HYPOLIMNETIC OXIDATION SYSTEM PERFORMANCE: LAKE THUNDERBIRD 2010-2012

Paul Koenig & Steven Cadenhead
Oklahoma Water Resources Board

OWRB
the water agency

CENTRAL OKLA. MASTER CONSERVANCY DISTRICT
Lake Thunderbird
Serving
• NORMAN
• DEL CITY
• MIDWEST CITY
EST. C.O.M.C.D. 1965

DATA SOURCES

Lake Thunderbird Capacity and Water Quality 2001

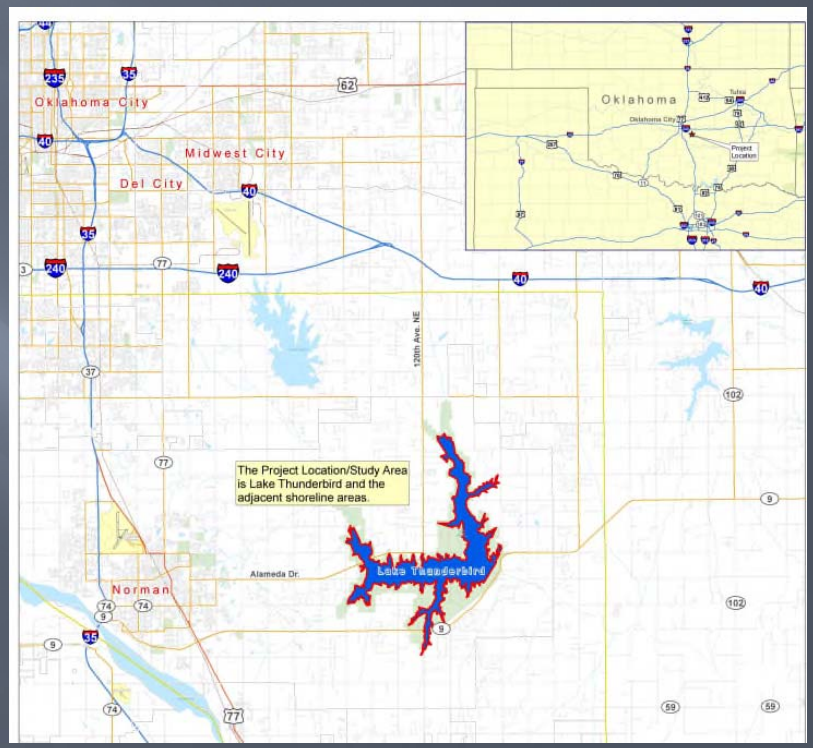
Developing In-Lake BMPs to Enhance Raw Water Quality of Oklahoma's Sensitive Water Supply

Lake Thunderbird Water Quality 2012

http://www.owrb.ok.gov/studies/reports/reports.php

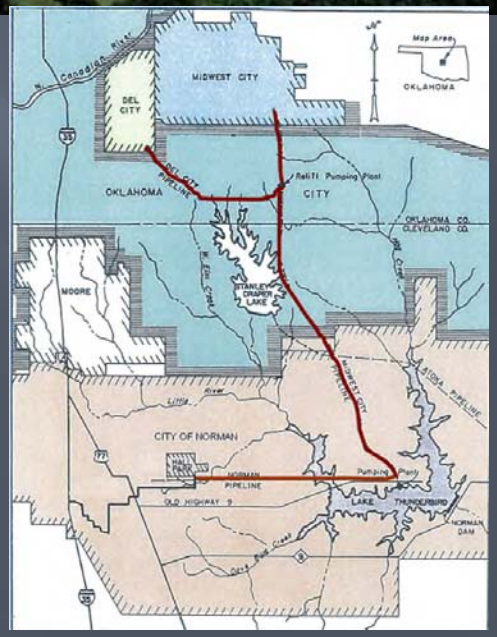
Lake Thunderbird

- Cleveland County, OK
- 13 miles east of Norman, OK
- Normal Pool Capacity
  - 106,669 ac-ft
- Yield
  - 21,600 ac-ft (Conjunctive)
  - 15,600 ac-ft (Basic)



Lake Thunderbird

- Federally Owned Lake, Constructed in 1965
- Jurisdiction of Bureau of Reclamation
- Operated and Maintained by the Central Oklahoma Master Conservancy District
- Raw water for Norman Midwest City and Del City



Beneficial Use Designation

Primary- Municipal Water Supply

Flood Control

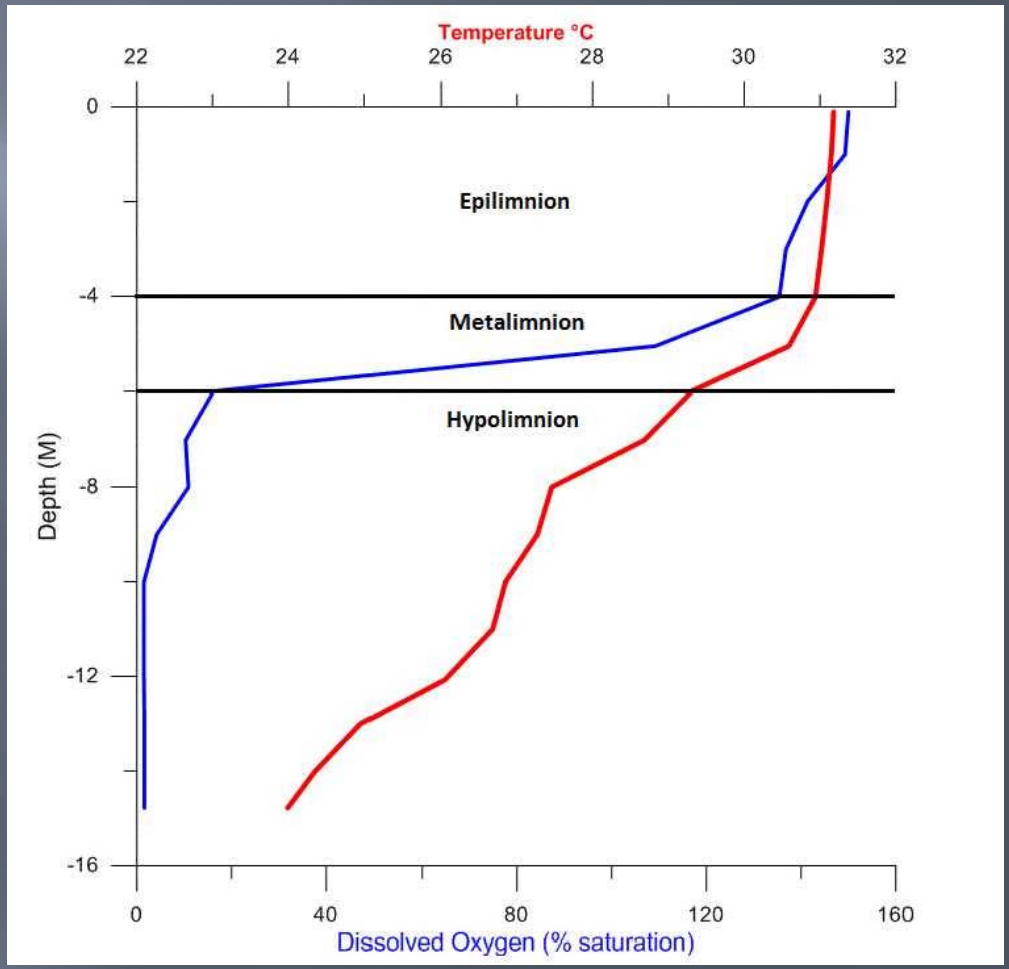
Recreational

Category 5 on the State 303 (d) list:

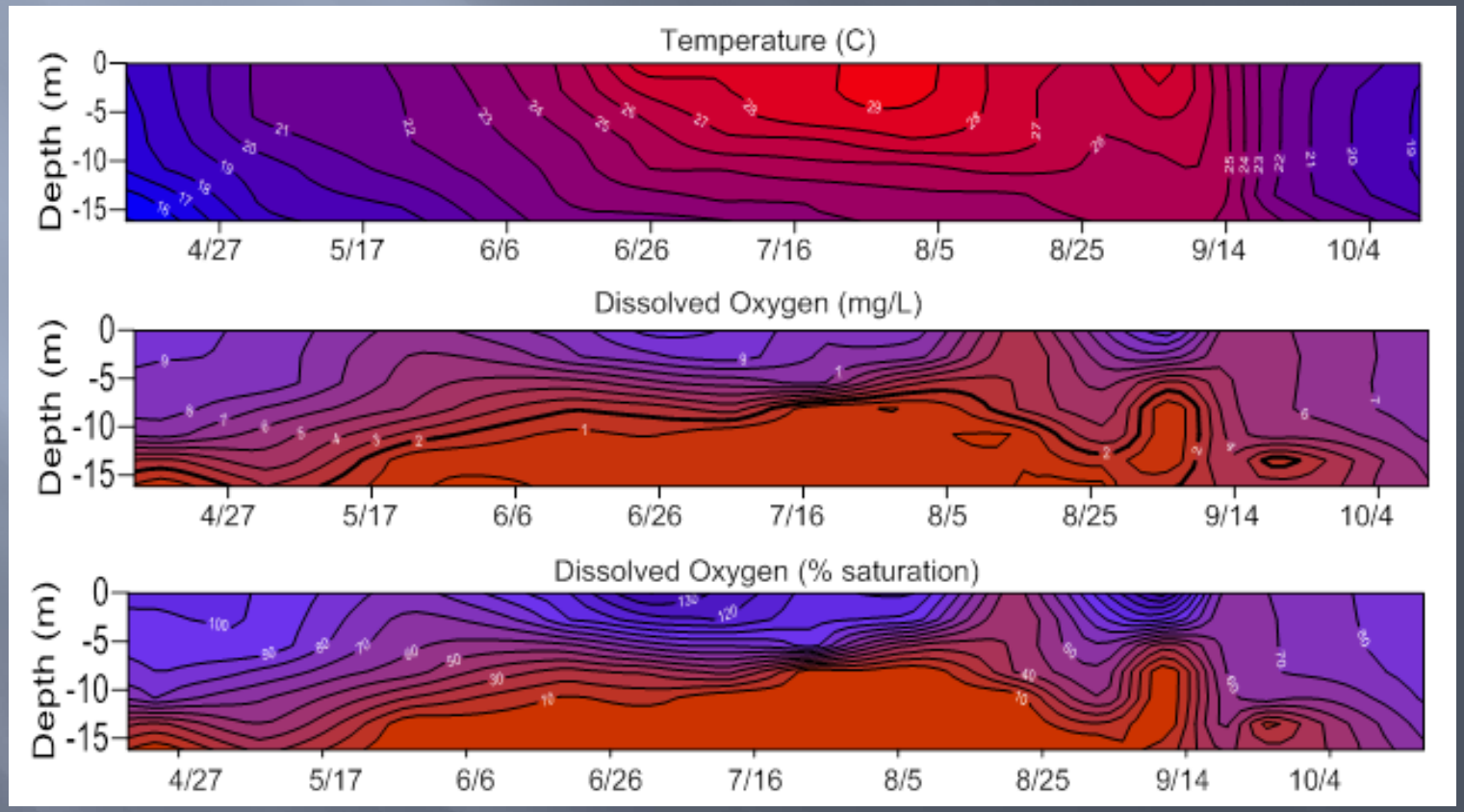
- Turbidity and Low Dissolved Oxygen Impairments
- Designated Sensitive Water Supply (SWS)
  - 10 ug/L chlorophyll a
    - elevated TOC due to excessive algae

Key Feature

Lake Thunderbird Stratification



2012 Seasonal Stratification



Process Selection

Goal: Treat anoxic condition in the hypolimnion without disrupting the natural stratification

Identified and Evaluated three processes:

- Artificial Circulation
- Depth Selective Flow Routing
- Supersaturated Dissolved Oxygen Injection System

  (SDOX by BlueInGreen, LLC)- Selected Option

Process Selection

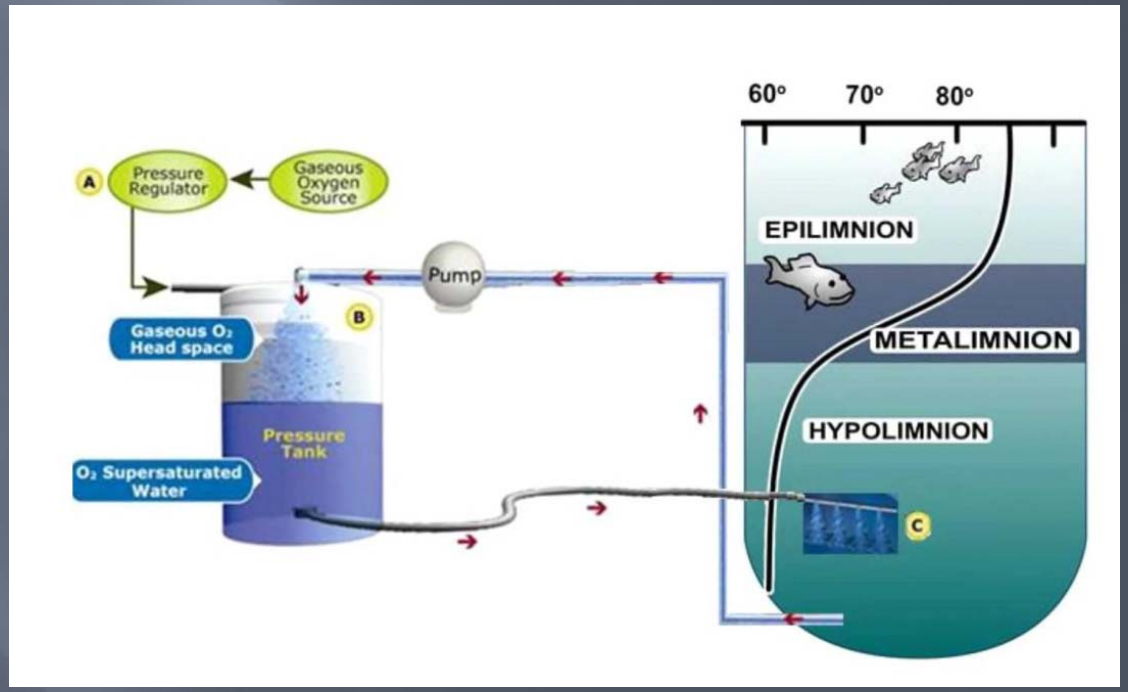
- COMCD and OWRB secured approval and funding from EPA in 2010 under ARRA. EPA approved SDOX as a "Green Project"
- Total Loan Amount: $1,501,285
  - Interest and principal free
  - Clean Water State Revolving Fund (CWSRF)
- Funded construction, startup and O&M for a two-year period

Selected Process SDOX

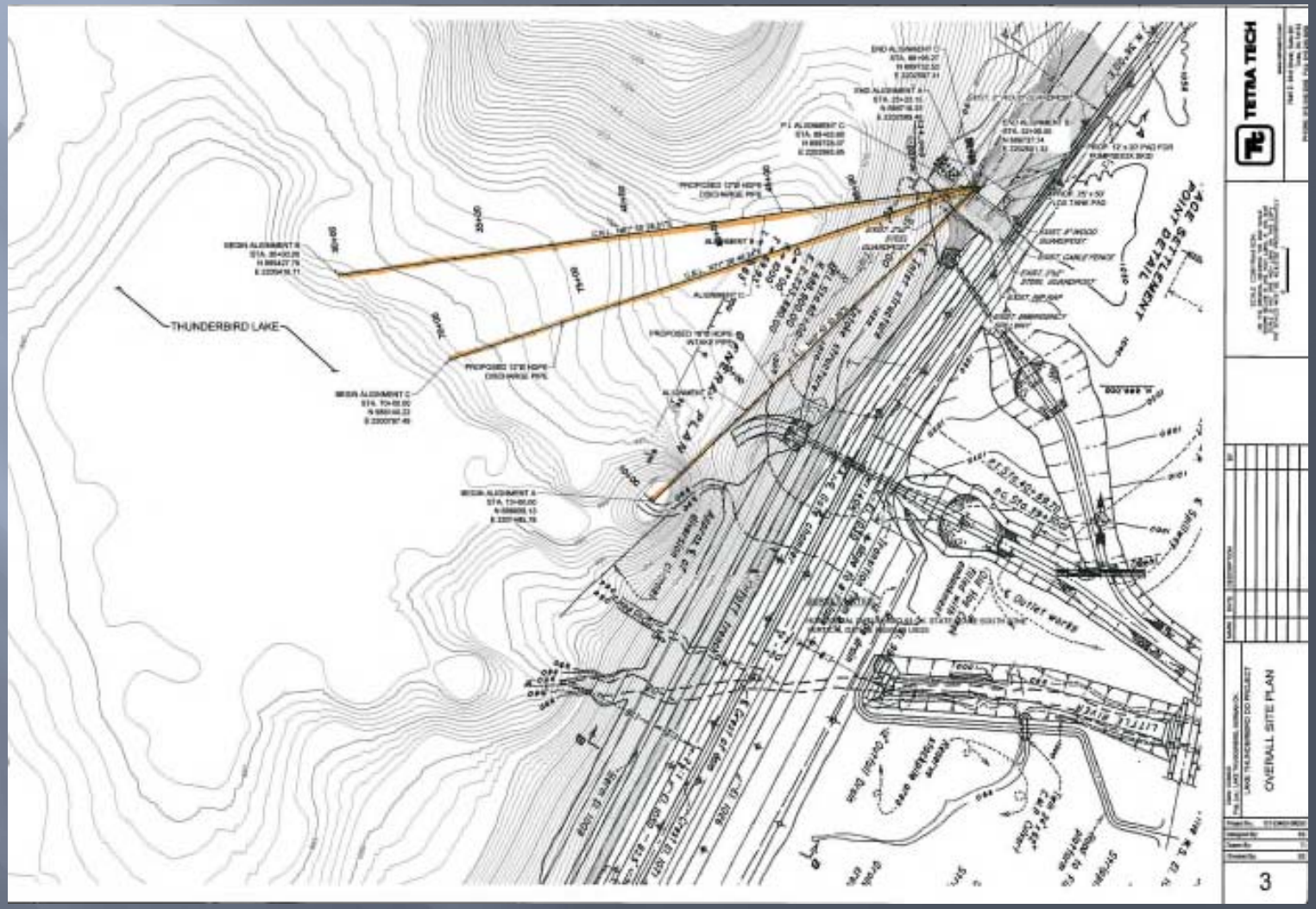
2,000 acre-feet of HypolimnionTargeted

- 480 acres of sediment

SDOX Process Concept



System Layout



Design Parameters

- Recirculation Flow: 1,536 gpm
- Oxygen Delivery: 5,202 lb/day
- Saturation Chamber: 80” dia X 60” high; 150 psig
- 200-hp pump, 480 V
- Liquid Oxygen Tank: 11,000 gallons

Construction

Modifications

April 2011 nozzles stretched further out

- West ~11m deep
- East ~ 12 m deep

Spring 2012 nozzle redesigned

- installed July
- West line shut off (break in line)

Construction

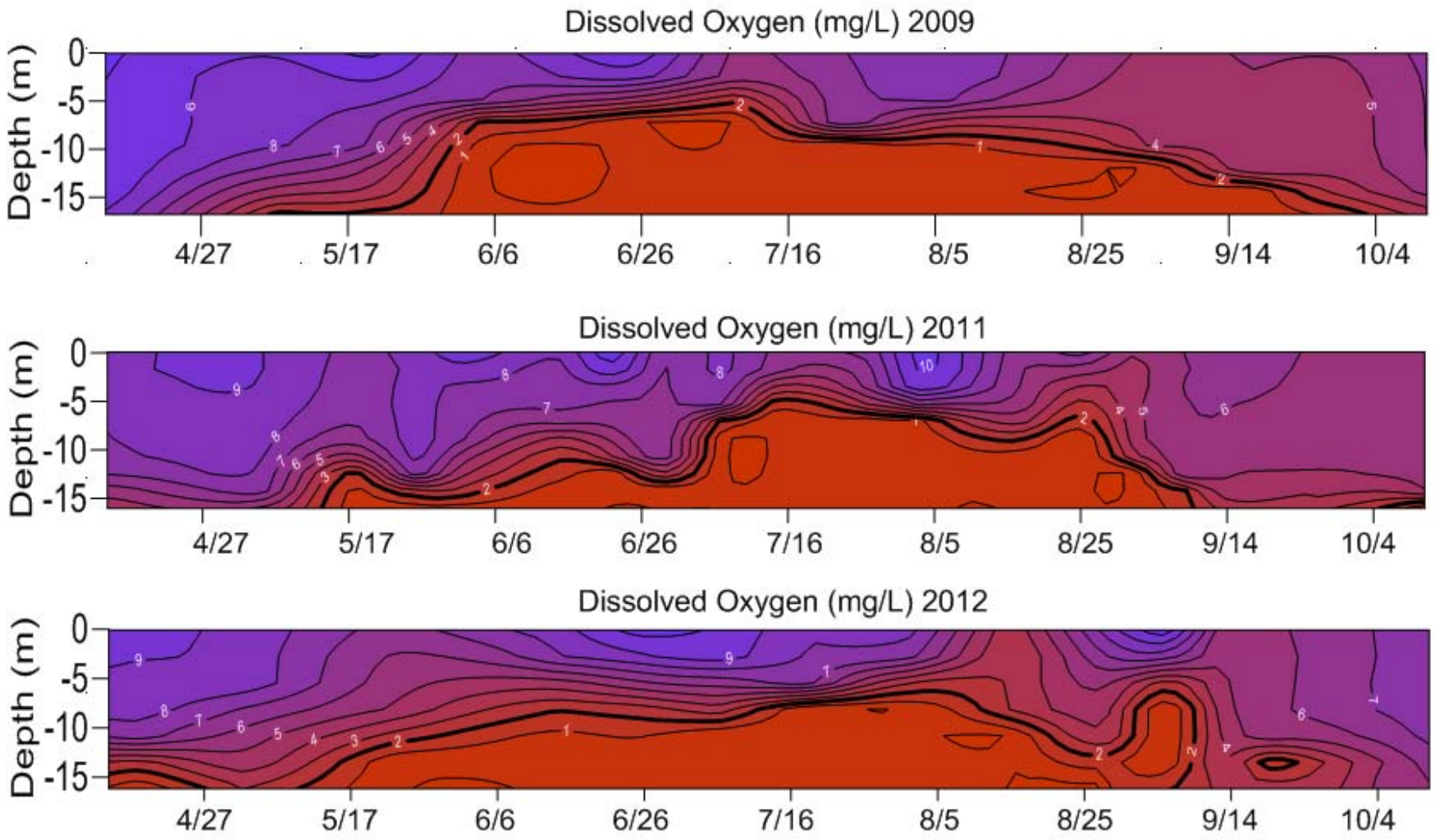
Construction Schedule

Design Start	September 22, 2009
Design Completed	December 1, 2009
Approval/Bidding	February 29, 2010
Construction	March 1, 2010
Completion	August 2010 (Original June 2010)

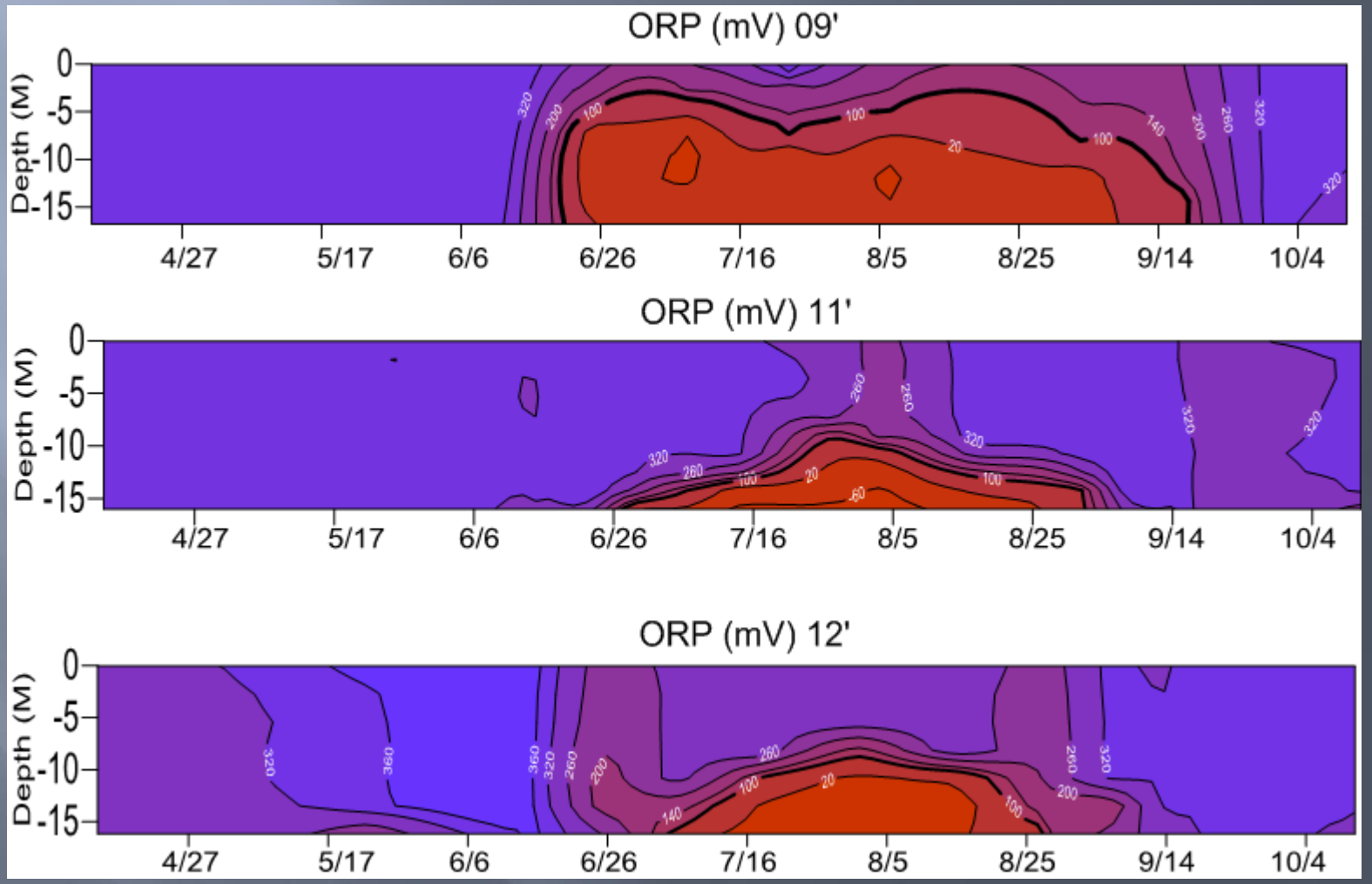
Operational Performance

- Partial operation in 2010
- Full season operation in 2011 and 2012
- Primary effects:
  - Increase hypolimnetic DO without disrupting metalimnion
  - Increase oxidation-reduction potential
- Secondary effects:
  - Reduce anaerobic mediated nutrient release
  - Reduce dissolved metals
  - Reduce taste & odor reports
  - Reduce cyanotoxins

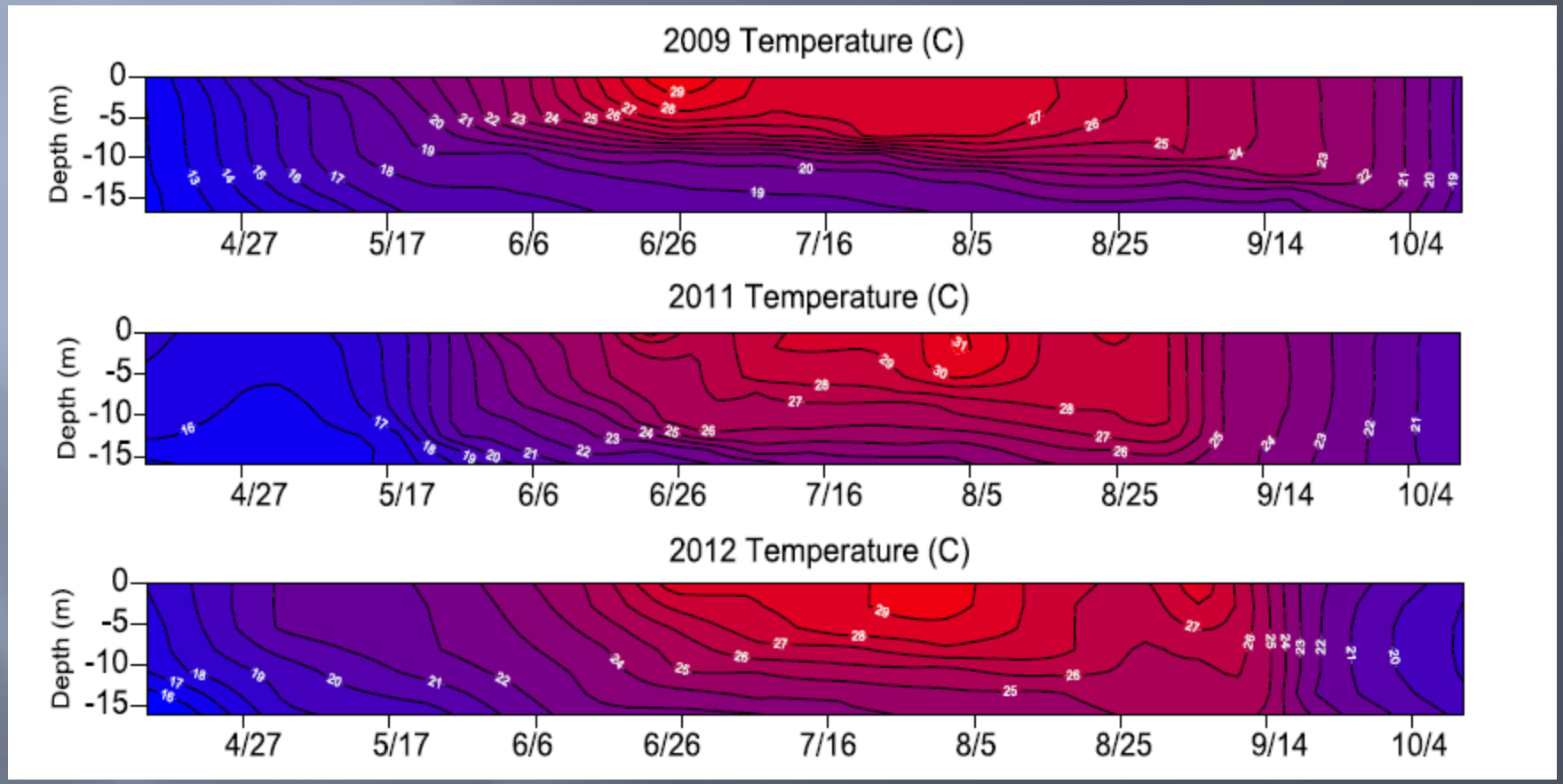
Dissolved Oxygen



ORP

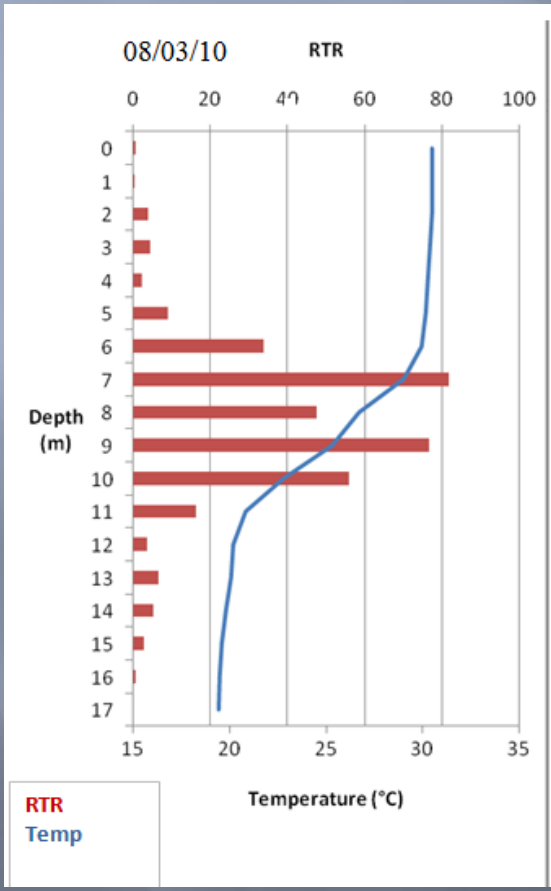

ORP (mV) 09'
Depth (M)
0
-5
-10
-15
4/27
5/17
6/6
6/26
7/16
8/5
8/25
9/14
10/4
ORP (mV) 11'
Depth (M)
0
-5
-10
-15
4/27
5/17
6/6
6/26
7/16
8/5
8/25
9/14
10/4
ORP (mV) 12'
Depth (M)
0
-5
-10
-15
4/27
5/17
6/6
6/26
7/16
8/5
8/25
9/14
10/4

Temperature

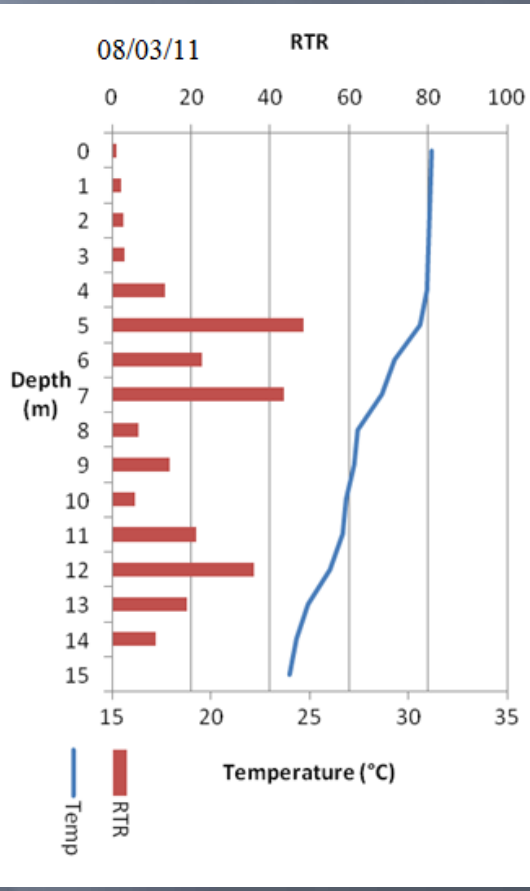


Deepening of 'Mixing Zone'

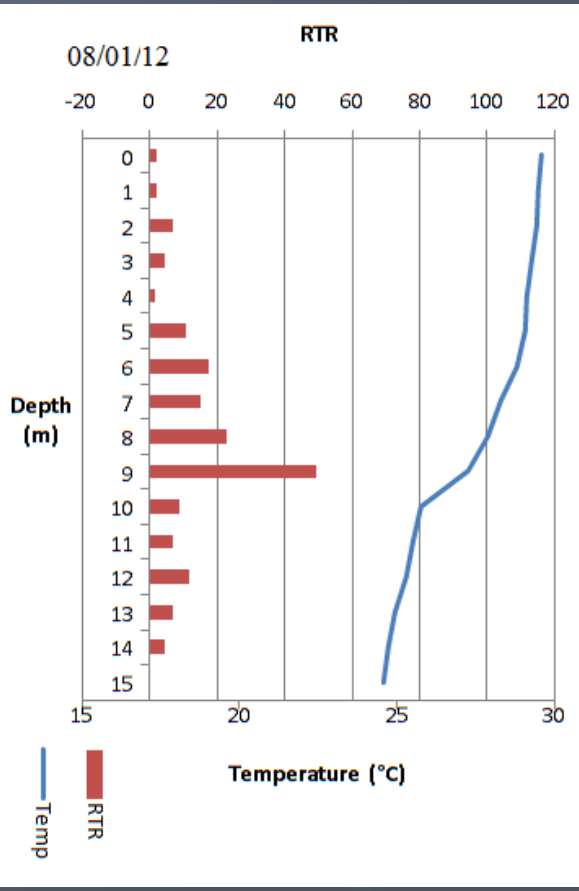
No SDOX



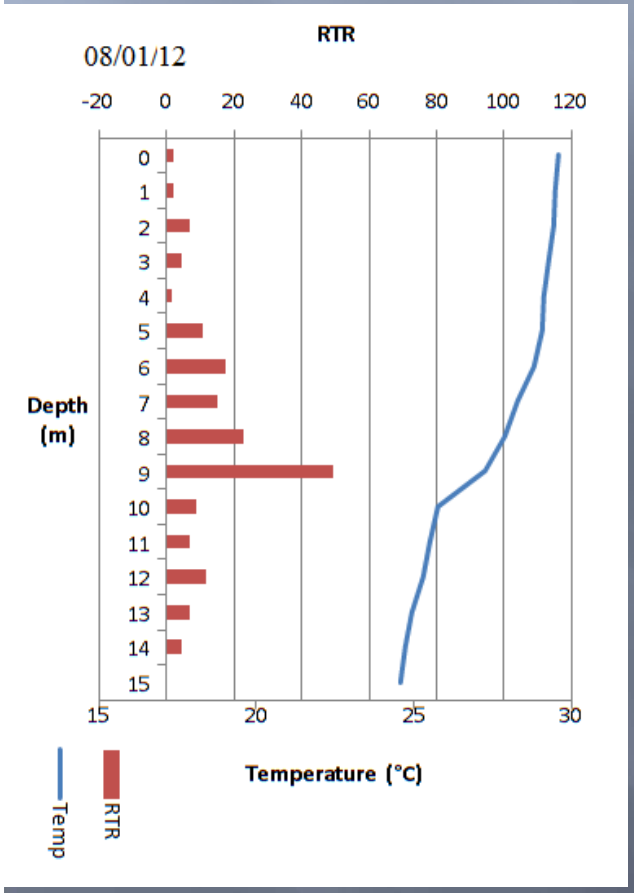
11' Configuration

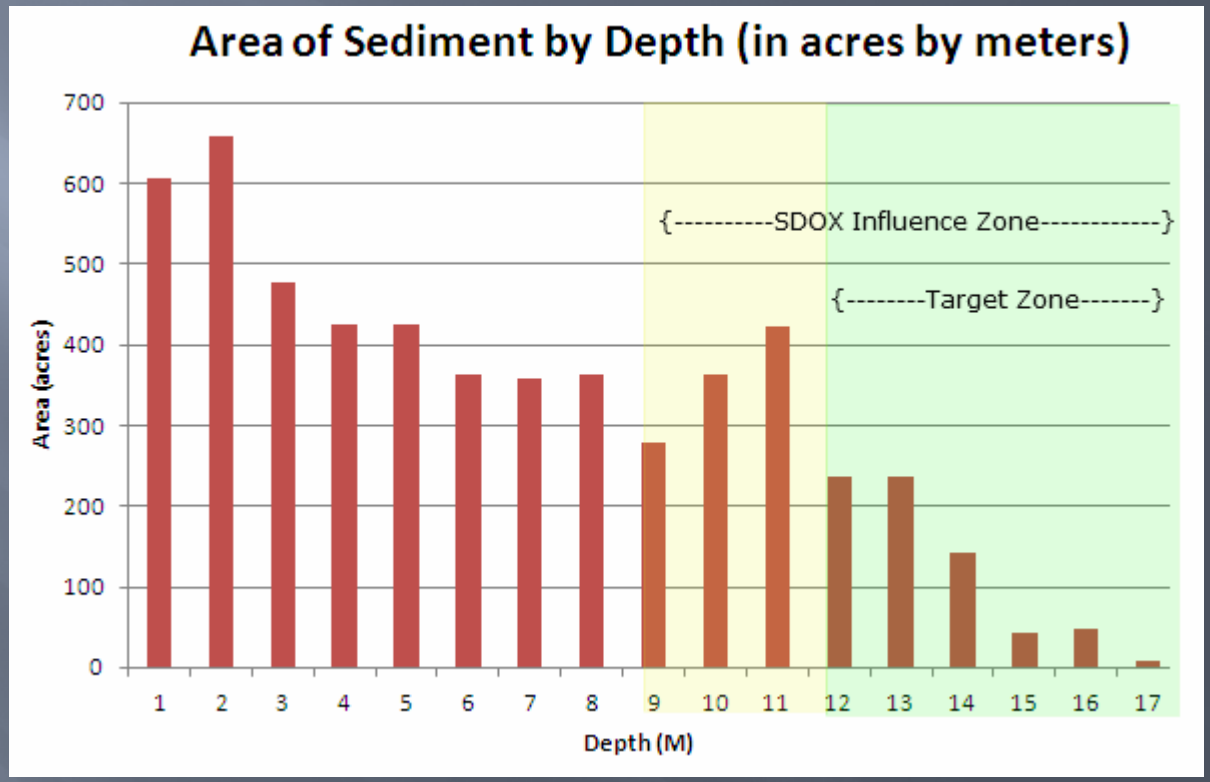


Current Configuration



Target area vs. Influenced area



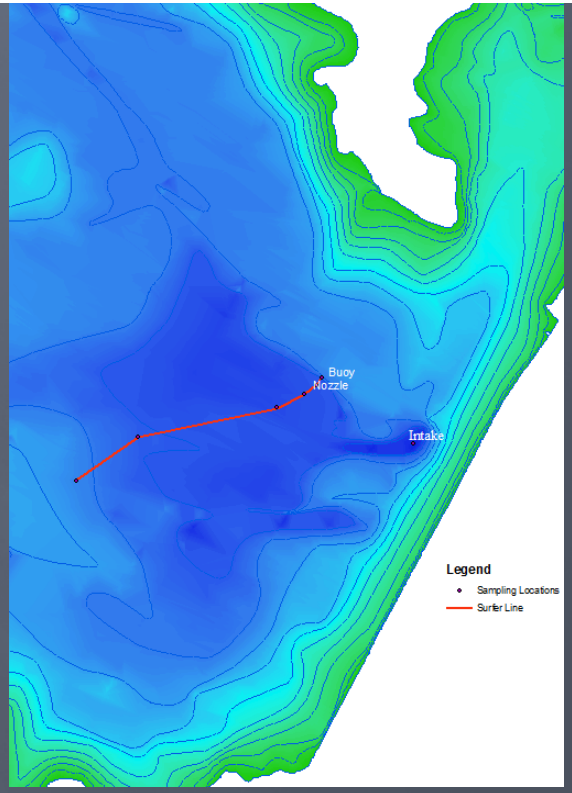


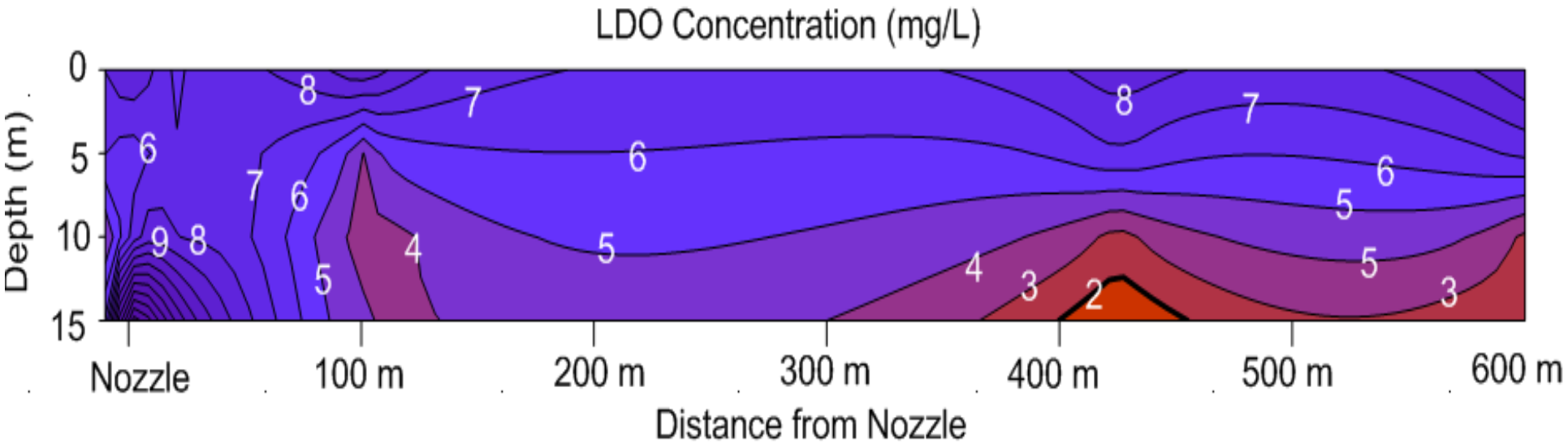
SDOX system attempting to treat 3 times the sediment area, and 6 times the volume than designed.

Data from 8-28-12

LDO Concentration near nozzle : 19mg/l (300% Saturation)

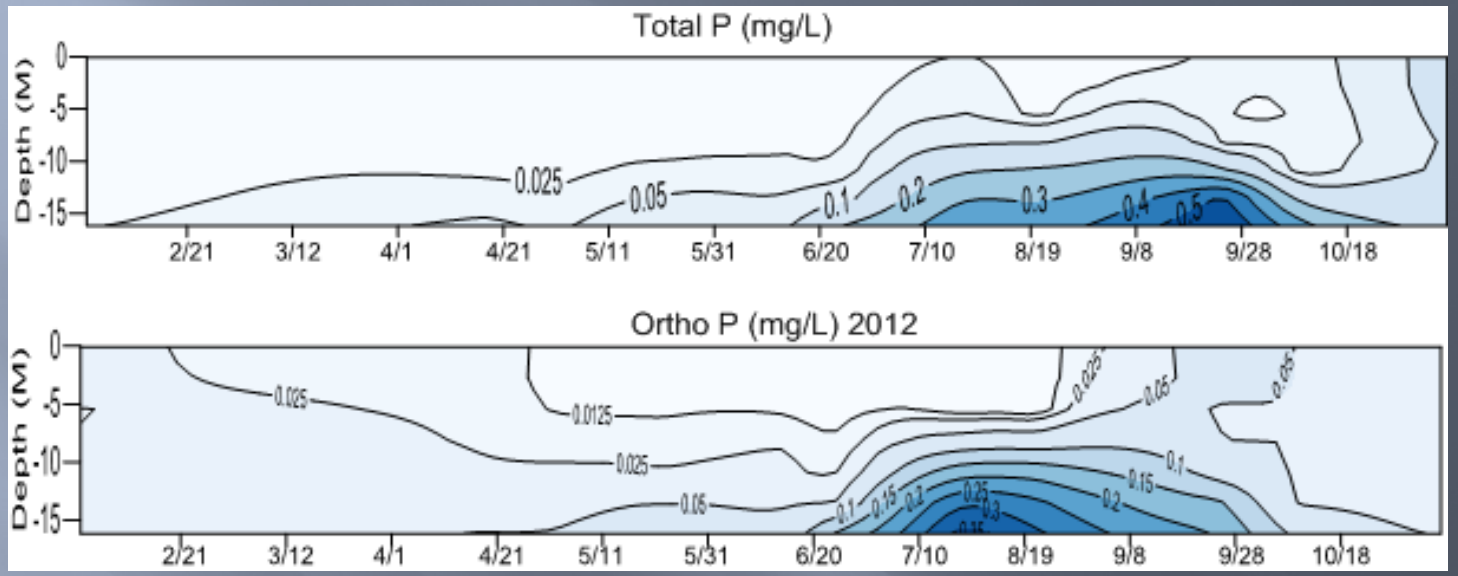
LDO Concentration is largely above 2mg/L within "target zone"





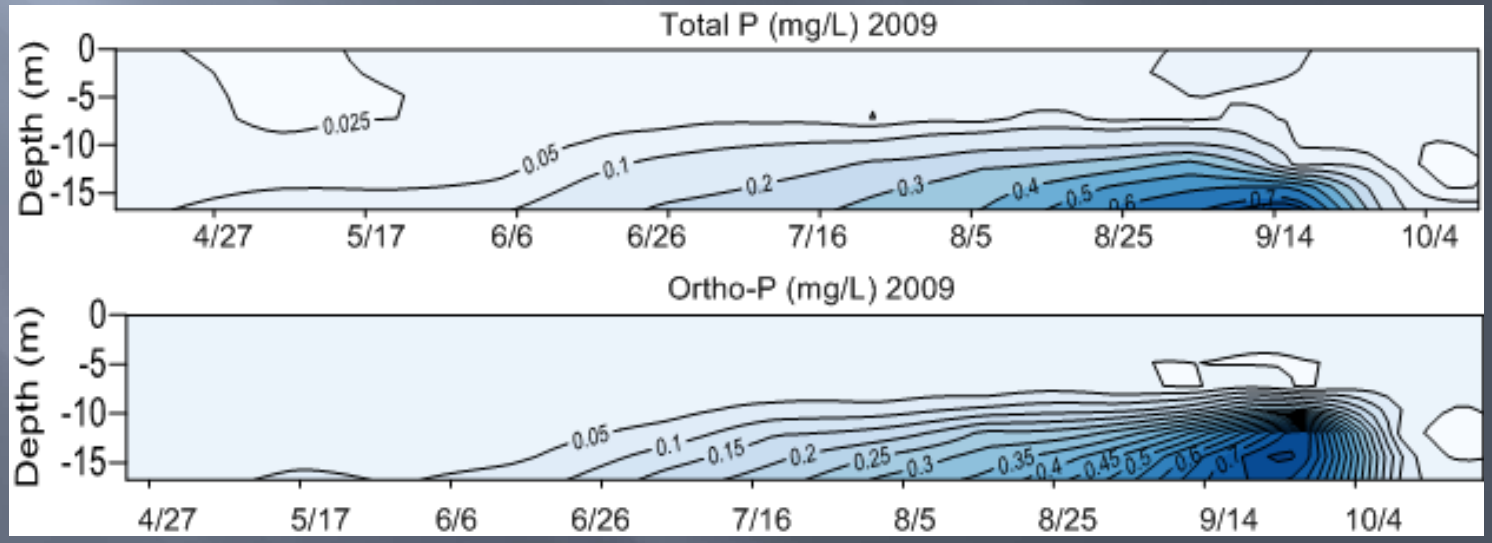
Phosphorus

2012

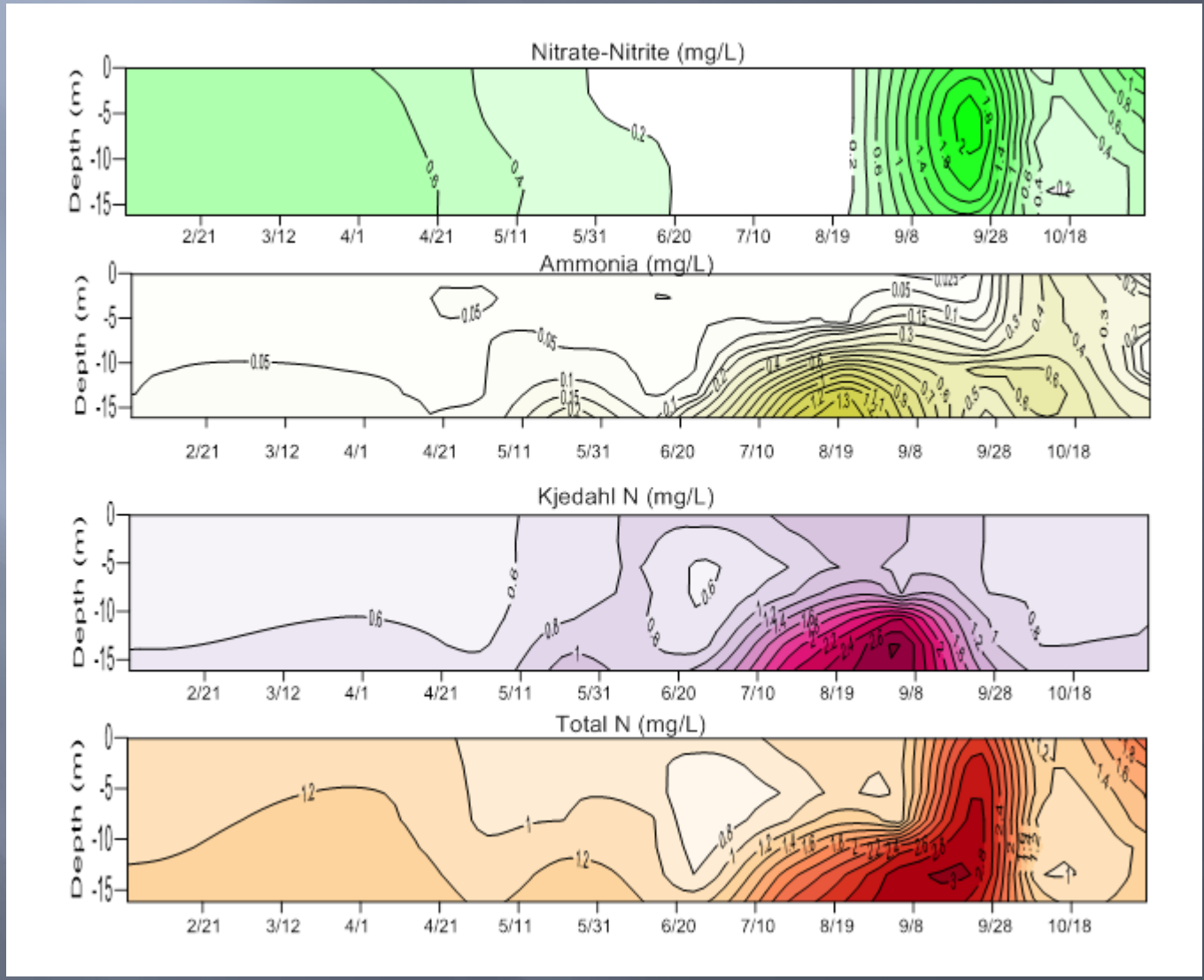


Anaerobically Mediated P release peaks mid July….

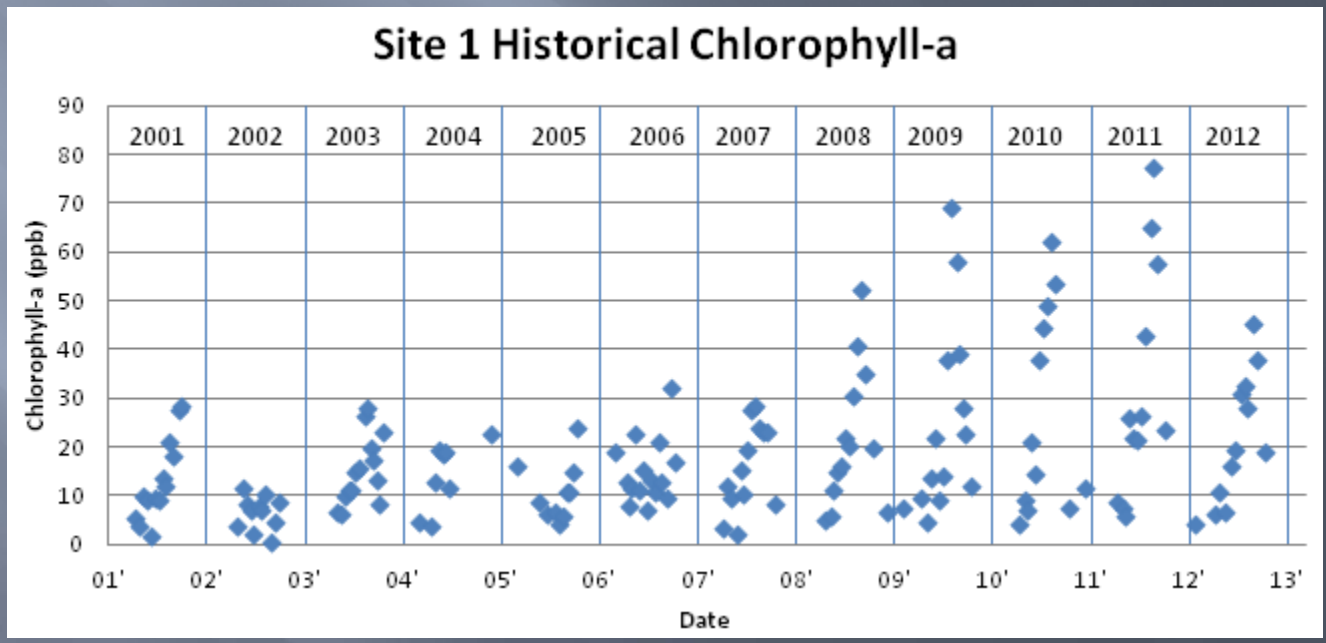
2009



Nitrogen Data

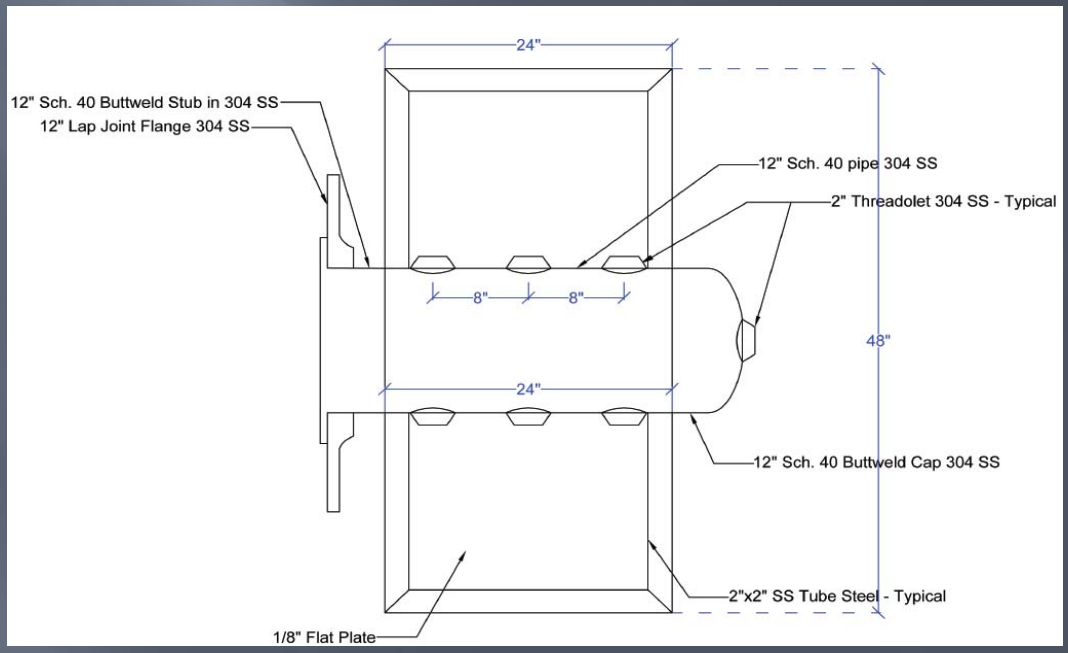


Historical Chl-*a* Dam Site



SDOX Effects

- July 2012-system modified
  - New Nozzle
  - Shut off torn west line
- Data collected suggests modification made significant impact



Performance Summary

The Good

- Modifications reduced mixing, more oxygen to the hypolimnion
- Increased dissolved oxygen & ORP; less dissolved nutrients
- Reduced peak Chl-a, lacustrine chl-a 20% less than 5 year average

The Bad

- Larger zone of influence
- Like 2011, 2012 showed artificial heat transfer to the lake bottom.
- Chl-a still is double the criteria for SWS lakes

Questions?

Thanks to Srini Sundaramoorthy of Tetra Tech and the Bureau of Reclamation Oklahoma Office