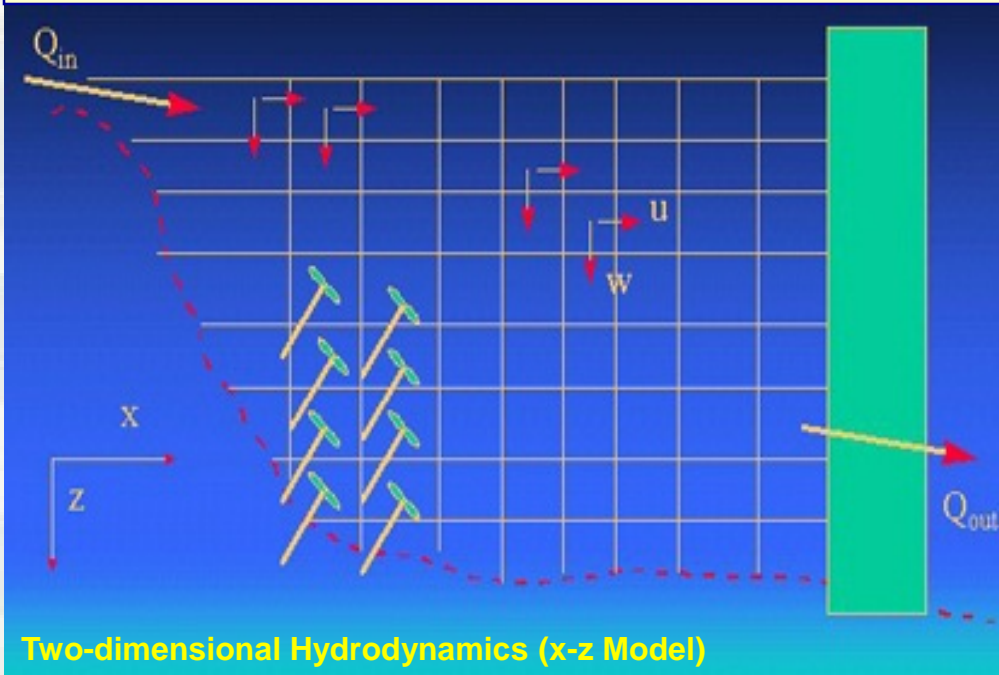
- Coldwater Fishery Habitat
- Potential for Low Dissolved Oxygen Levels in Powerplant Discharges
- Possible Water Quality Management Options



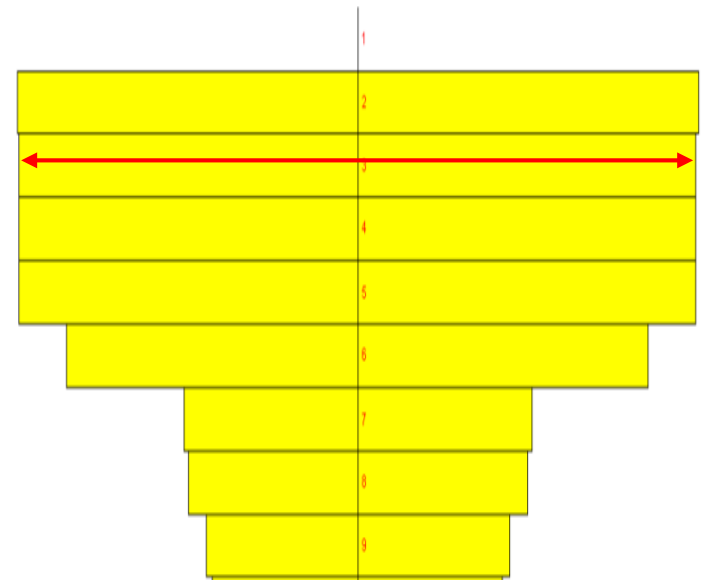
W2 Model

Two-Dimensional (Longitudinal and Vertical) Laterally-Averaged Model

Side View



End View



W2 Model Inputs

Weather Conditions (Hourly Observations)

- 
- Air Temperature
 - Dew Point Temperature
 - Wind Speed
 - Wind Direction
 - Cloud Cover
 - Incident Solar Radiation

Inflow (Q_{in})



Water Quality (C_{in})

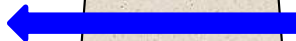
- Water Temperature
- DO
- Nutrients
- TOC



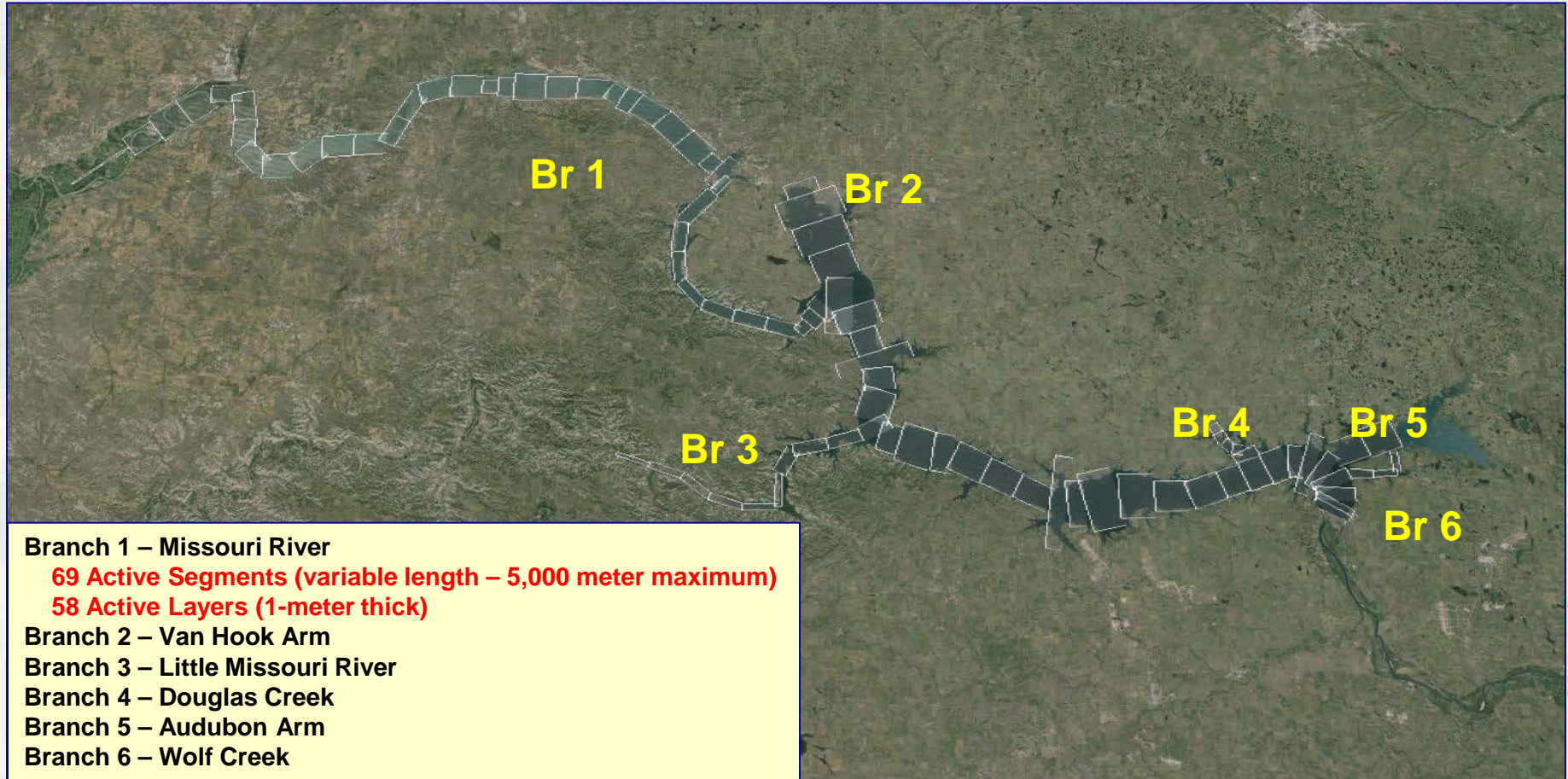
W2



Discharge (Q_{out})



Application of the W2 Model to Lake Sakakawea



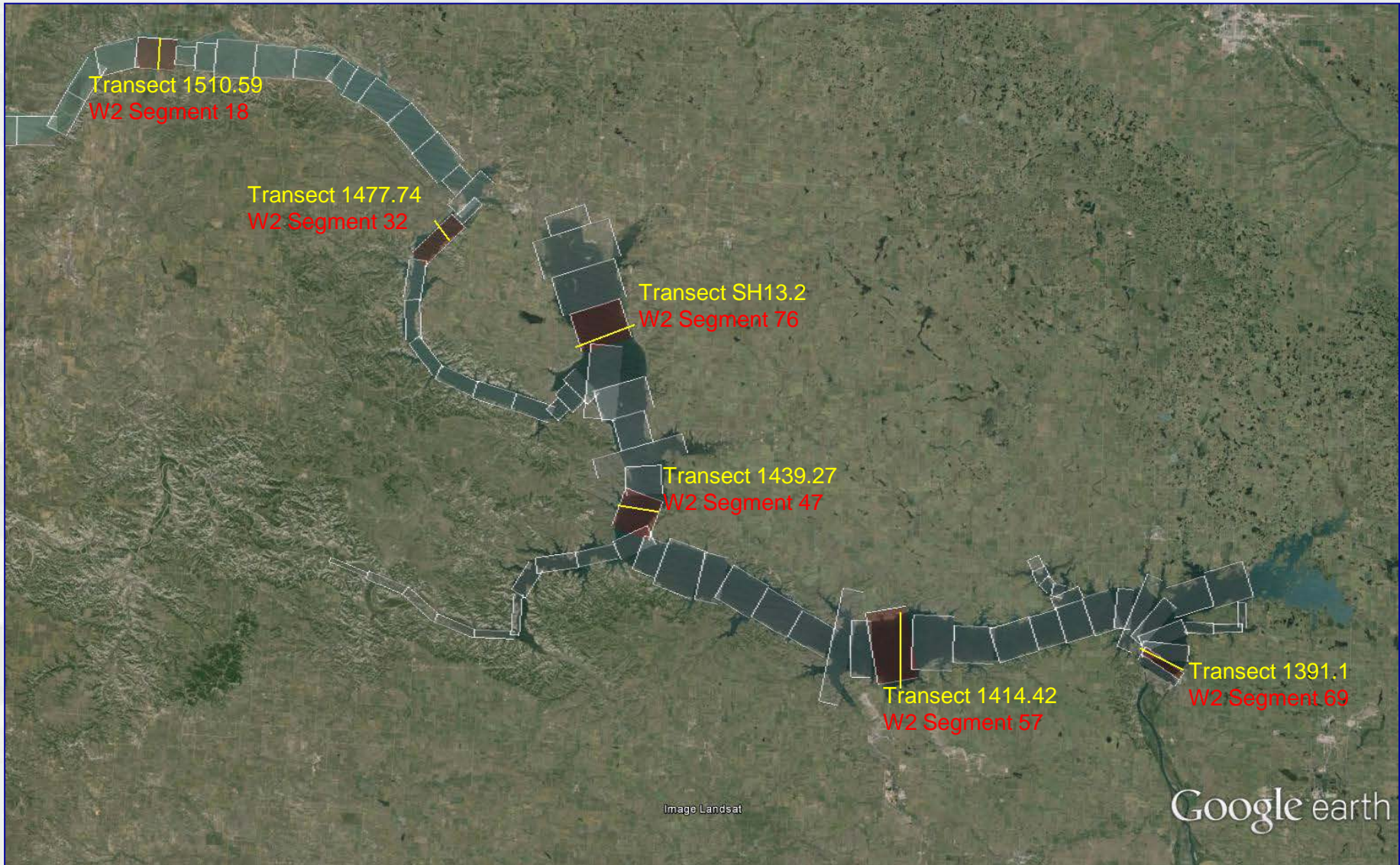
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W2 Bathymetry Developed from 2010-2012 Bathymetric Survey

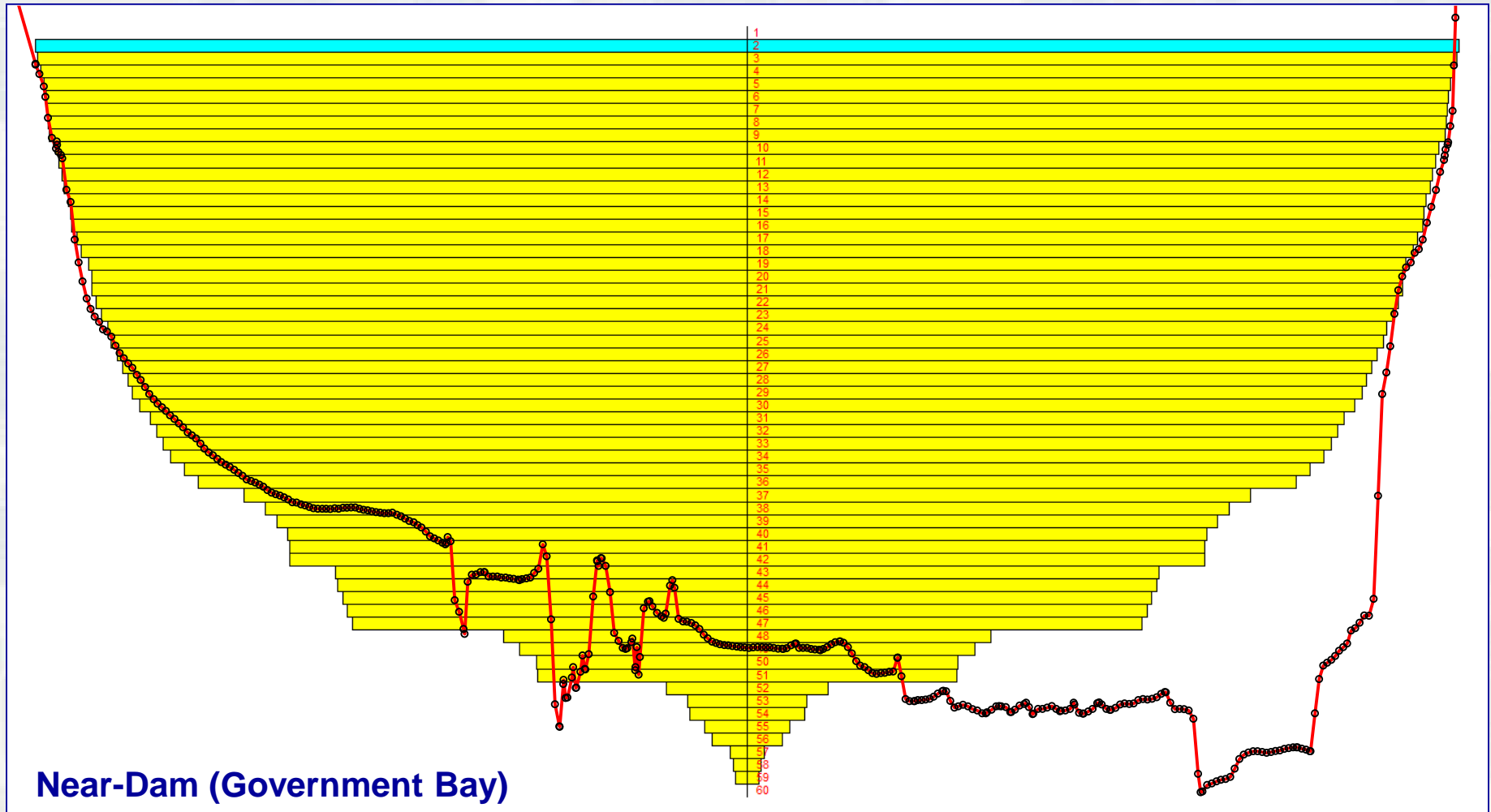
W2 Segments and Survey Lines



Comparison of Cross-Sectional Profiles: W2 vs. Surveyed Six Selected W2 Segments



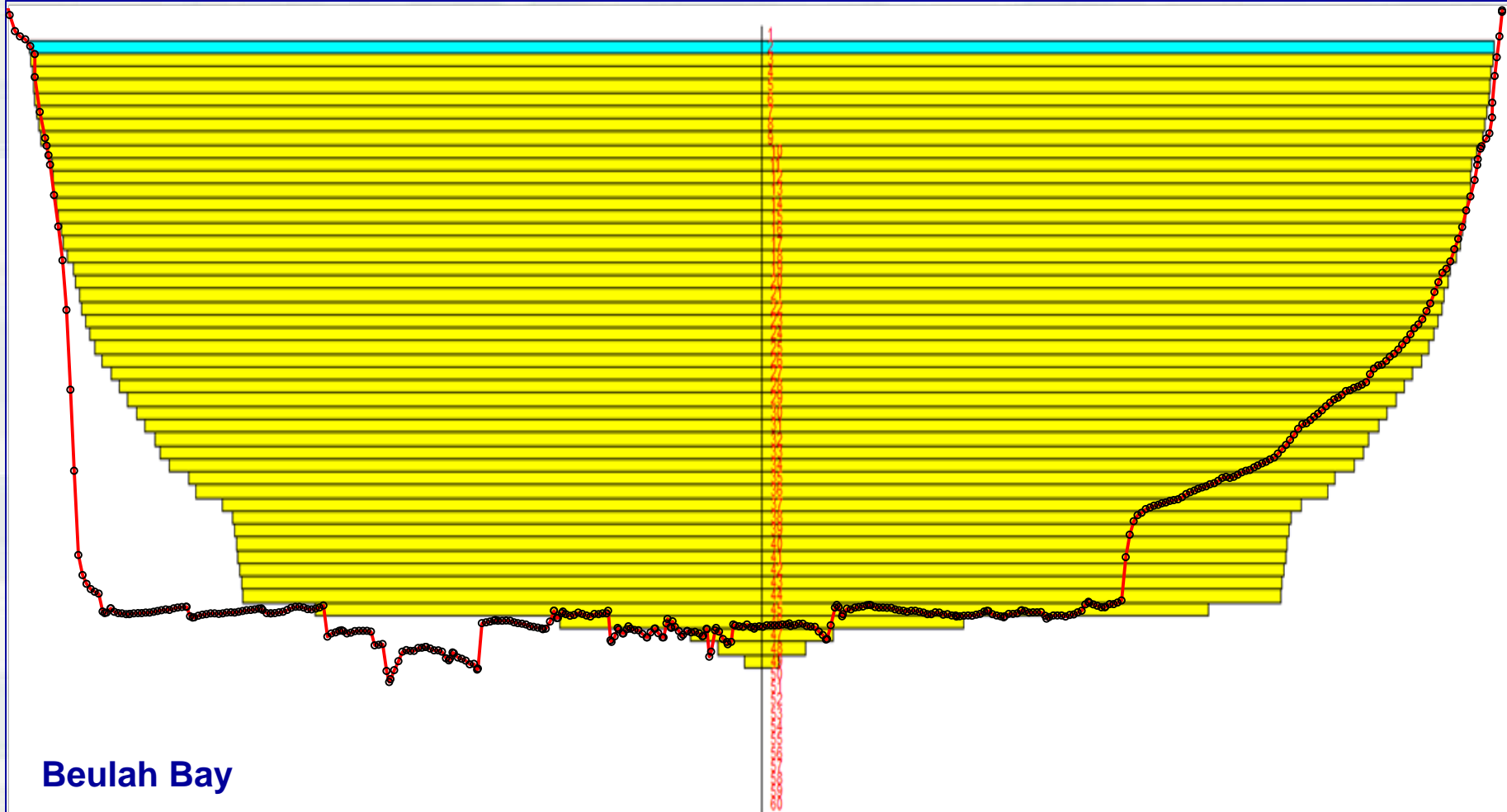
1-Meter Layers Defined for Segment 69 of the W2 Model Compared to 2010-12 Survey Data



Near-Dam (Government Bay)



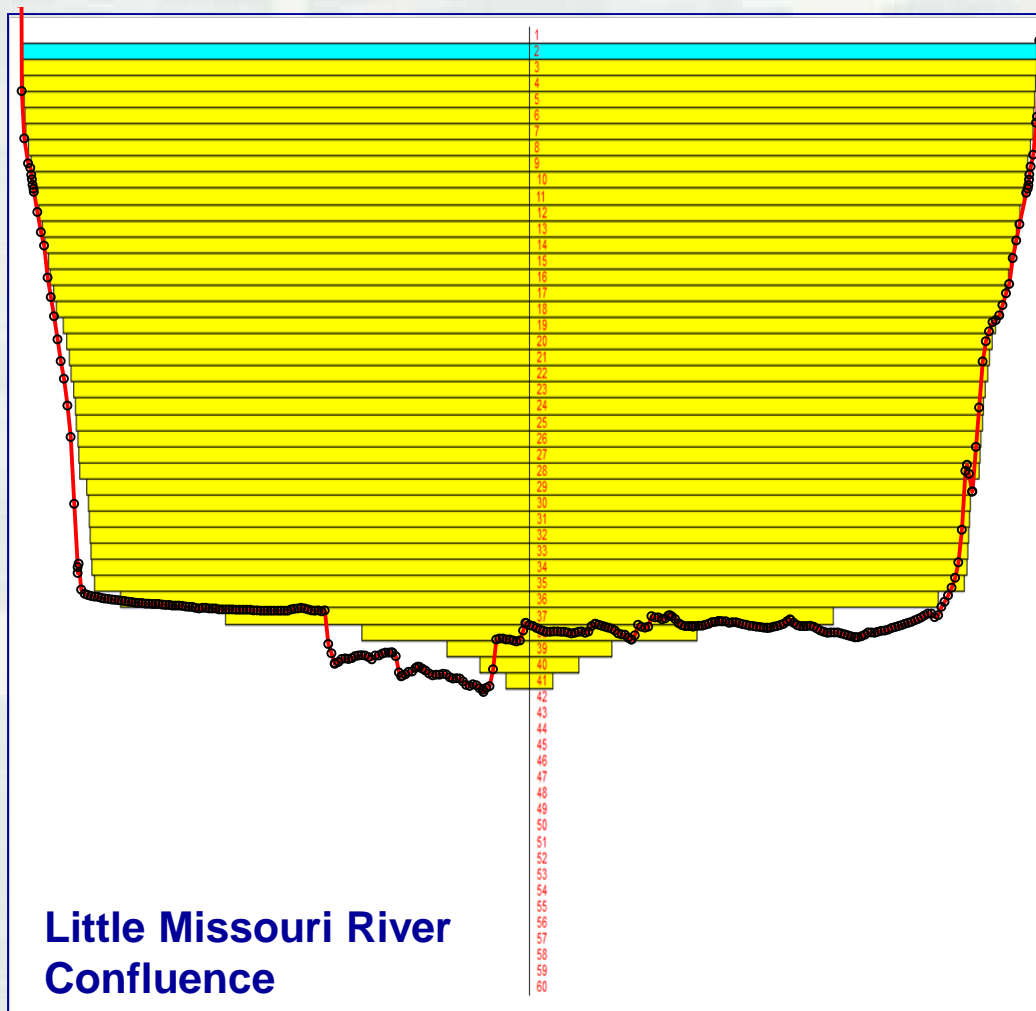
1-Meter Layers Defined for Segment 57 of the W2 Model Compared to 2010-12 Survey Data



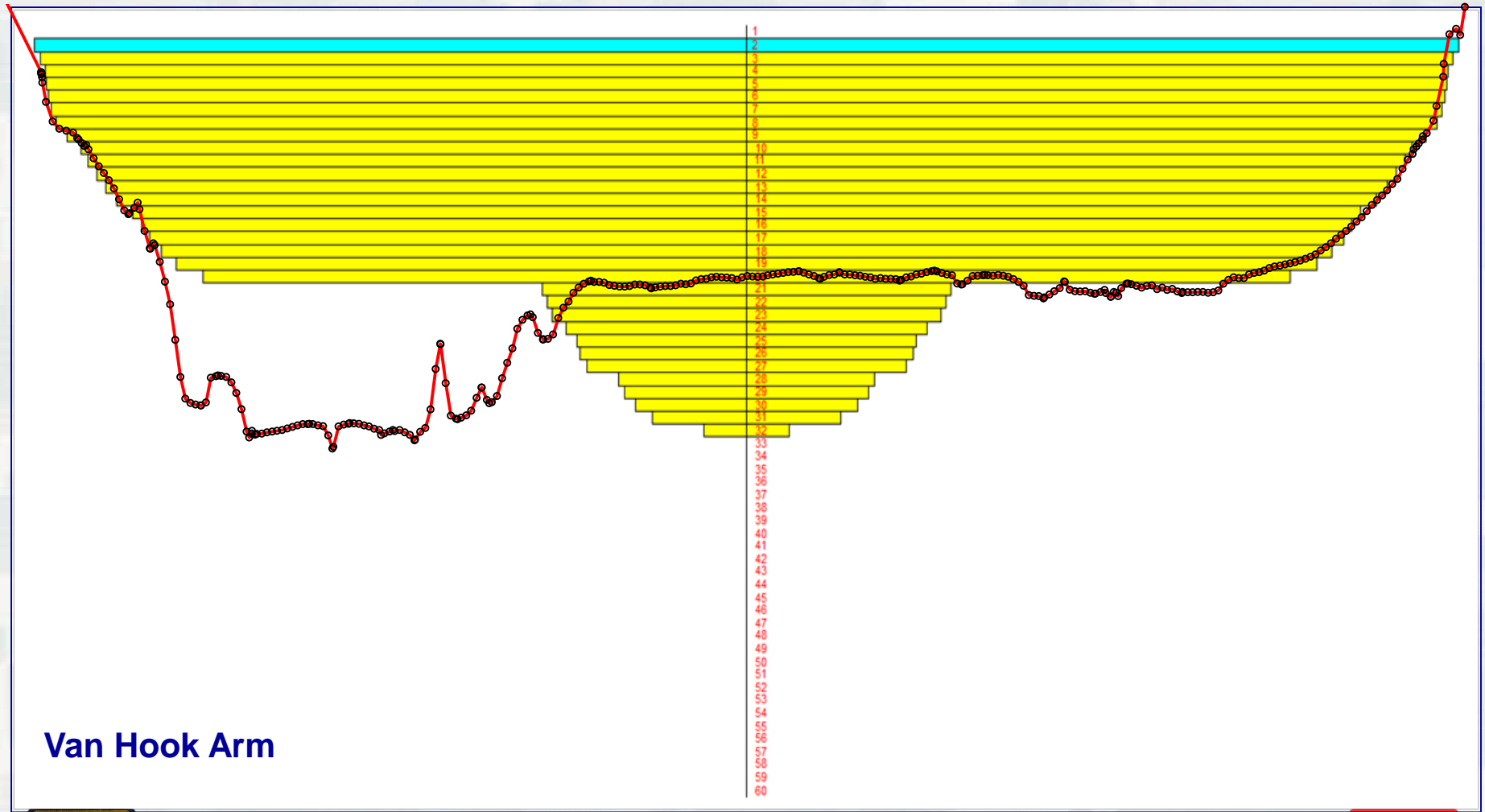
Beulah Bay



1-Meter Layers Defined for Segment 47 of the W2 Model Compared to 2010-12 Survey Data



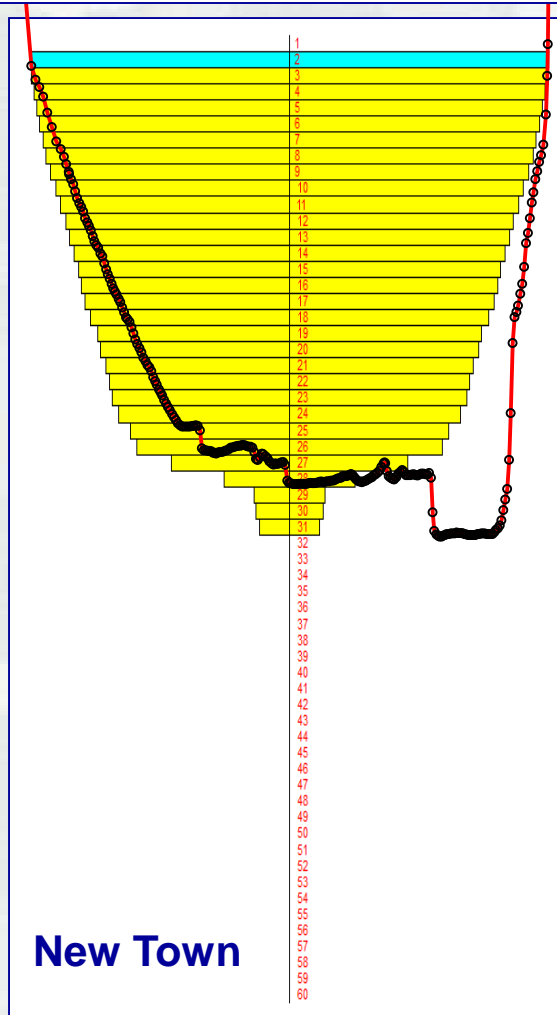
1-Meter Layers Defined for Segment 76 of the W2 Model Compared to 2010-12 Survey Data



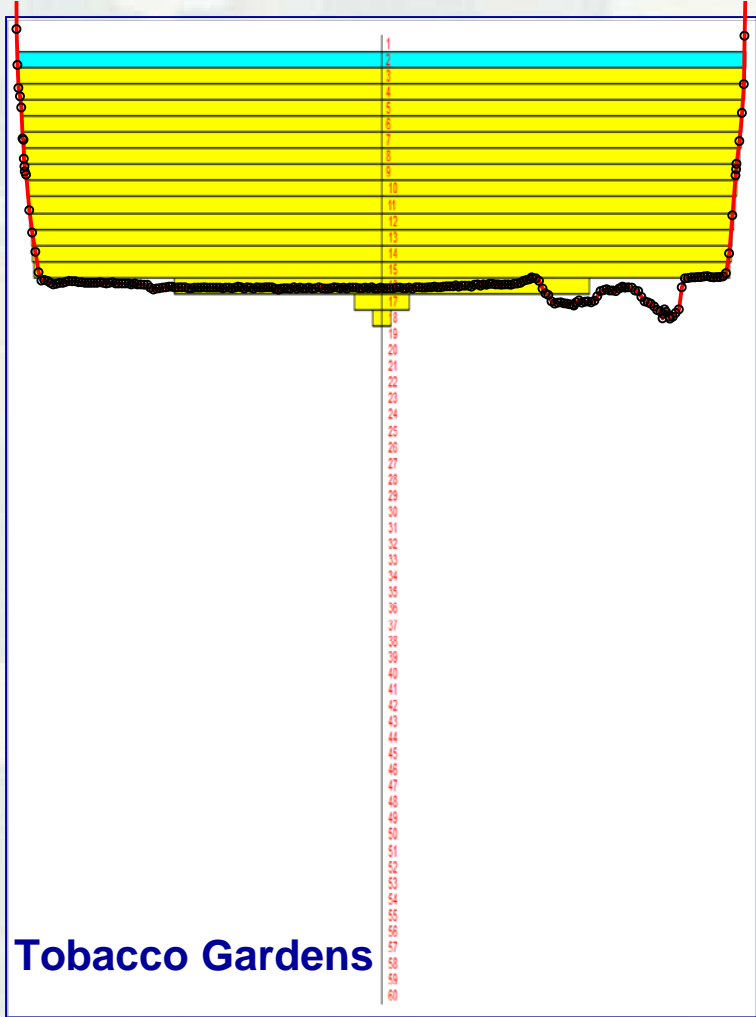
Van Hook Arm



1-Meter Layers Defined for Segment 32 of the W2 Model Compared to 2010-12 Survey Data



1-Meter Layers Defined for Segment 18 of the W2 Model Compared to 2010-12 Survey Data



Calibration of W2 Model for Lake Sakakawea

Assumption: Corps' Current Area and Capacity Curves for Lake Sakakawea are Accurate

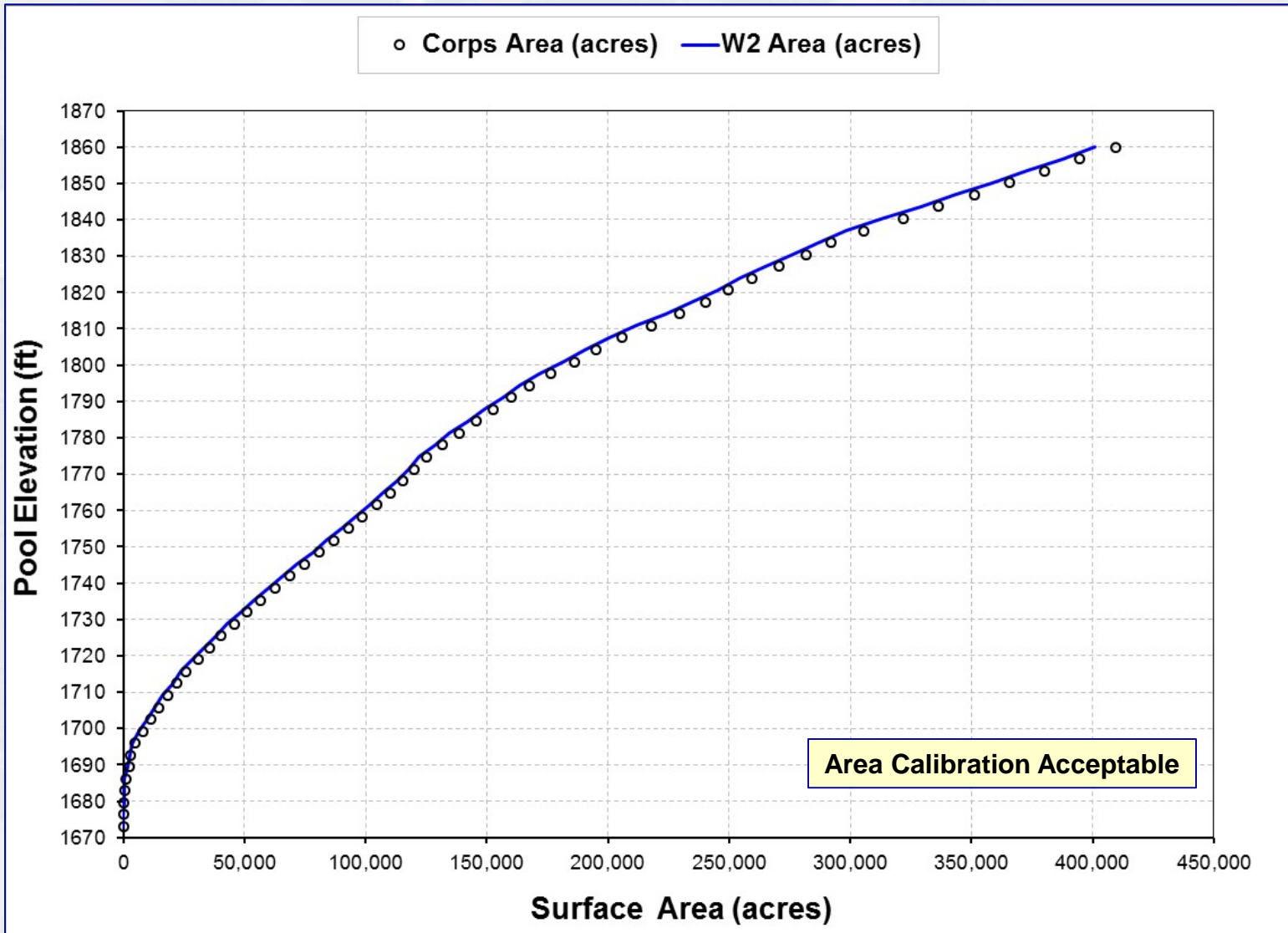
W2 Calibrated by Comparing:

- Corps' area and capacity curves to W2 modeled curves
- Observed and W2 modeled pool levels
- Measured and W2 modeled depth-profiles for temperature and dissolved oxygen



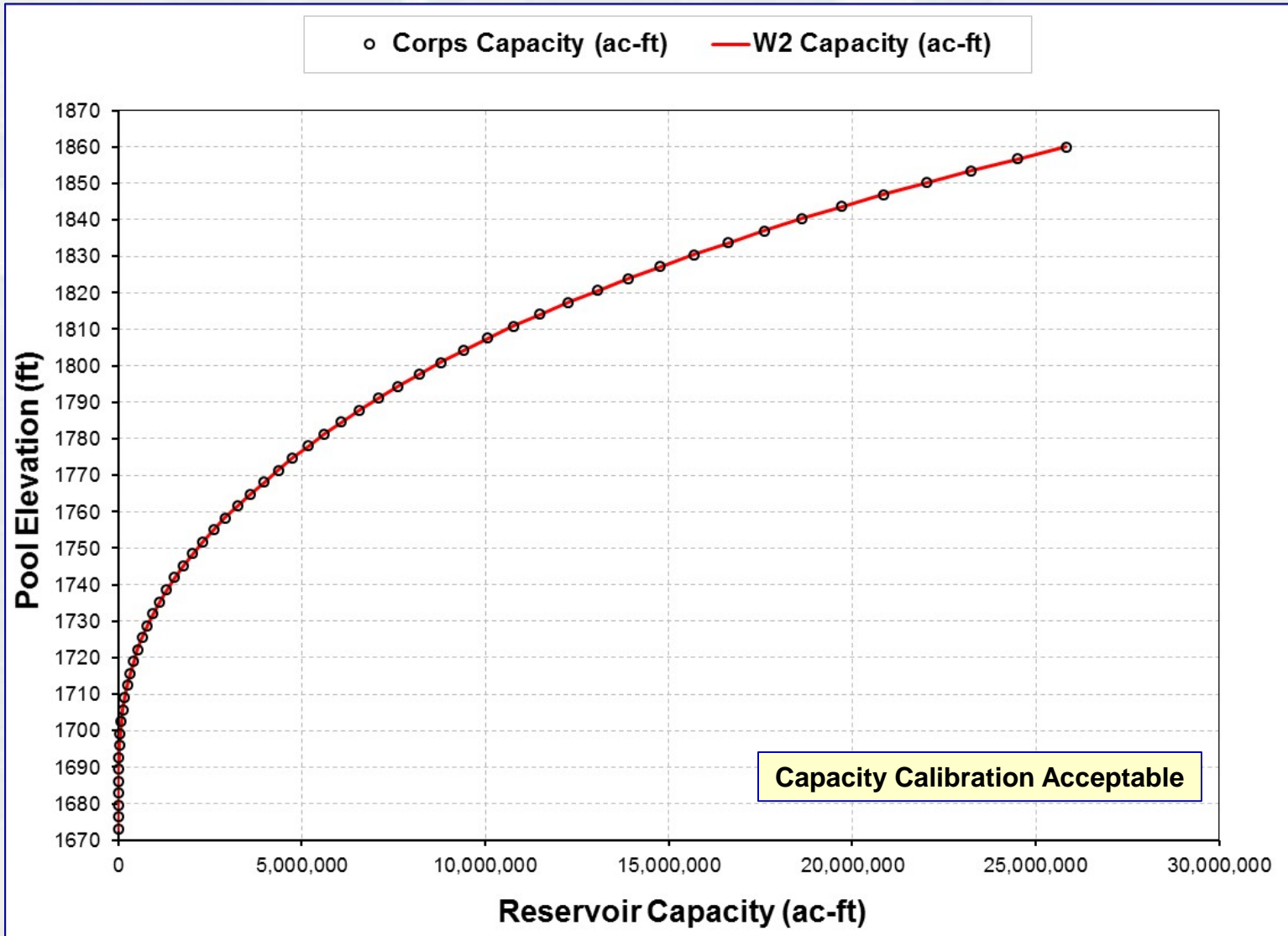
W2 Bathymetry File Calibration

Corps Current Area Curve vs. W2 Modeled Area Curve



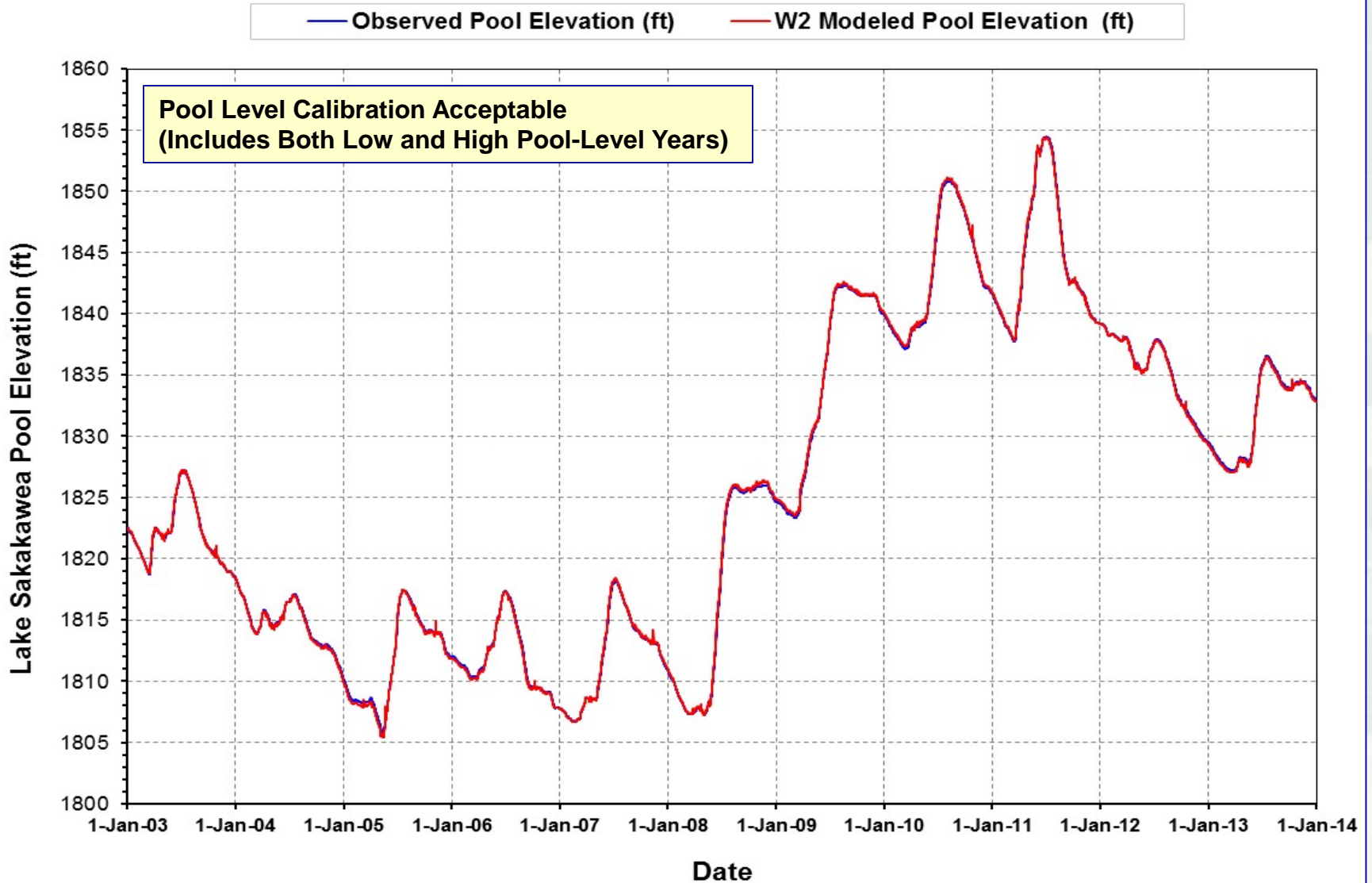
W2 Bathymetry File Calibration

Corps Current Capacity Curve vs. W2 Modeled Capacity Curve



W2 Bathymetry File Calibration

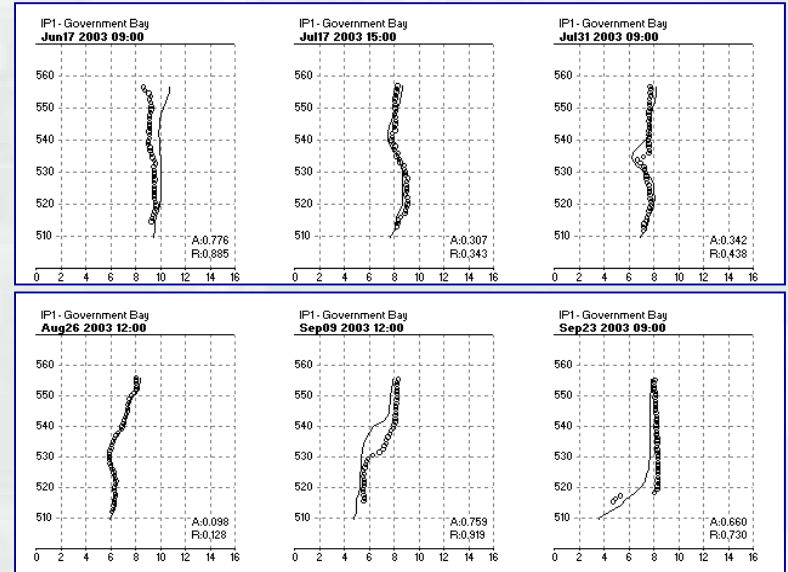
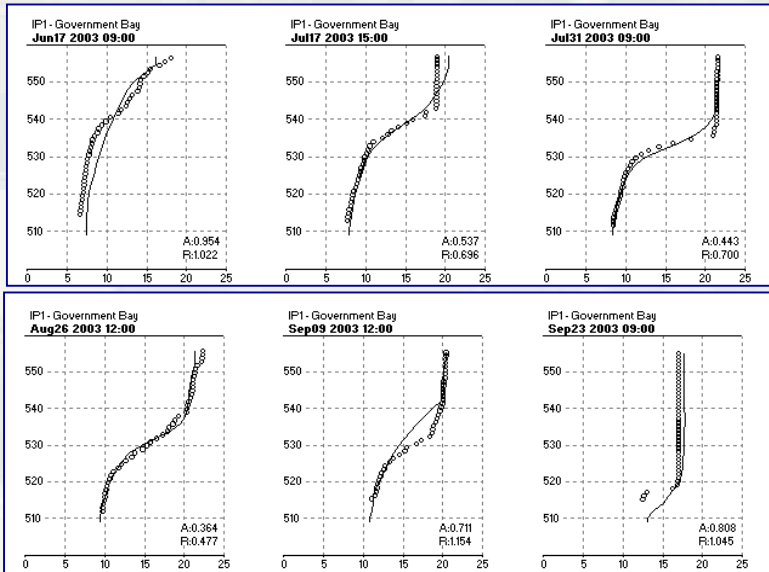
Observed Pool Levels vs. W2 Modeled Pool Levels (2003-2013)



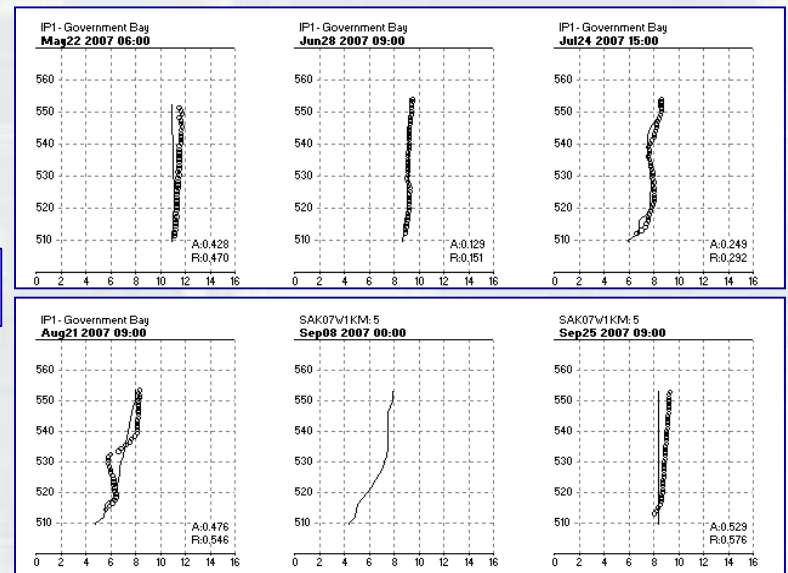
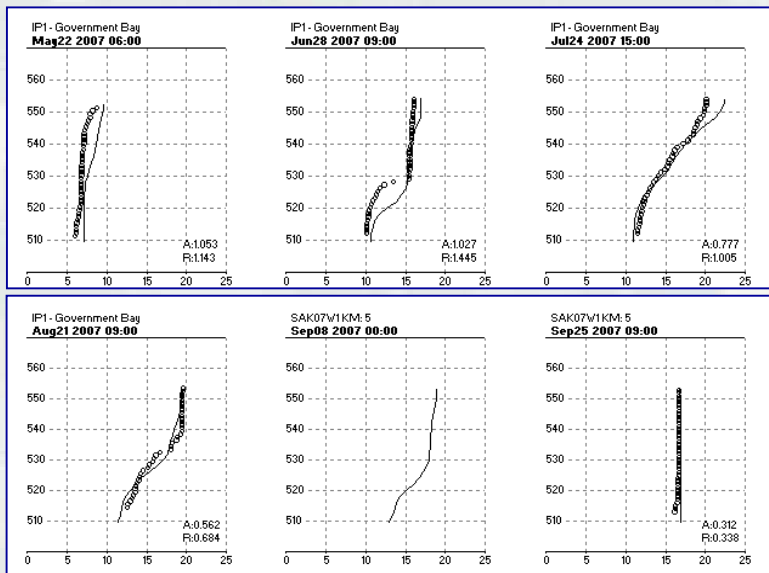
Comparison of Measured and W2 Modeled Depth-Profiles Near-Dam Temperature

Near-Dam Dissolved Oxygen

2003

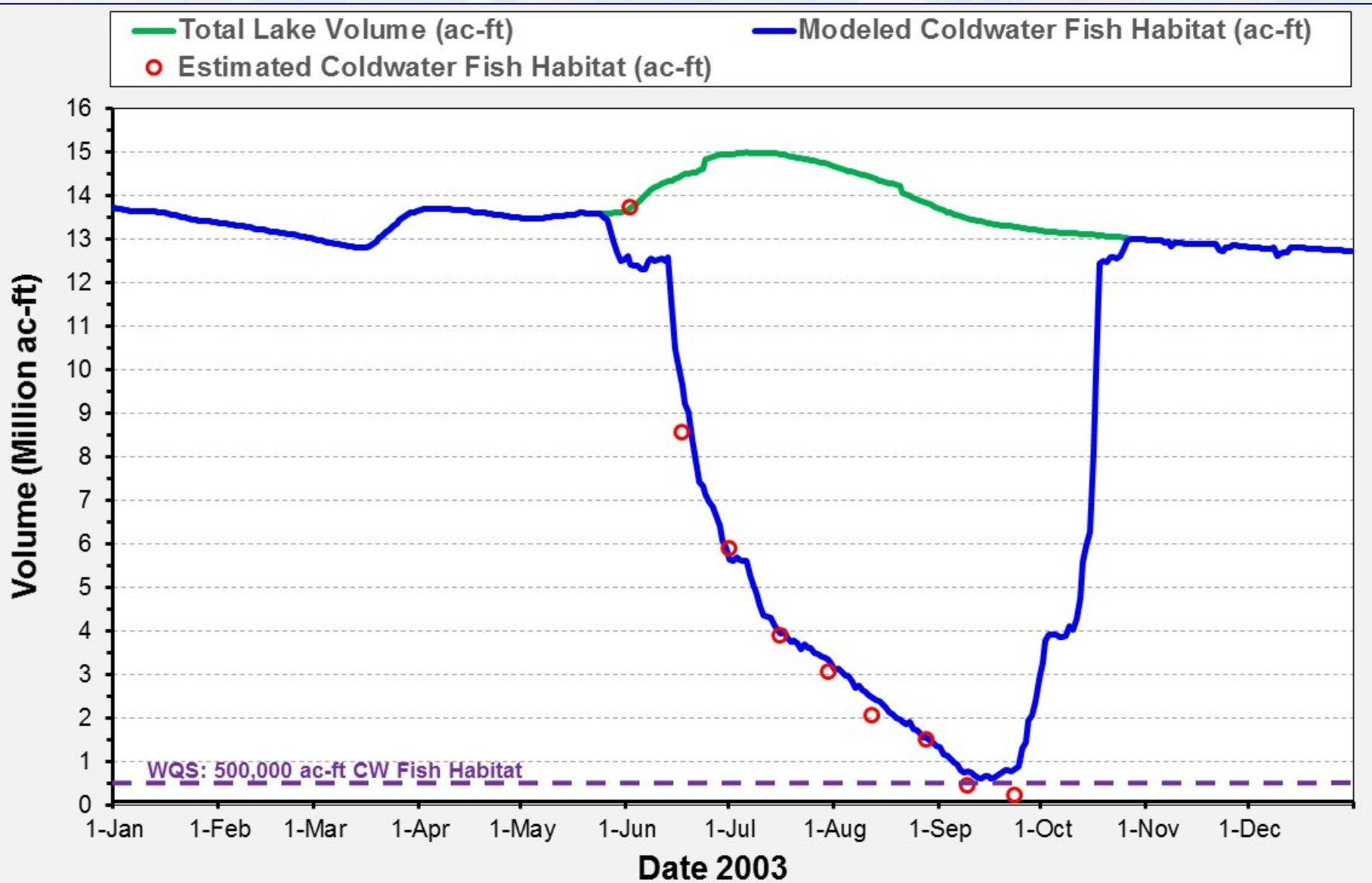


2007



Lake Sakakawea Coldwater Fishery Habitat – 2003

W2 Modeled vs Estimated (Depth-Profiles)

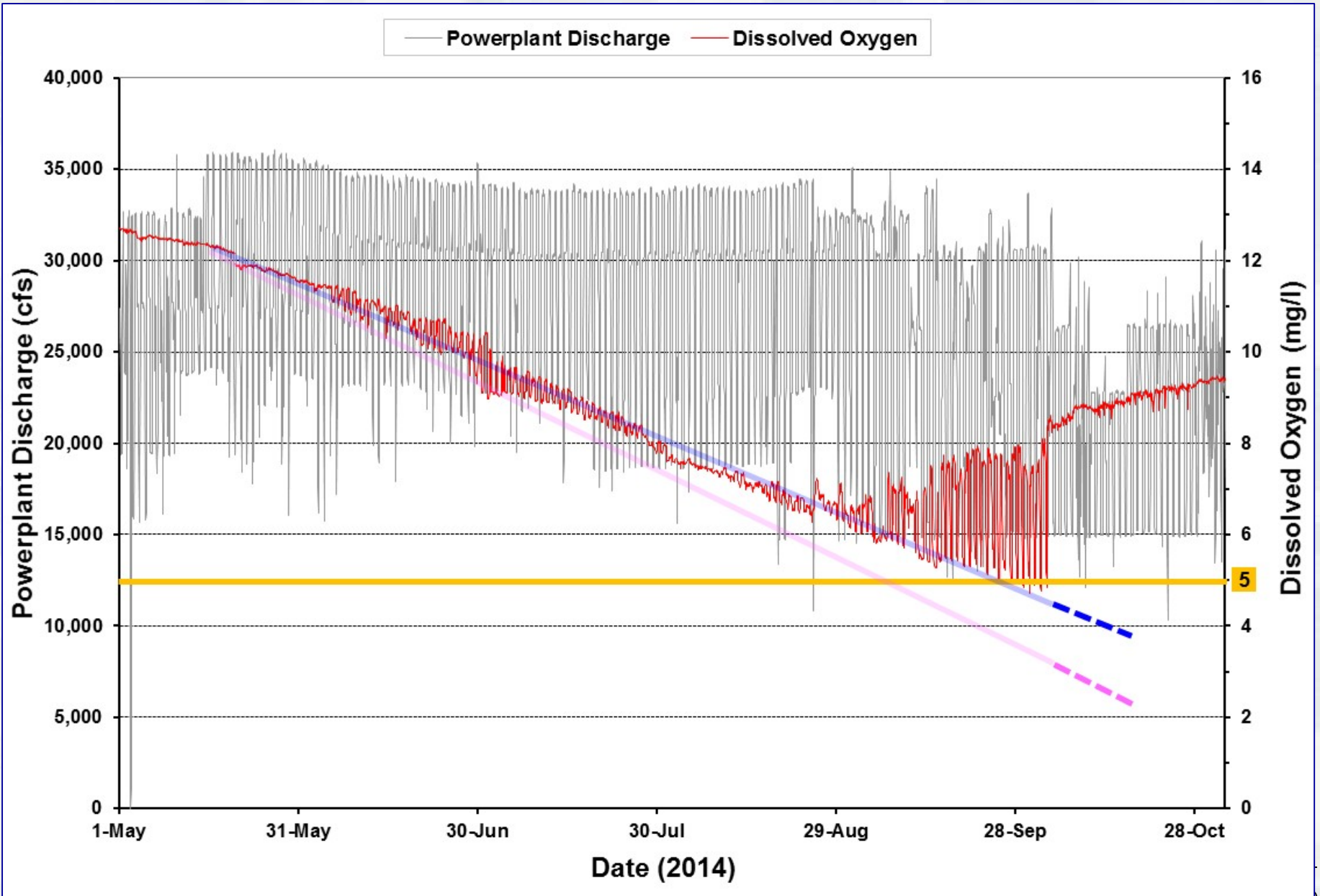


The Corps will Utilize W2 to Facilitate Future Water Quality Management Planning at the Garrison Project

- **How does the Corps' Reservoir Regulation Effect Coldwater Fishery Habitat in Lake Sakakawea?**
 - **Pool Levels**
 - **Dam Discharge Rates**
 - **Withdrawal Elevations**
- **Are Low Dissolved Oxygen Levels in Powerplant Discharges to the Missouri River a Future Concern?**
- **Does Future Eutrophication of Lake Sakakawea and/or Climate Change Pose a Threat to Coldwater Fishery Habitat in the Reservoir and Dissolved Oxygen Levels in Powerplant Discharges?**



Are Climate Change or Eutrophication a Concern at Lake Sakakawea?



Water Quality Management Measures Implemented at Garrison Dam to Enhance Coldwater Fishery Habitat during 2003-2008 Drought Period

Plywood Barriers Installed on Power Tunnel Trash Racks to Draw Water from Higher Elevations in the Reservoir during Power Production

Dam Intake Structure Shown During Construction



Garrison Dam 10 Dec. 1952

Trash Rack Section with Plywood Installed



- The W2 model will be used to evaluate this and other possible water quality management measures and scenarios

Questions?

