OKLAHOMA CLEAN LAKES AND WATERSHEDS
23rd ANNUAL CONFERENCE AGENDA

SUCCESS STORY:

20 YEARS

of HYPOLIMNETIC OXYGENATION of

a RESERVOIR

ECO$_2$

Agenda

- EBMUD & Camanche Reservoir
- Water Quality Challenges
- Speece Cone Technology
- Effects of Hypolimnetic Oxygenation on Water Quality

East Bay MUD

East Bay Municipal Utility District
in Oakland, CA

Supplies about
1.5 Million Residents
in the East Bay of San Francisco
with Drinking Water

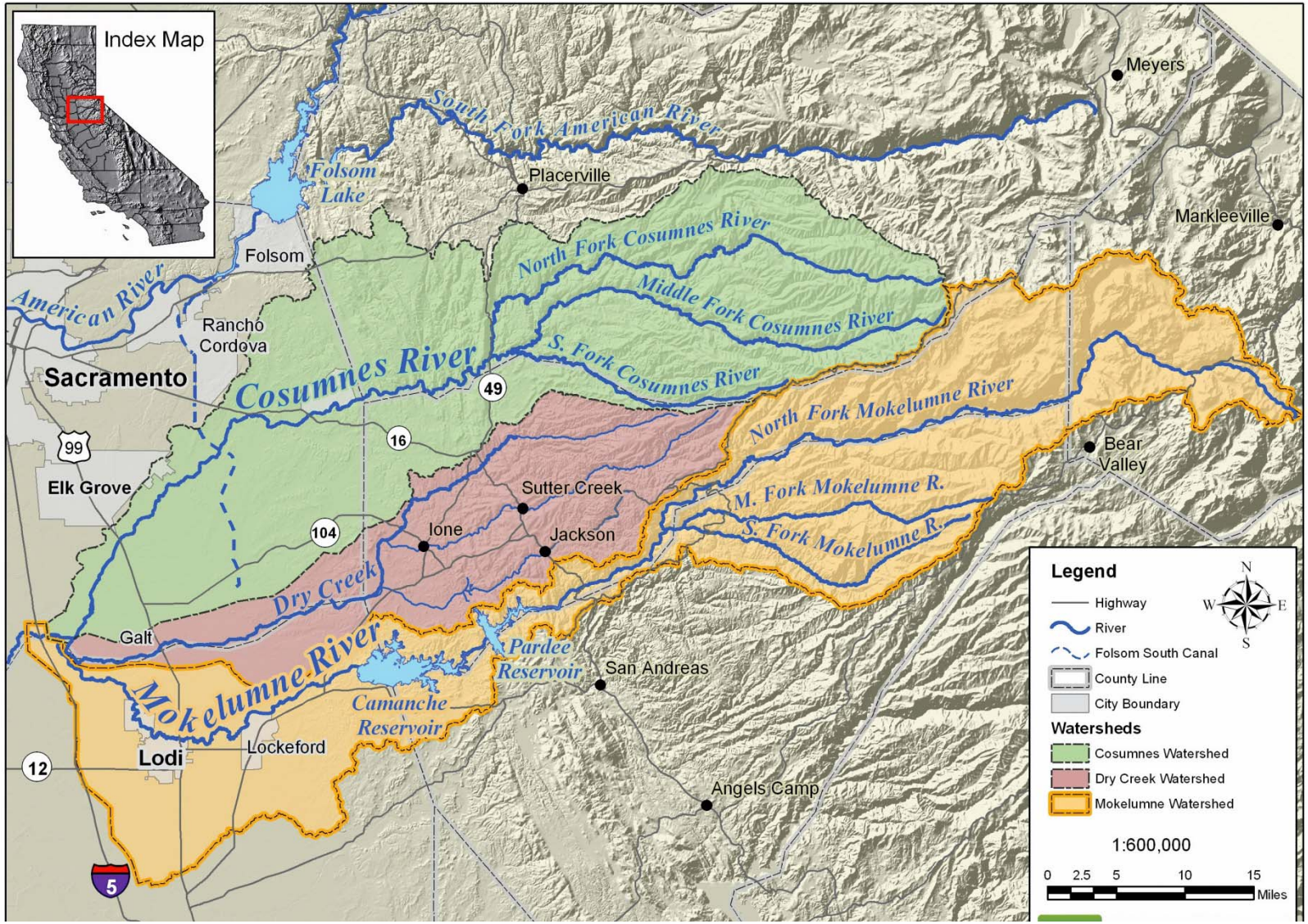
ECO2

East Bay MUD

In 1929 the Pardee Reservoir was built on the Mokelumne River

In 1964 the Camanche Reservoir was built 10 miles downstream of Pardee Reservoir

Lower Mokelumne River



Fishing in Lower Mokelumne River

The river supports several introduced and native fish:

- Chinook Salmon
- Steelhead Trout
- Largemouth Bass
- Stripers

Lower Mokelumne River Fish Hatchery

Built in 1964 at the base of the Camanche Dam to mitigate the loss of spawning habitat caused by the reservoir.

Camanche Reservoir

Used for:
- Flood Control
- Flow Regulation for downstream Irrigation Purposes
- Protection of In-stream Resources,
- Recreation
- Hydroelectric Power Generation

417,000 acre-feet max. volume
135ft max. depth

Camanche Lake Characteristics

Eutrophic

Summer Stagnation → Stratification

Droughts in 1987 and 1990 caused fish kills downstream

Cause: Seasonal Hypolimnetic Anoxia
& H_2S Generation in Sediment

Project Goals

- Prevent Fish Kills
- Eliminate H_2S, Prevent Anaerobic Conditions
- Maintain Cold Water Fish Habitat
- No impact on EBMUD's water supply needs

Balance Fishery Needs with Water Supply Needs

Alternatives Evaluated

- Hypolimnetic Oxygenation

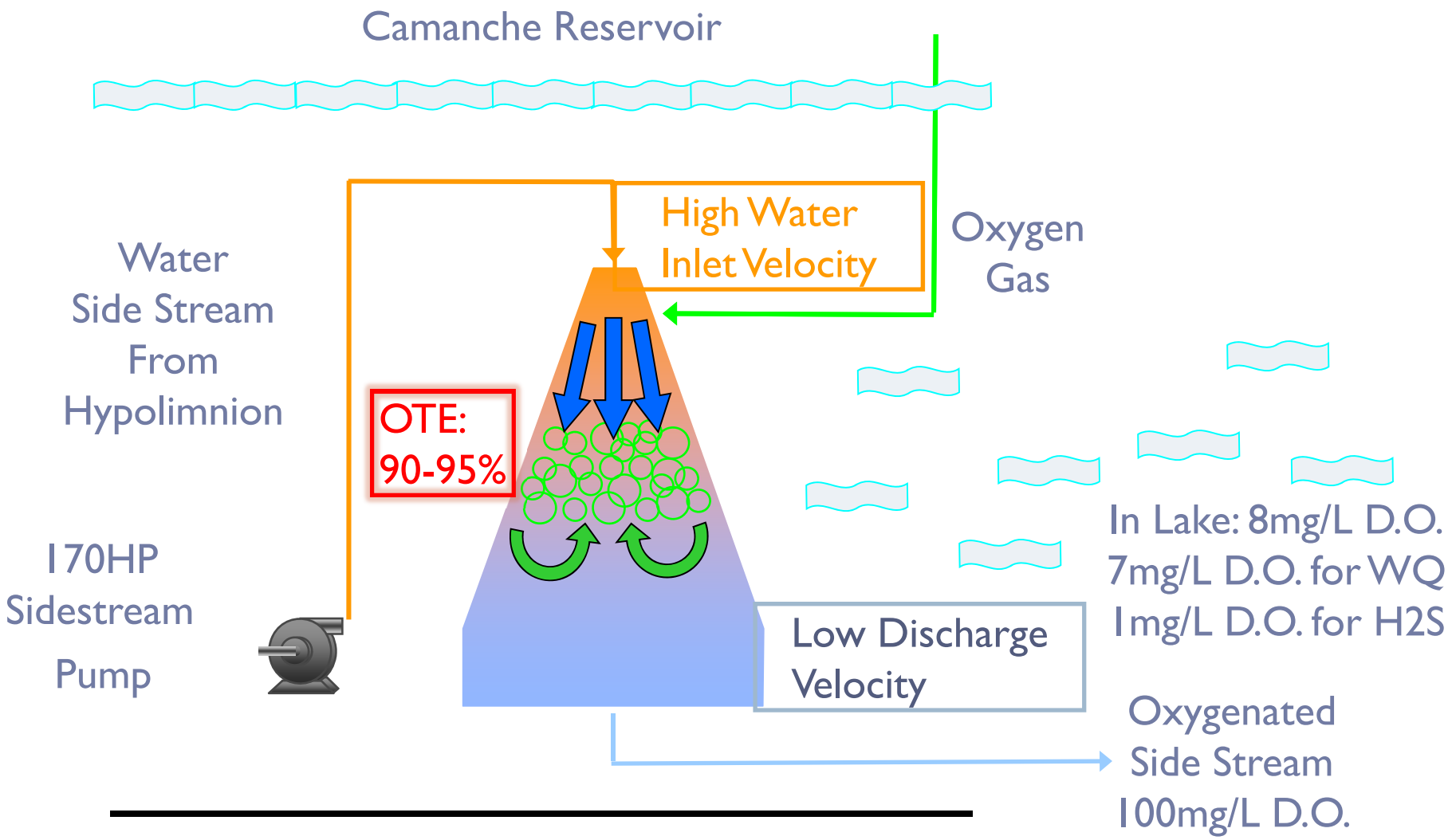
most cost-effective & feasible

- Multi-level intake structures

- Applying potassium permanganate plus aeration

- Diversion from Pardee Reservoir

“Speece Cone” Technology

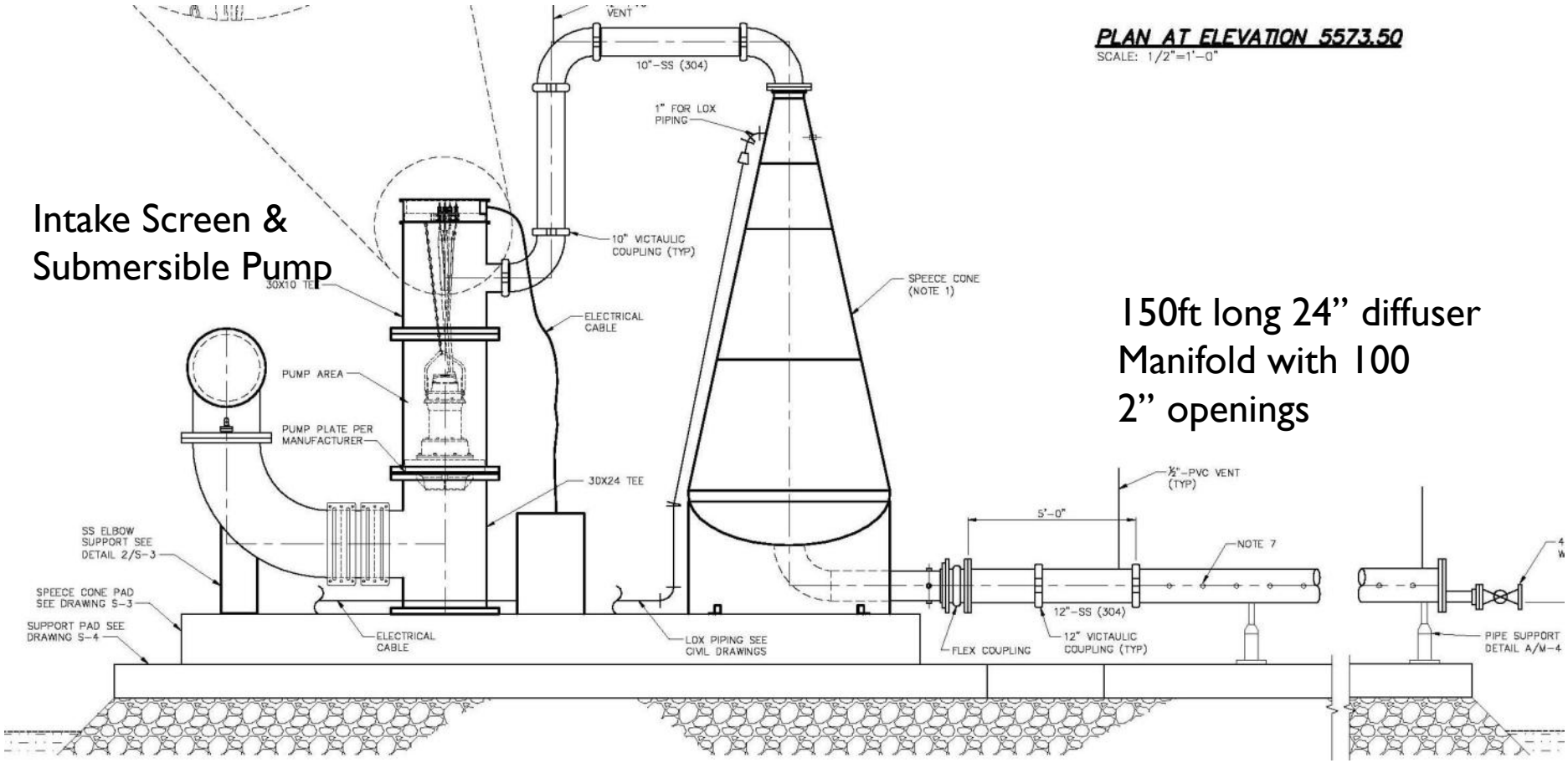


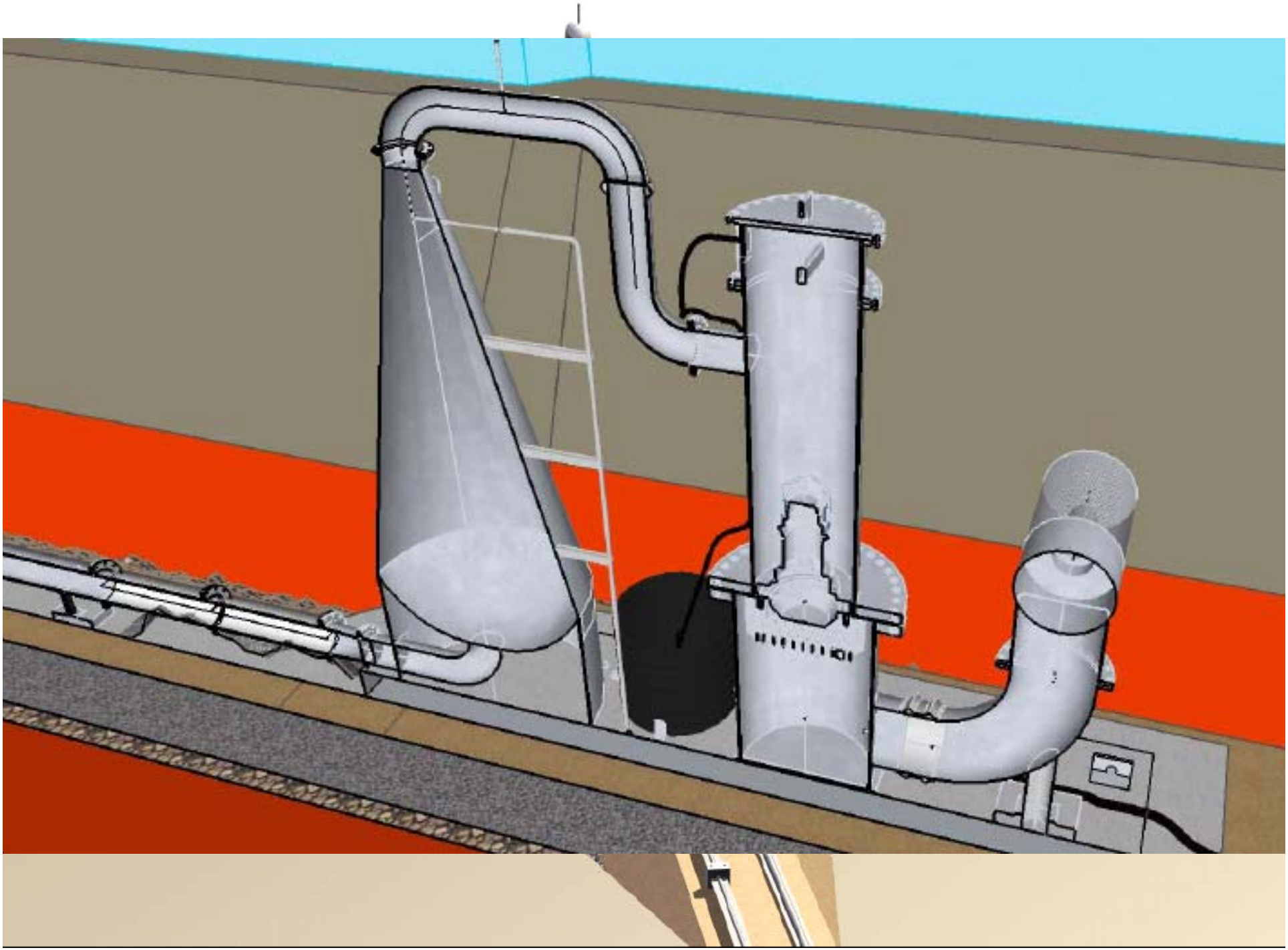
“Speece Cone” Detail

12ft diameter Speece Cone, 25ft high

Intake Screen & Submersible Pump

150ft long 24” diffuser Manifold with 100 2” openings





Speece Cone Installation, 1993

350ft from Dam @ approx. 100' depth
70-200scfm depending on depth 16,000 lb O2 / day

Cone D.O. Discharge 100 mg/L

Effects on Water Quality

D.O. Increase 2m off the Bottom

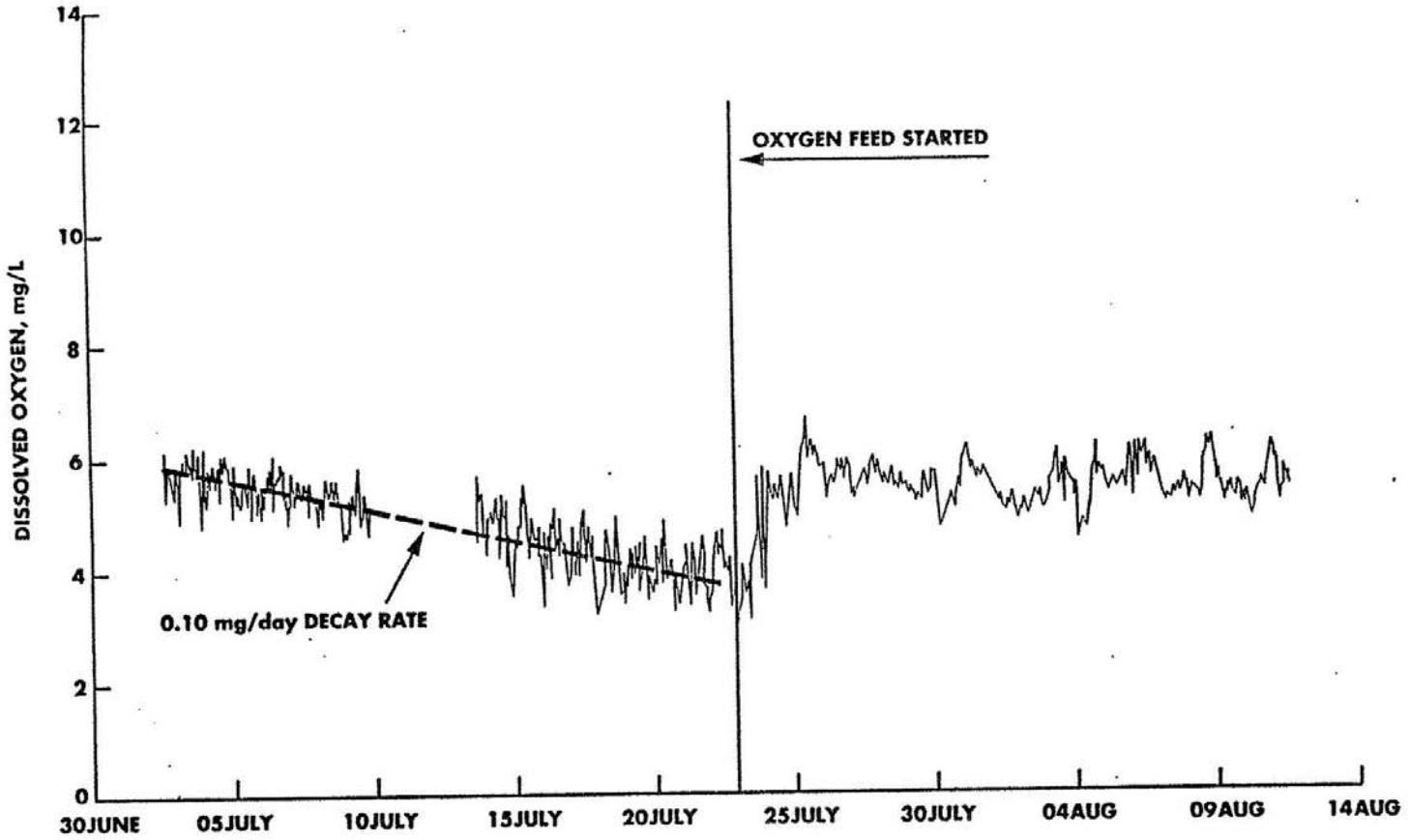
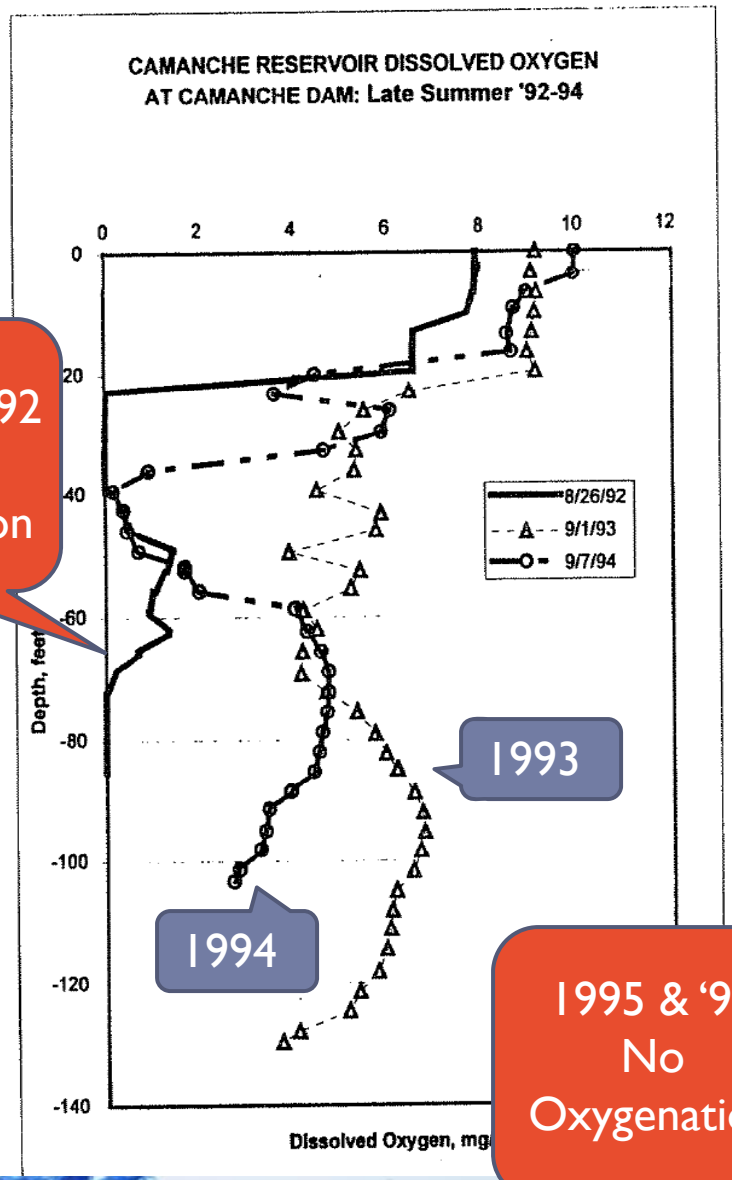
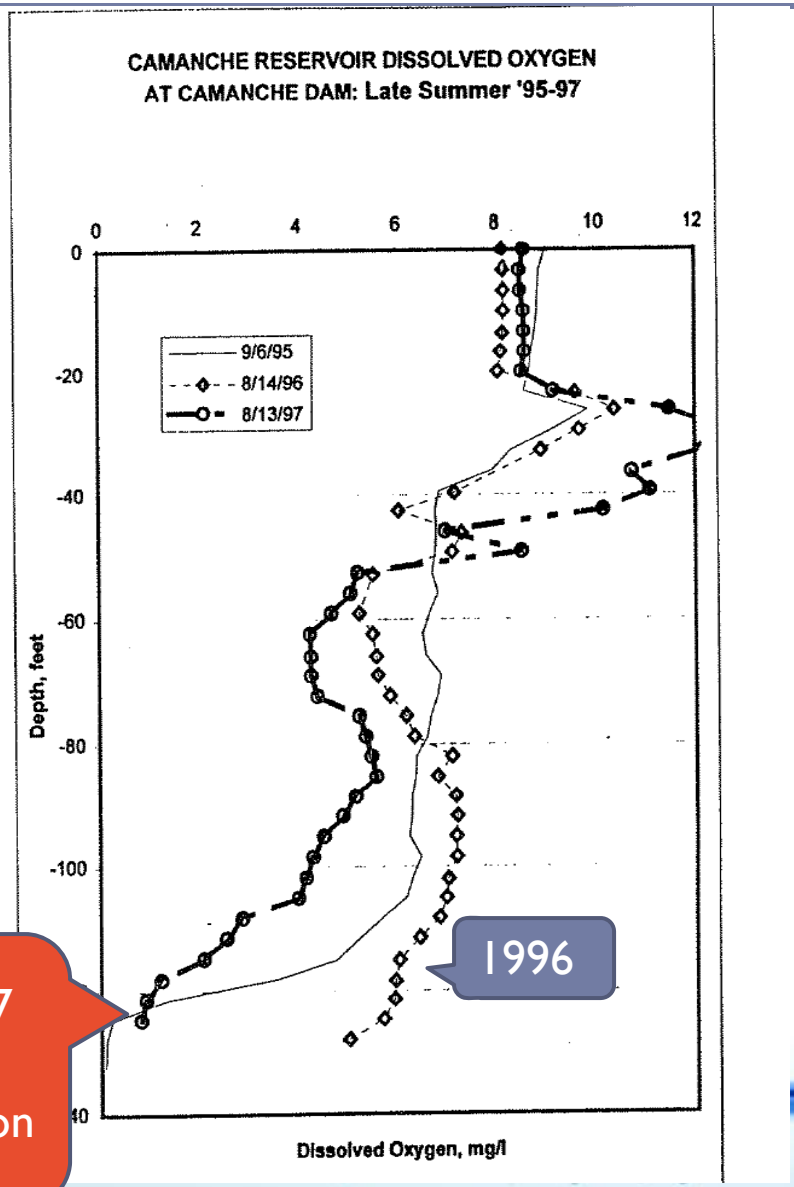


Figure 5 Initial effects of the oxygenation system on dissolved oxygen near the Speece Cone in 1993 (About 2m off the bottom).

D.O. Profile





Baseline 1992
No
Oxygenation

1993

1994

1995 & '97
No
Oxygenation

1996

Oxygen Plume

Oxygen plume extended > 10,000ft
After 40 days of oxygen feed

H_2S Oxidation requires a minimum of 24hours
→ Plume was large enough to provide this

Final plume extends **3 miles** into the reservoir

Nutrient Levels

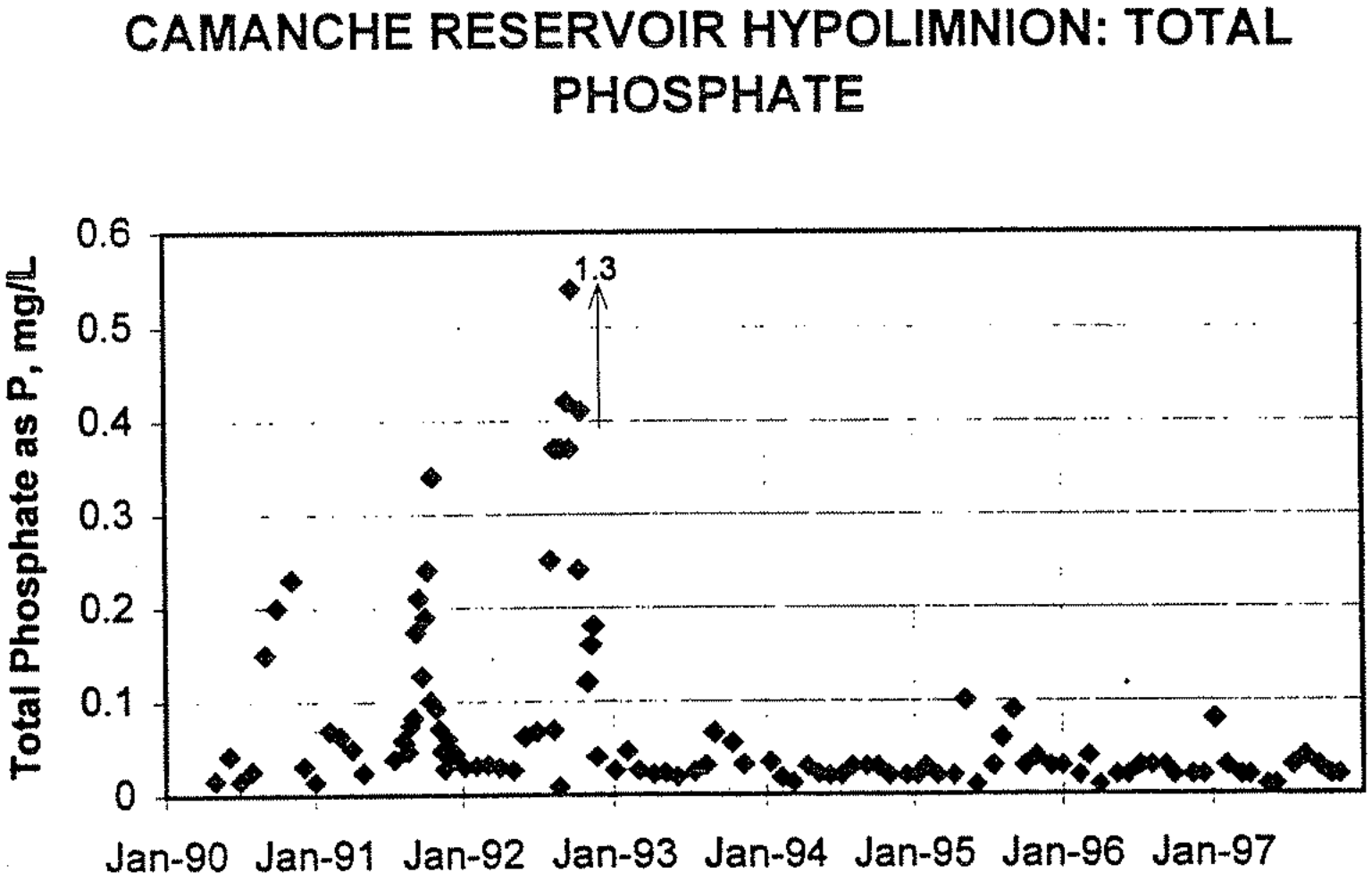
Oxygenation suppressed internal nutrient loading !

All nutrient levels decreased:

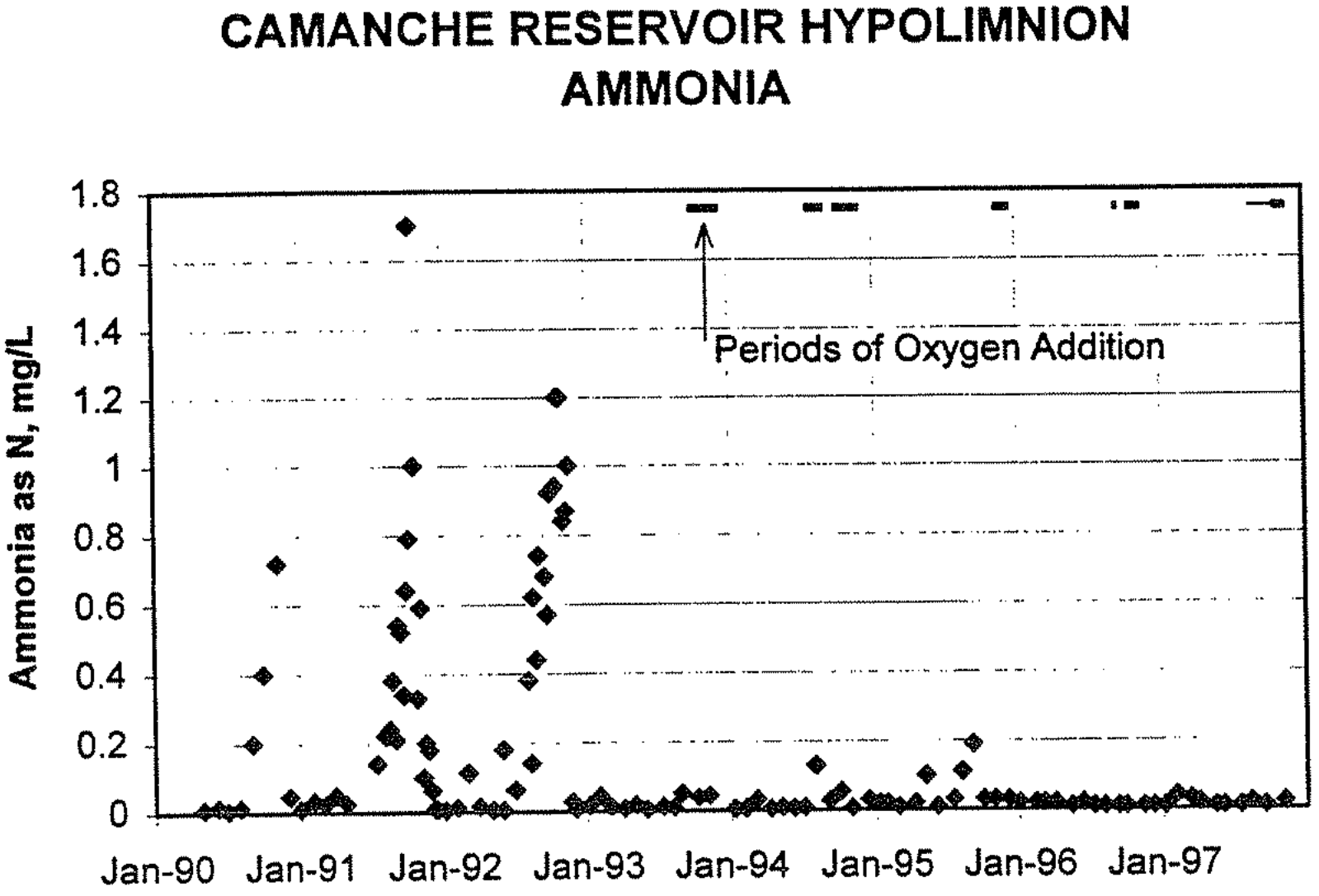
Soluble Phosphorous in the Hypolimnion declined three-fold from 123 to 38 µg P/L

Ammonia fell ~ 70 fold (706 to < 10 µg N/L)

Nutrient Levels - Phosphate



Nutrient Levels - Ammonia



Later Winter Surface Conditions

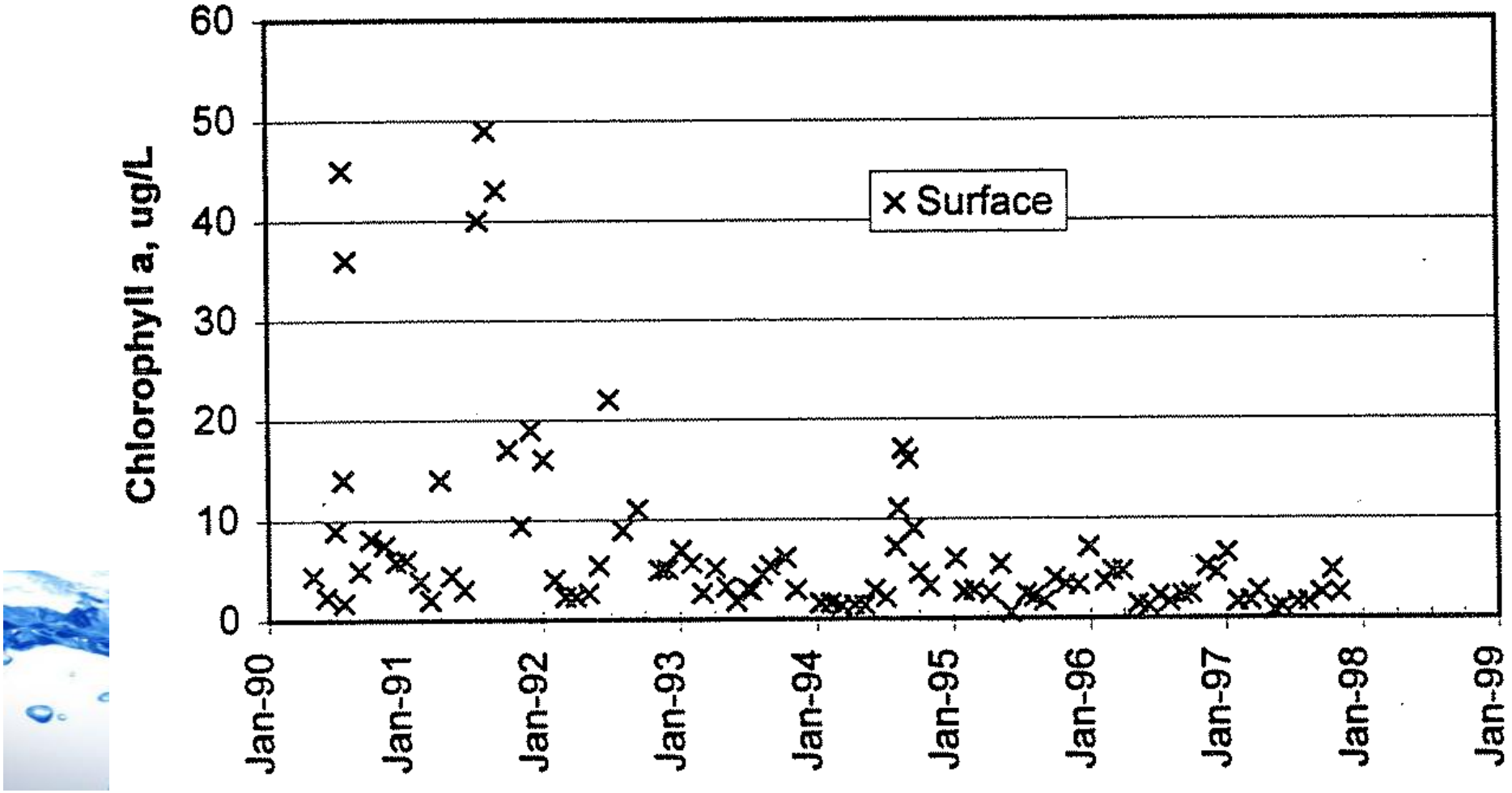
Nutrients available for Spring algae bloom:

TP fell 58% (33 to 14 µg/L),

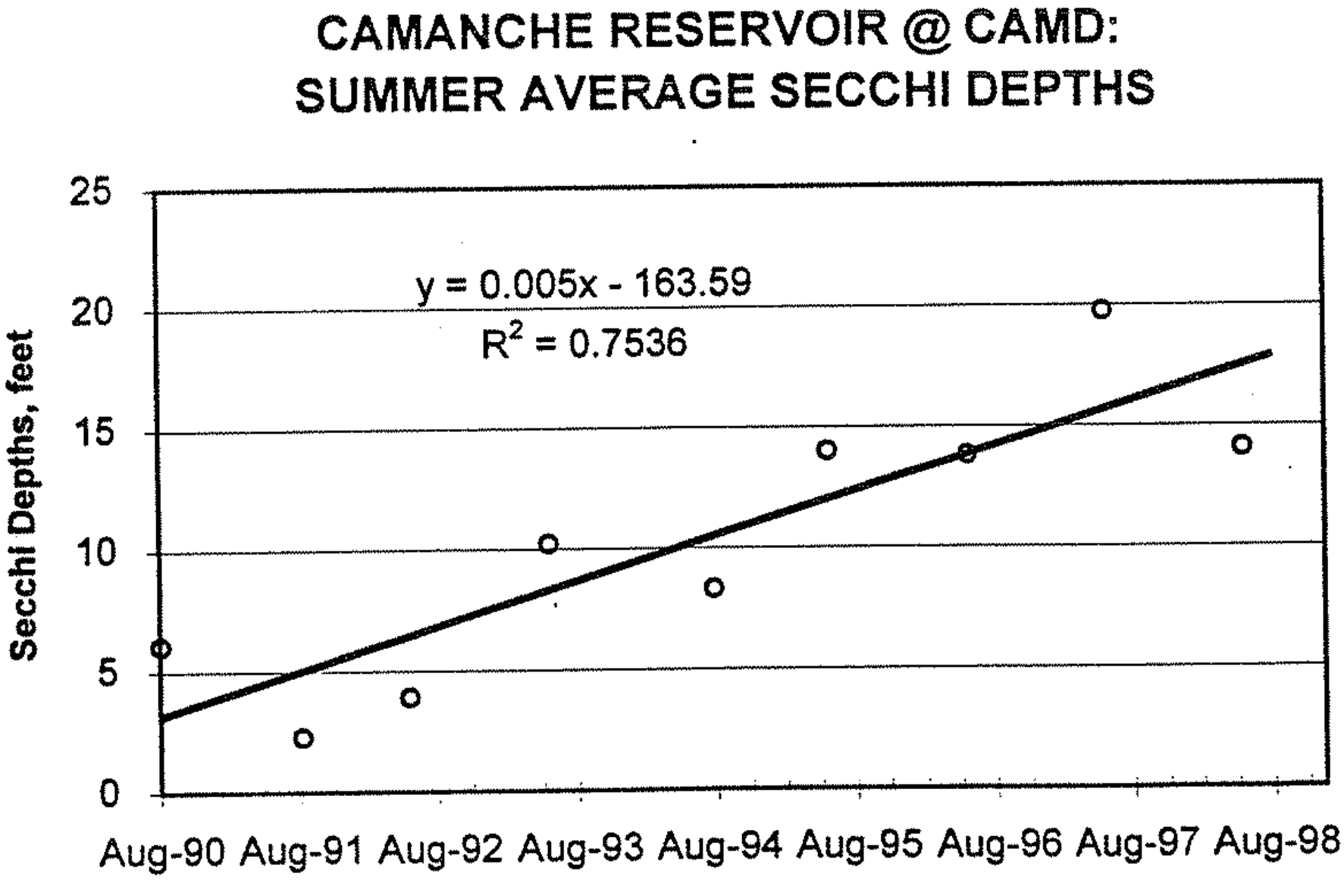
TIN was down 88% (190 to 23 µg/L)
(Relative to pre-HOS conditions)

TIN : TP ratio fell from 6 to 1.6.

Chlorophyll A at the Surface



Secchi Depth



Algae Growth

After 12 years of Hypolimnetic Oxygenation:

Nitrate declined further (42 to 3 µg N/L)

Chlorophyll declined an additional 50% (88% overall).

Low inorganic nitrogen apparently forced algae to oligotrophic low levels despite the moderate TP values that indicate mesotrophy.

Algae Growth

Large blooms of the colonial blue-green algae,
Aphanizomenon and *Anabaena*

declined by over 93% in the first five years
and over 99% thereafter

The common colonial diatom *Fragilaria* dropped 71%.

Conclusion

20 Years of Hypolimnetic Oxygenation

Switched the trophic stage of Camanche Reservoir from

Eutrophic → Mesotrophic

No more H_2S / Fish Kills

Due to the cold, dense and horizontally flowing blanket of high D.O. concentrations above the bottom sediment.

Questions ?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