CCR DESTRATIFICATION SYSTEM

AND OTHER IN-LAKE TREATMENT

Wayne Lorenz

CHERRY CREEK BASIN WATER QUALITY AUTHORITY

WWE
WRIGHT WATER ENGINEERS, INC.

AGENDA – BASIS OF STUDY

- Describe the Existing Compressed Air Destratification System
- Overview the Performance of the Existing Destratification System
- Investigate Expansion of the Existing System Based on Hydros Model
- Identify Other Possible Technologies for In-Reservoir Treatment

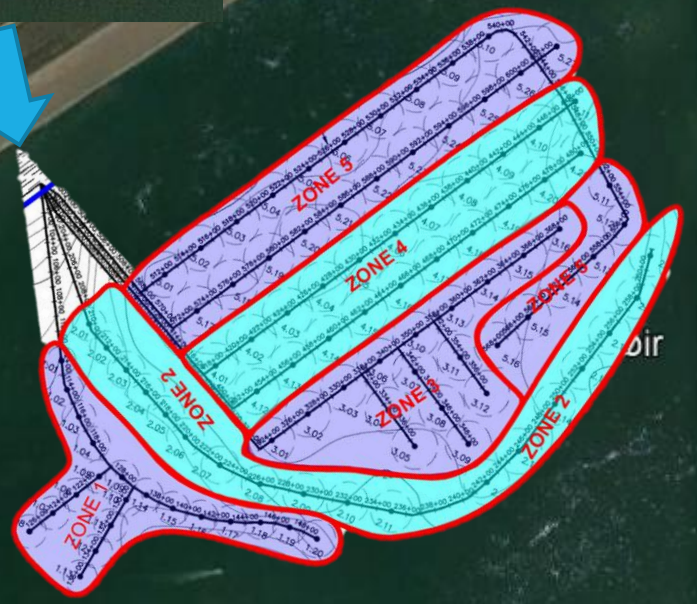
DESTRATIFICATION SYSTEM OBJECTIVES - 2005

- Reduce Nutrient Releases from Sediment
- Decrease Seasonal Mean Chlorophyll α by About 8 ug/L
- Decrease Annual Peak Chlorophyll α
- Increase Dissolved Oxygen Concentrations at Bottom
- Reduce Blue-Green Algae

DESTRATIFICATION SYSTEM

Manifold Manholes (5)

Compressor Building

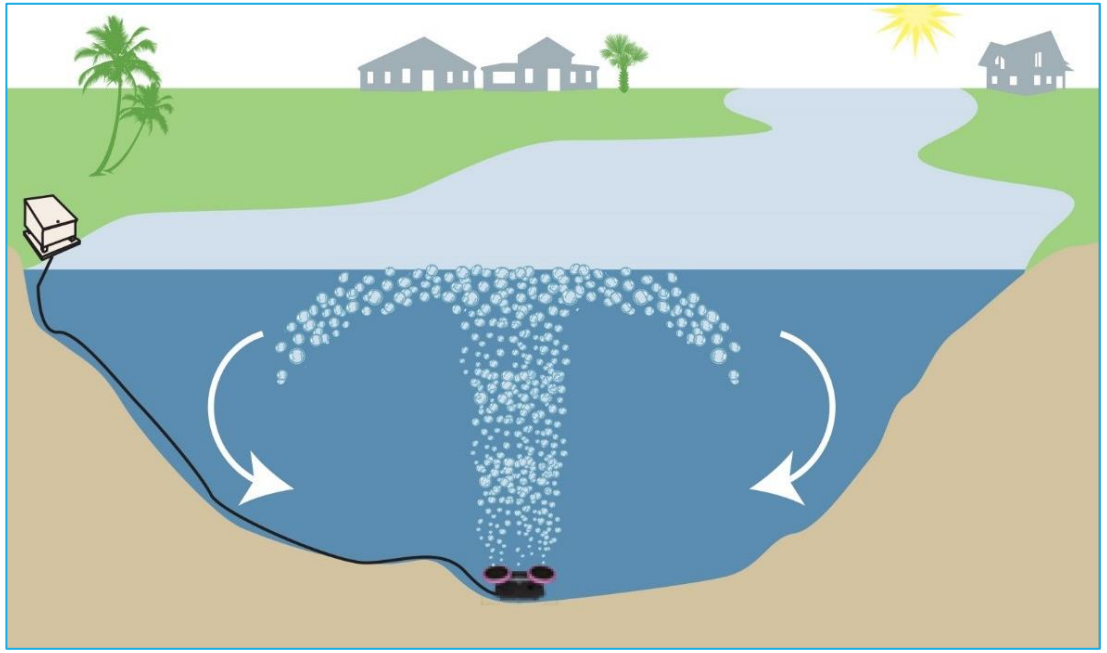


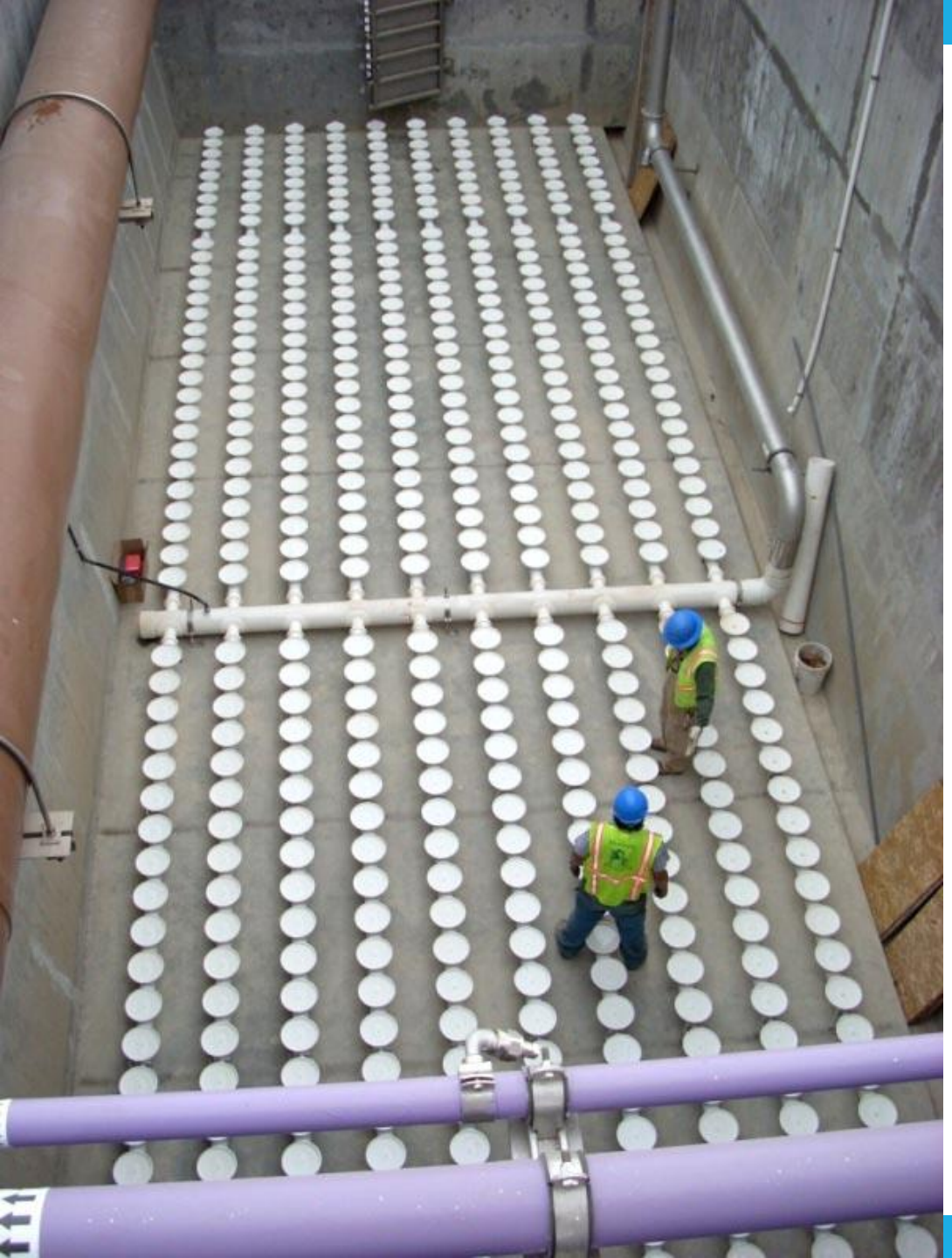
2928 ft

Google Earth

EXISTING SYSTEM DESCRIPTION

- Bubble Plume Diffusers – Rely on Lake Surface Oxygenation
- Diffuser Spacing 250 to 350 Feet
- Rotary Screw Air Compressor – 125 Horsepower
- Original 102 Diffusers – In 2009 Increased to 116 Diffusers
- Compressor Building
- Capital Costs $970,000



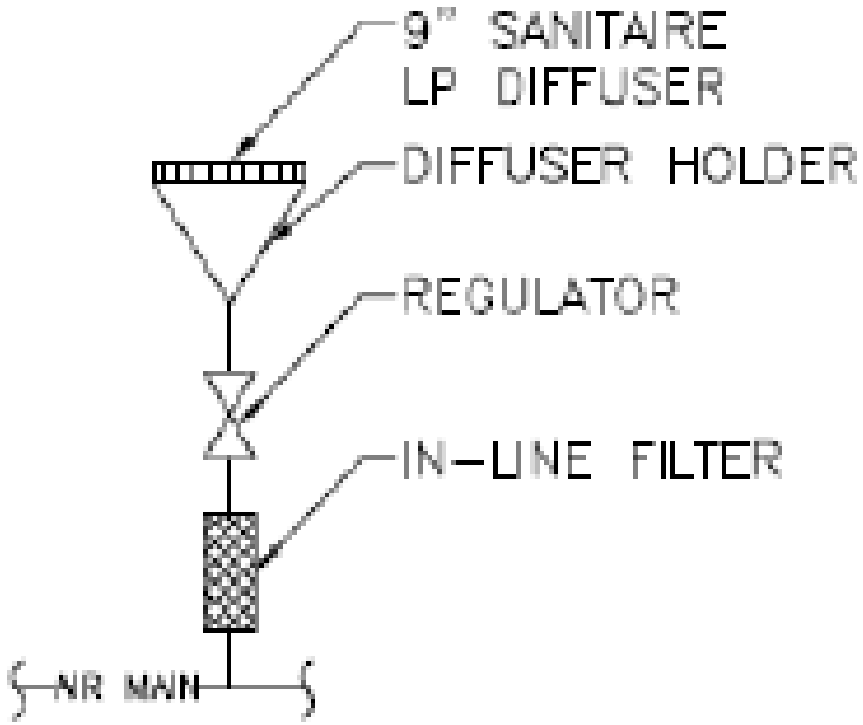


UNLIKE WASTEWATER TREATMENT PLANT REACTORS


NOT AN
EXIT

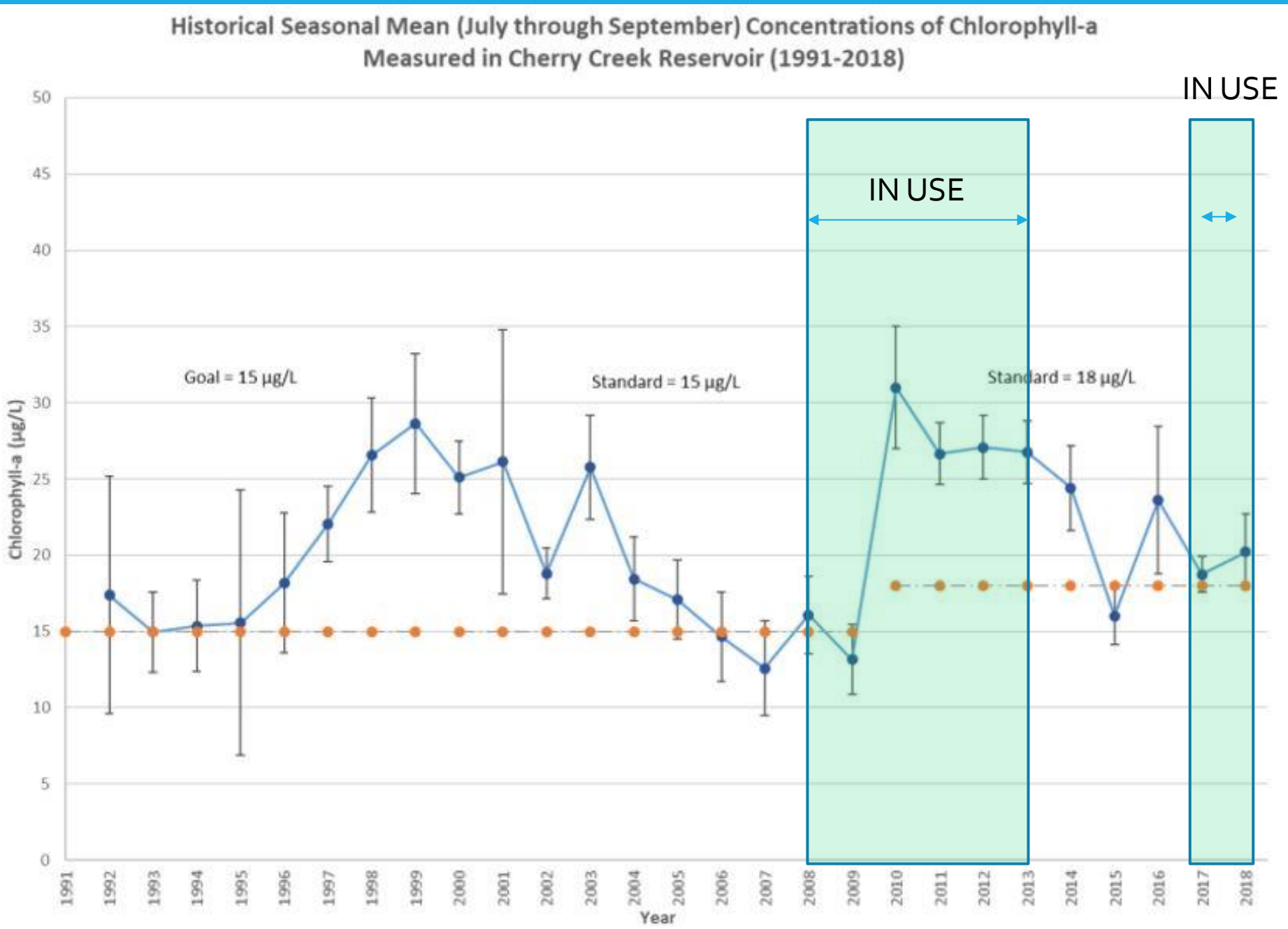

ZONE 200
WATER
ZONE 100

DIFFUSER ASSEMBLY – 116 TOTAL



HISTORY – CURRENT SYSTEM

- 2006 Design
- 2007 Construction
- 2008 Startup
- 2012 Evaluation of Compressor Overheating and Noise
- 2014, 2015, and 2016 Did Not Operate System
- 2017 and 2018 Operated May through July 1

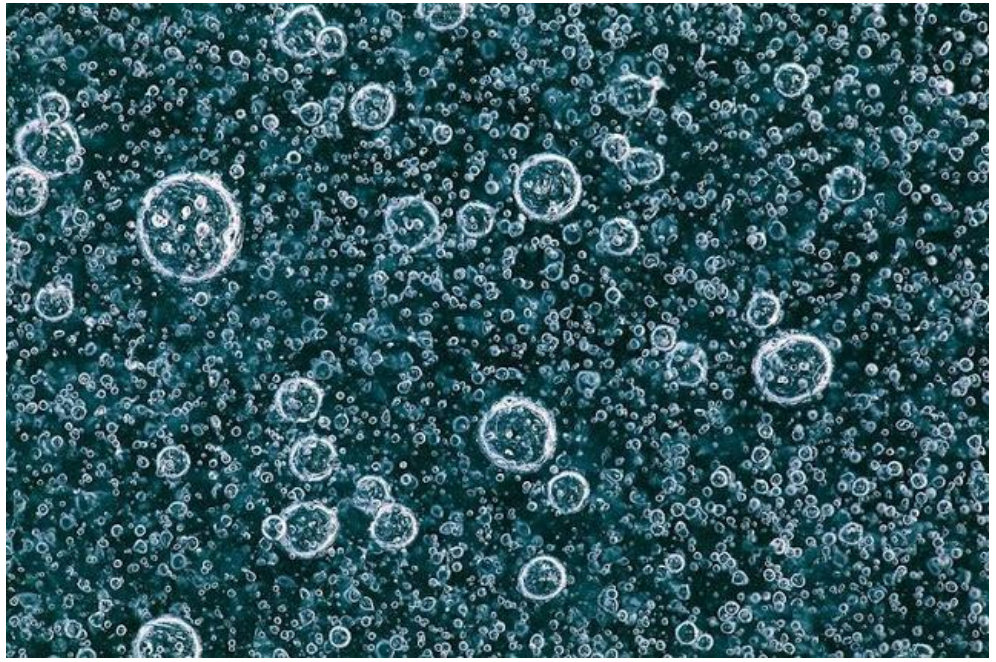

Historical Seasonal Mean (July through September) Concentrations of Chlorophyll-a
Measured in Cherry Creek Reservoir (1991-2018)
IN USE
IN USE
Goal = 15 µg/L
Standard = 15 µg/L
Standard = 18 µg/L
Chlorophyll-a (µg/L)
Year
0
5
10
15
20
25
30
35
40
45
50
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

SUMMARY - EXISTING SYSTEM ISSUES

- Mixed Results as Measured by Water Quality
- Compressor Was Oversized Without Variable Speed or Receiver Tank
- Building Ventilation System Inadequate
- Overheating and Shut Down

MODIFYING AND EXPANDING THE DESTRATIFICATION SYSTEM

- Reservoir Bubble Plume Model Simulations (Hydros)
  - No Compressor Shutdowns
  - Increased Airflow to Existing Number of Diffusers
  - Additional Diffusers at Same Airflow to Each Diffuser
  - Additional Diffusers and Increased Air Flow to Each Diffuser

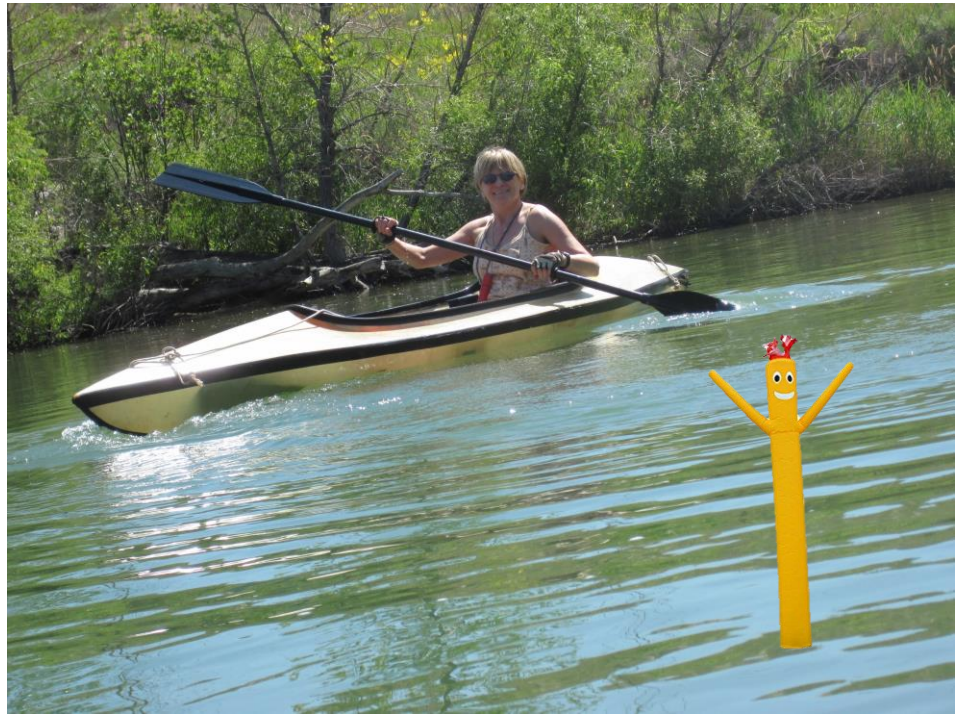


EXPANSION OF THE DESTRATIFICATION SYSTEM – TO SEE MODEST IMPROVEMENT

- Replace Existing Compressor
- Use Existing Building with a Modified Building Air System
- Expand the Number of Diffusers (to 232) and Consider Different Type of Diffusers
- Larger Pipelines to Deliver the Additional Air
- Estimated Capital Cost $2.14 million

OTHER IN-RESERVOIR APPROACHES

- Single Periodic Dose Aluminum Sulfate Treatment
- Sediment Removal and/or Deepening the Reservoir
- Side Stream Liquid Oxygen



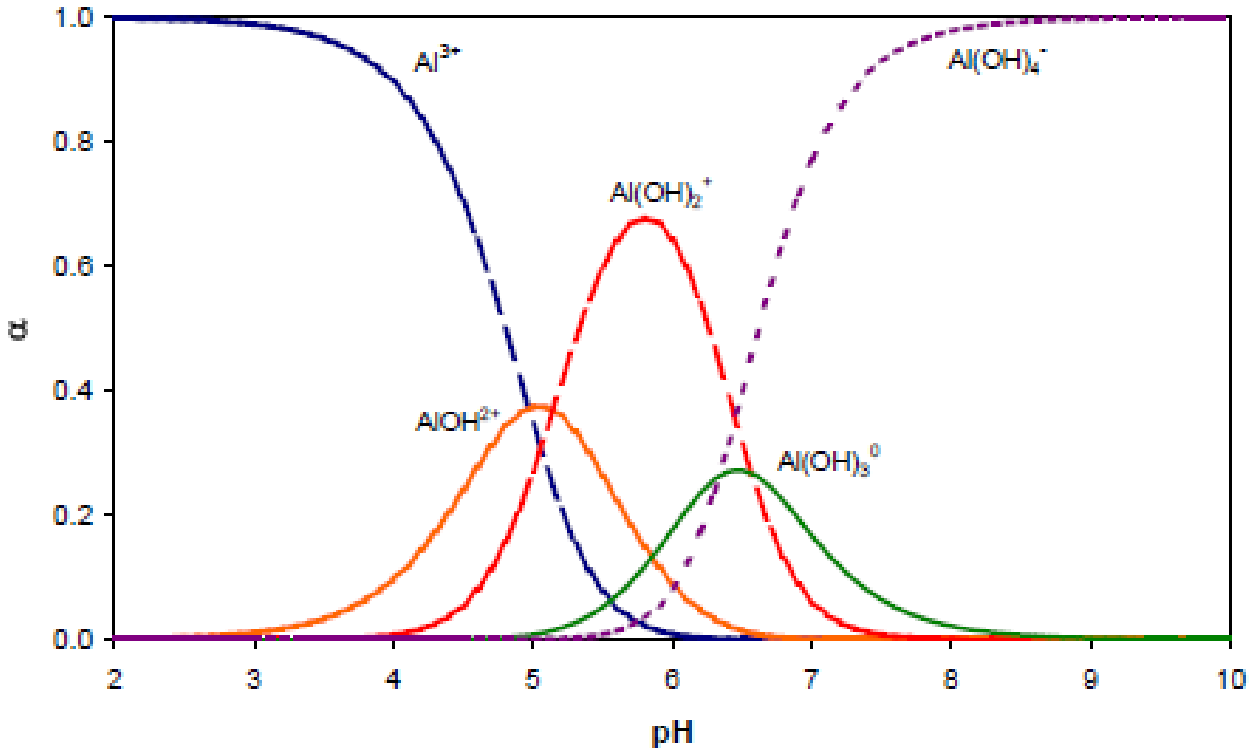
ALUM DOSE POSSIBLE BENEFITS FOR CCR

http://habaquatics.com/fremont-state-lake-20-a-case-study/

- Reduce Phosphorus
- Drive a Phosphorus Limit for Productivity
- Reduce Chlorophyll α
- Many Lakes Proven Water Quality Improvements

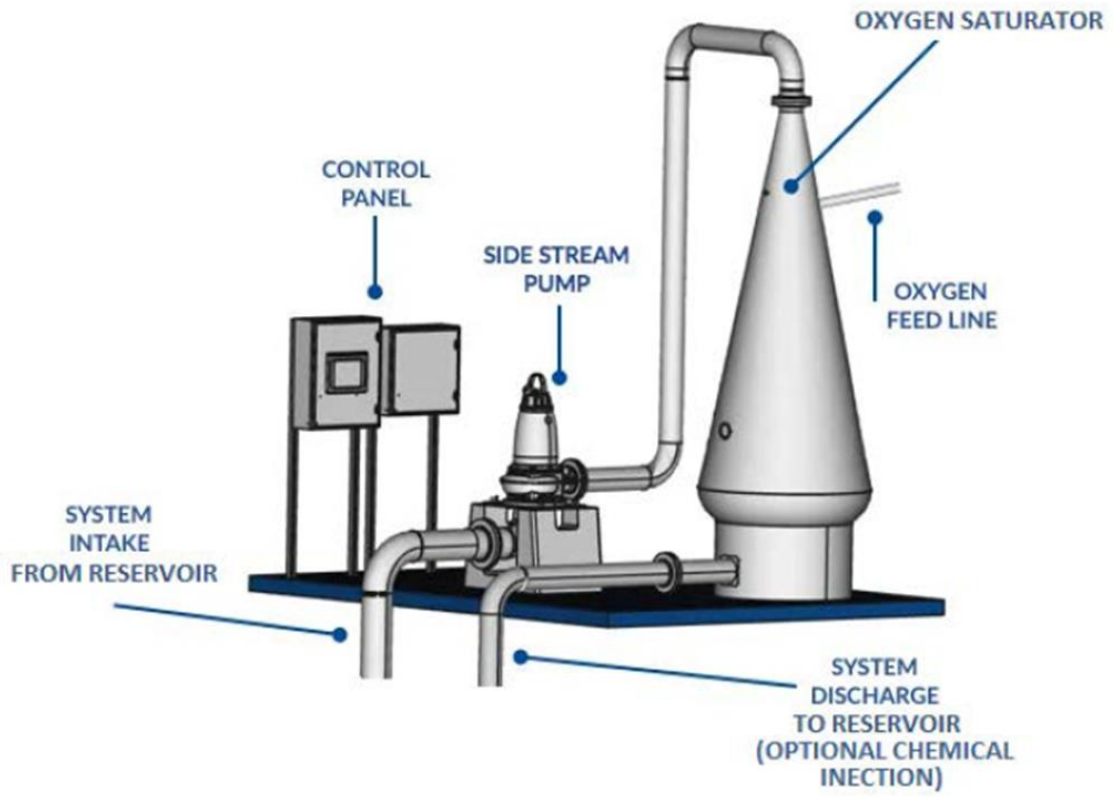
ALUM CONSIDERATIONS

- Model Simulations
- Ecological Aspects
- Water Quality Aspects
- Bench Scale Investigations
- Pilot Scale Investigations



SIDE STREAM LIQUID OXYGEN

- Good Track Record for Application
- Oxygen is Introduced at the Bottom of the Reservoir
- Oxygen Efficiency is Greatest
- Alum Addition Option



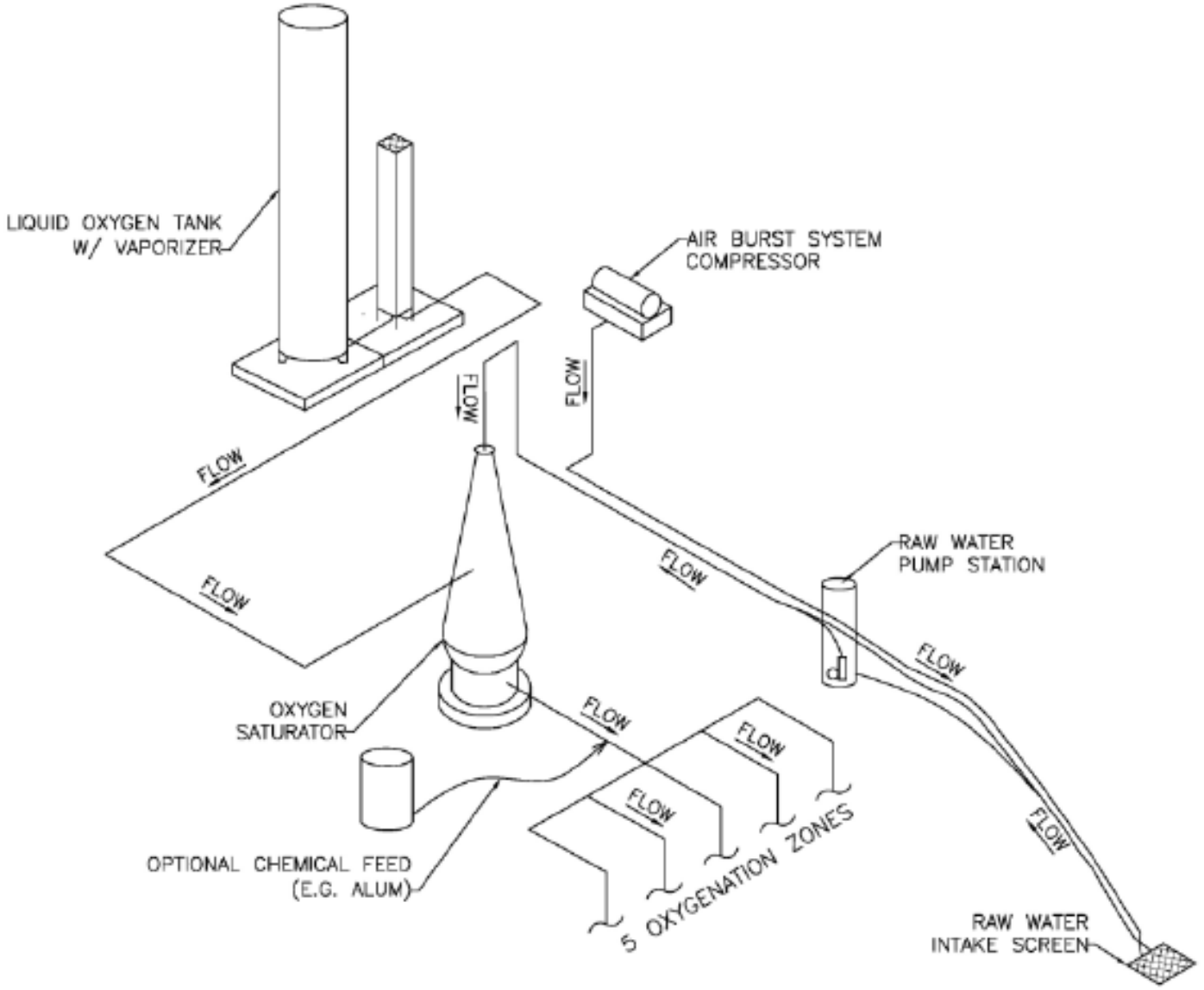


Figure 16. Conceptual Process Flow Diagram for the Side Stream Liquid Oxygenation System Alternative.

Figure 18. An Existing Liquid Oxygen Storage Tank and Vaporizers.

Liquid oxygen deliveries would include delivery of 20 tons of oxygen every two and a half weeks.

SUMMARY OF CONCLUSIONS

- Even with Significant Expansion, the Existing Aerated Destratification System Will Not Meet the Chlorophyll α Limit.
- Additional Diffusers Would Result in Lower Chlorophyll α
- Evaluation of the Proper Use of Alum May Represent Most Efficient Approach
- A Side Stream Liquid Oxygen System Could Provide Greater Water Quality Benefit
- Higher Dissolved Oxygen Levels to Bottom Portion
- Means to Add Alum During Periods of Higher Phosphorus