Lake Elsinore Sediment Oxygen Demand and Nutrient Flux Study

Lake Elsinore Canyon Lake TMDL
Task Force Meeting - March 3, 2025

GEI Consultants

Purpose

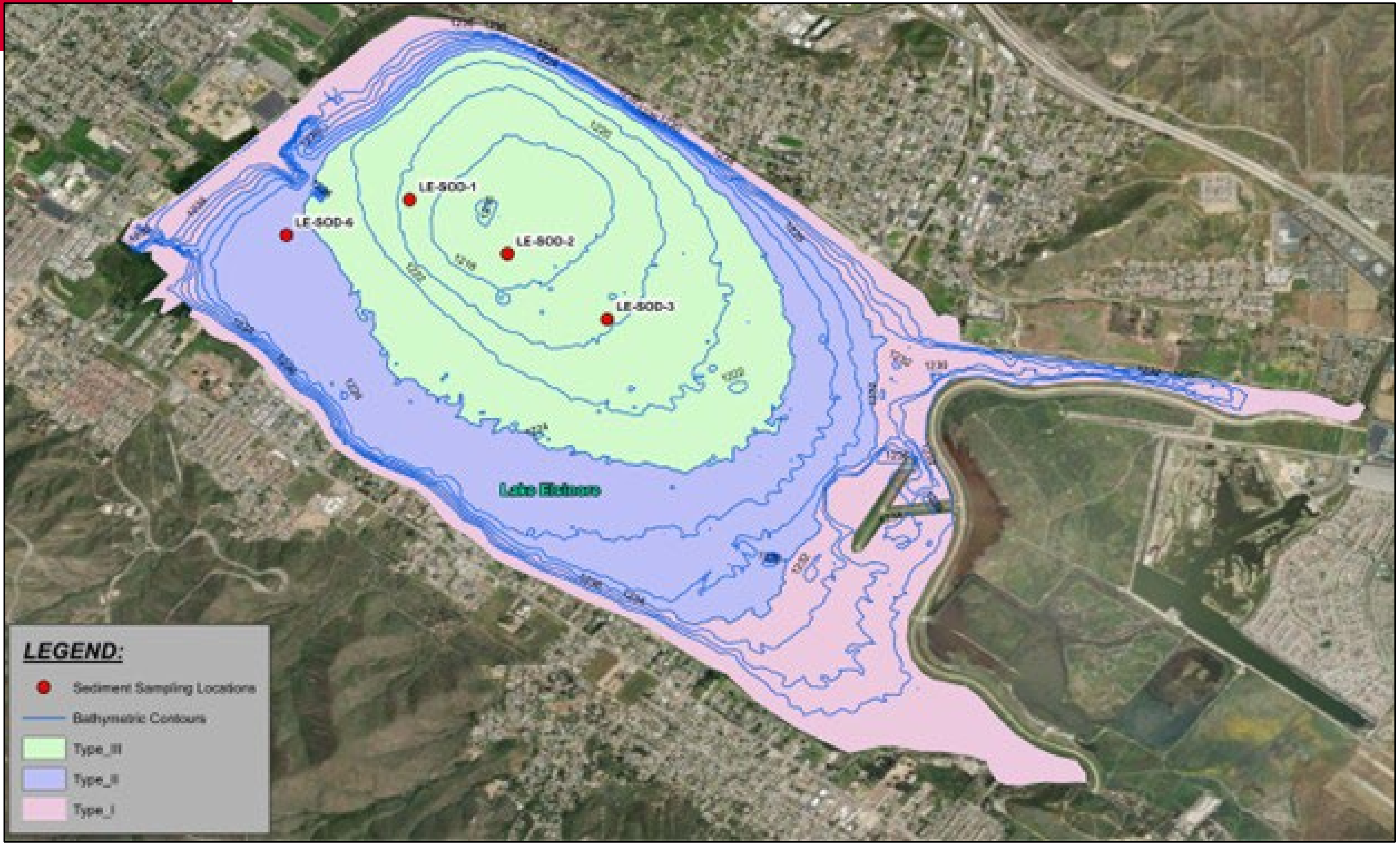
- Current LEAMS program used to offset nutrient load from EVMWD recycled water input in excess of their NPDES permit limit
- Organic-rich sediments consume oxygen through chemical and biological processes leading to low DO or anoxic layer at sediment water interface (SWI)
- This promotes flux of bioavailable nutrients from sediments into the water column

Purpose

- Anderson (2001) core study showed a reduction of 30% TP and 9% TN flux with elevated DO at SWI
- LEAMS effectiveness demonstration monitoring has shown sufficient TP and TN offsets until recently, may need replacement
- LEAMS Future Options Study Nearing Completion
- As part of this need new data to determine:
  - Sediment Oxygen Demand (SOD) of the current lake sediments
  - Potential annual TP and TN load reduction with high DO maintained at SWI

Sampling Locations

- Anderson (2001) Three Sediment Types in the Lake
  - Type I – low organics, sandy
  - Type II – moderate organics, silty sand
  - Type III – highly organic, silt/muck
- 95% of TP and TN internal sediment flux load from Type II and III sediments



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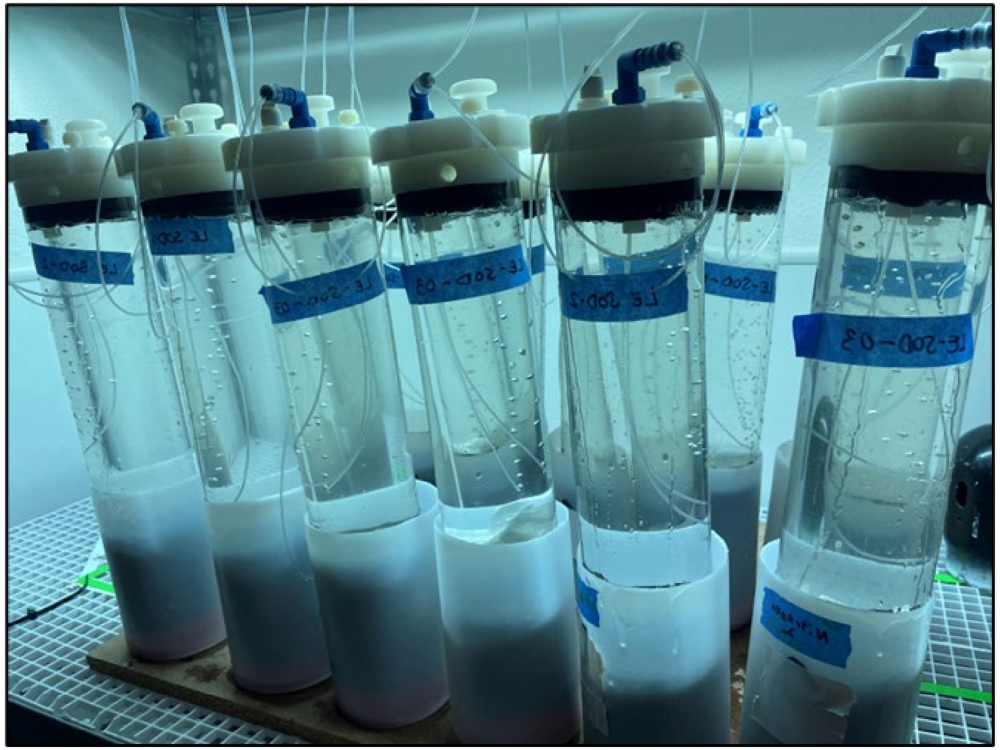
Field Sampling

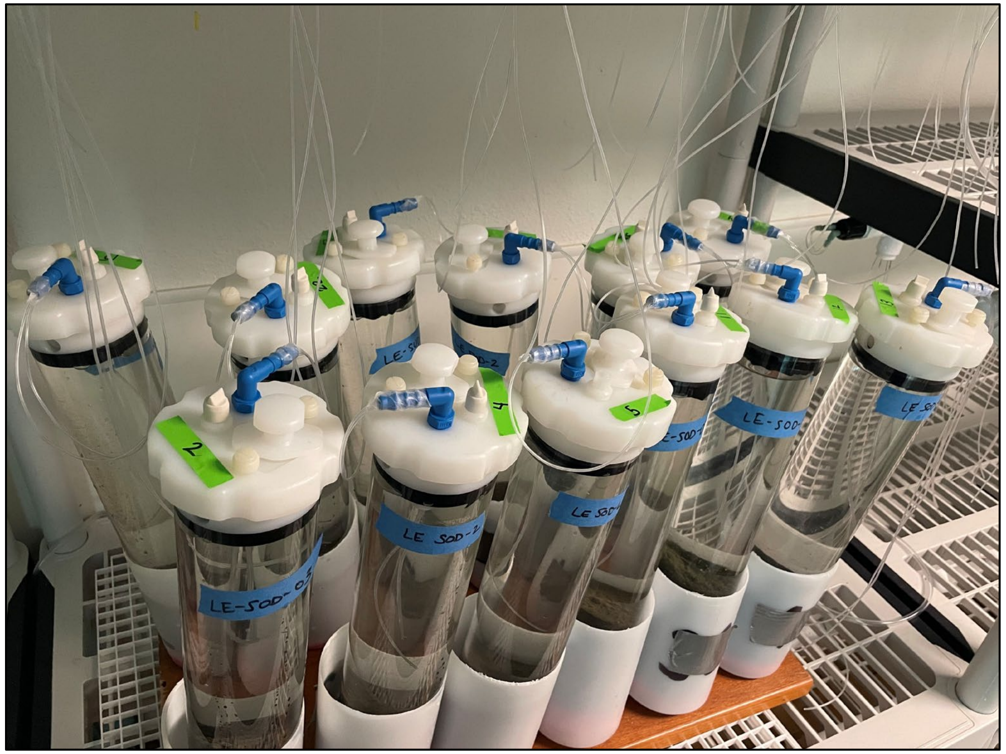
Lab Study Methods

- Four Sites, Three Treatments, Three Replicates = 36 Total Cores
- Three Treatments
  1. Static, No-Aeration – Sediment oxygen demand
  2. Nitrogen Gas Bubbled - **<u>Anoxic</u>** SWI condition nutrient flux
  3. Ambient Air Aeration - **<u>Oxic</u>** SWI condition nutrient flux
- 10 day Study
  - Oxic & anoxic treatments flipped after 5 days
  - Flip simulates natural lake stratification cycle



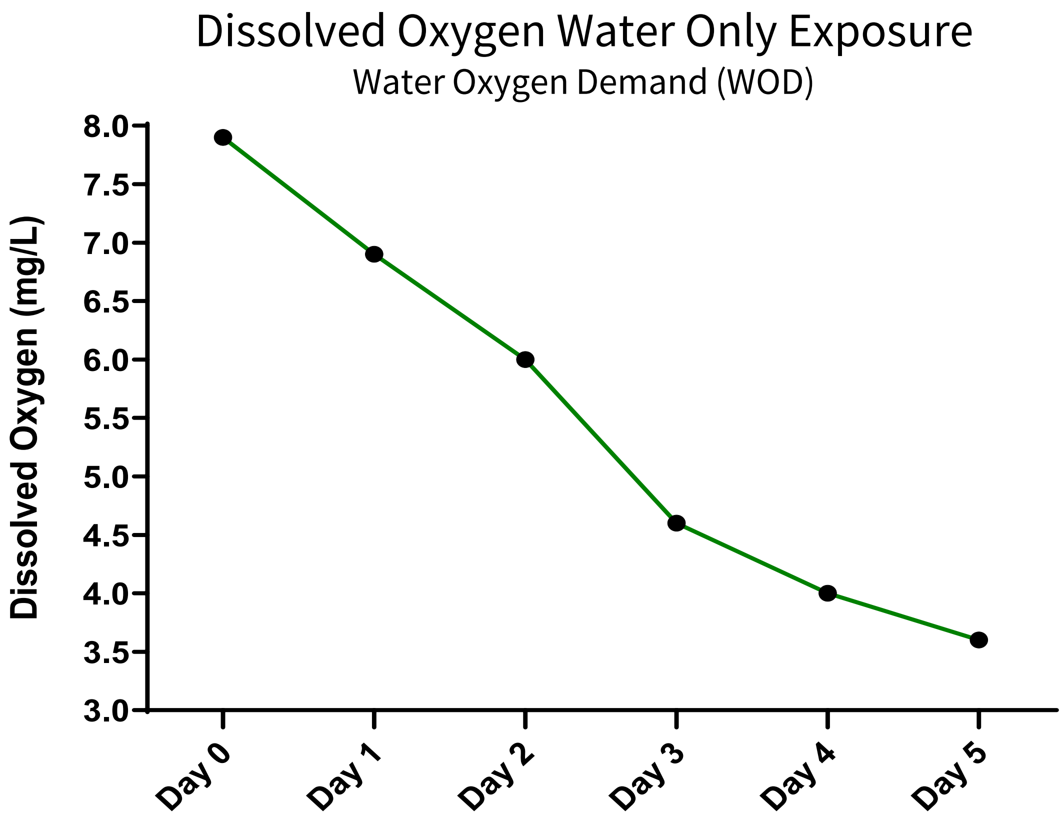
Lab Study Methods

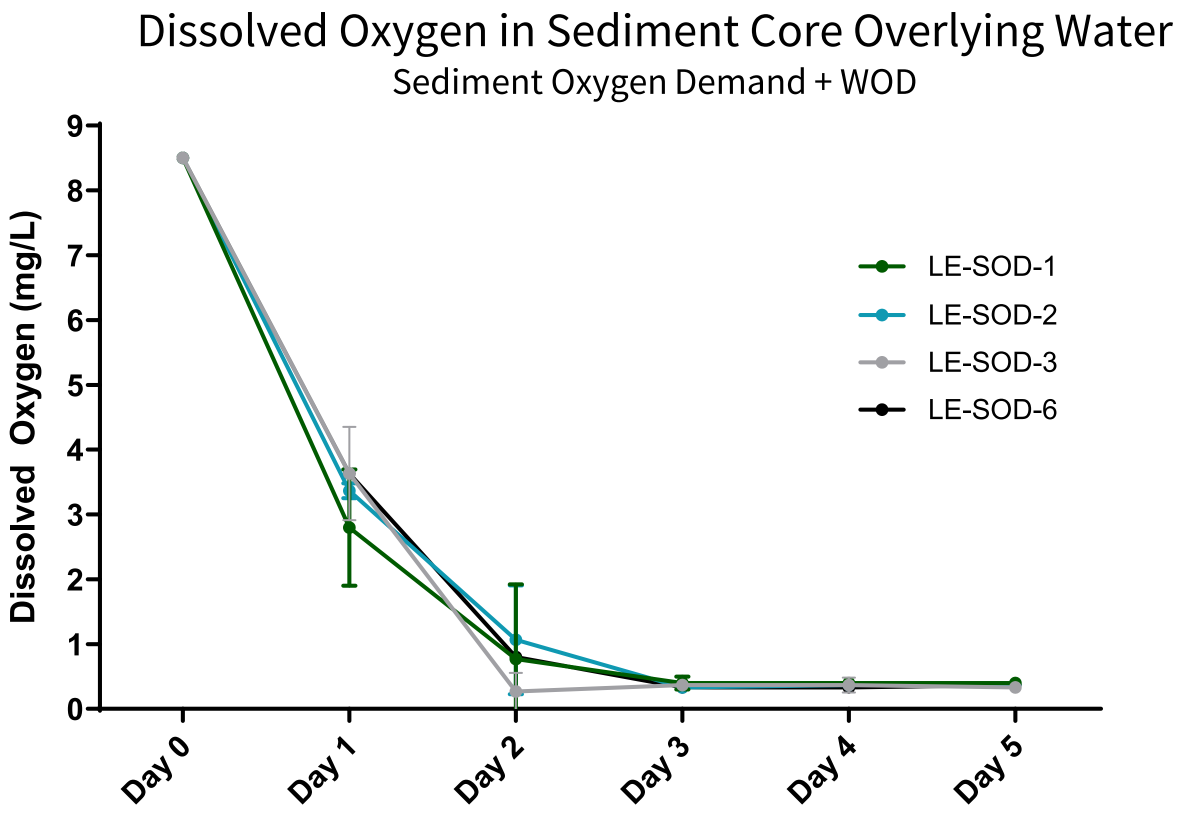
- Whole Sediment Chemistry
  - Total Phosphorus (and fractions)
  - Total Nitrogen, Ammonia, Total Organic Carbon
  - Sulfide, Iron
- Core Study Overlying Water Chemistry
  - Daily Water Samples
    - Total Phosphorus, Total Nitrogen
    - Soluble Reactive Phosphorus, Ammonia
    - Total/Dissolved Iron
- Over 1000 water samples collected!



Sediment Oxygen Demand

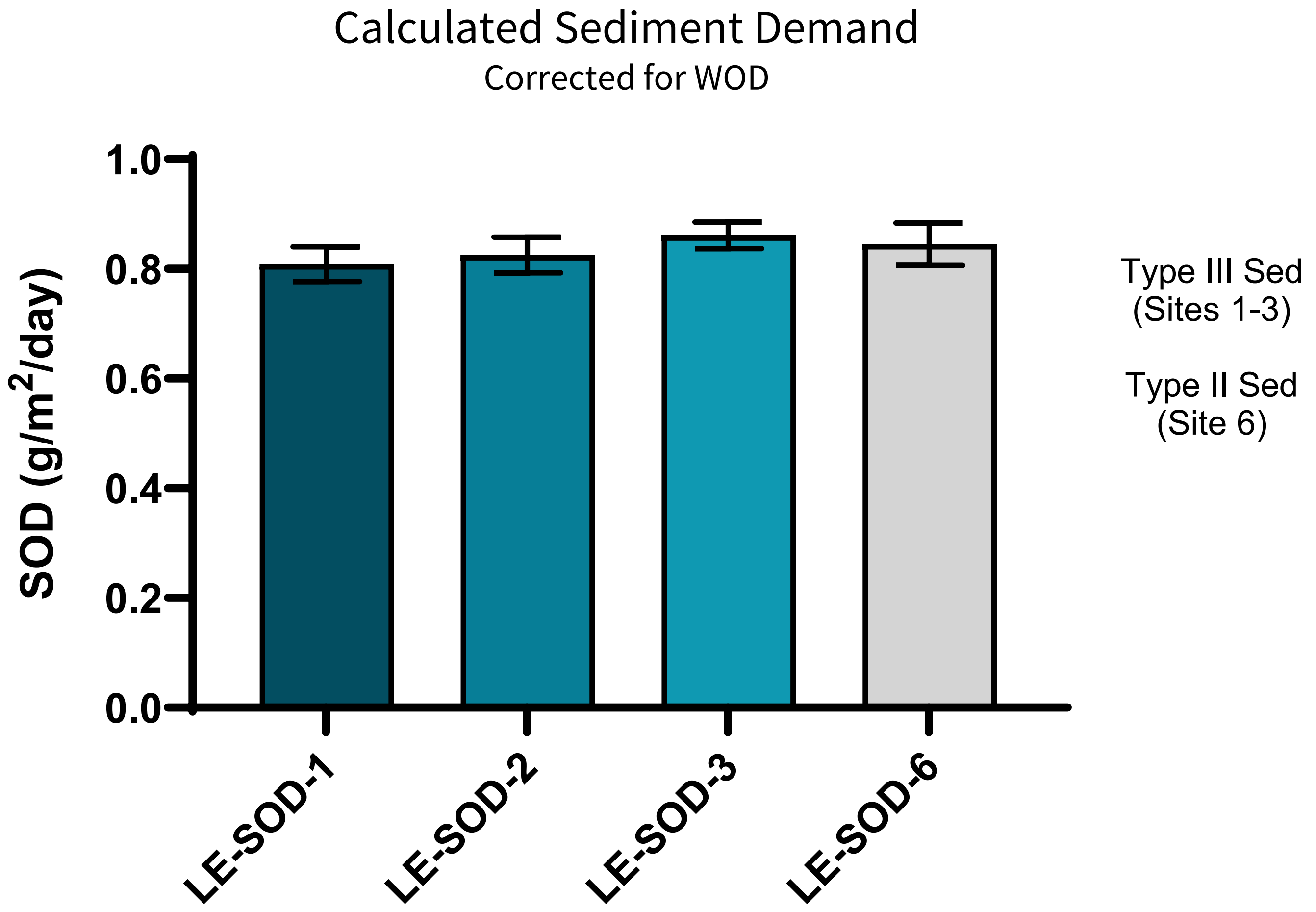
Static, Non-aerated Cores





Sediment Oxygen Demand

- Very consistent response across sites
- Mean SOD of 0.84 g/m²/day
  - Beutel (2000) – 0.92 to 1.8 g/m²/day
  - Anderson (2010) – 0.93 g/m²/day
- Extrapolating SOD rate to area of Type II and Type III sediments (approximately 2000 acres)
- Equates to ~15,000 lbs O_2/day consumed by sediment



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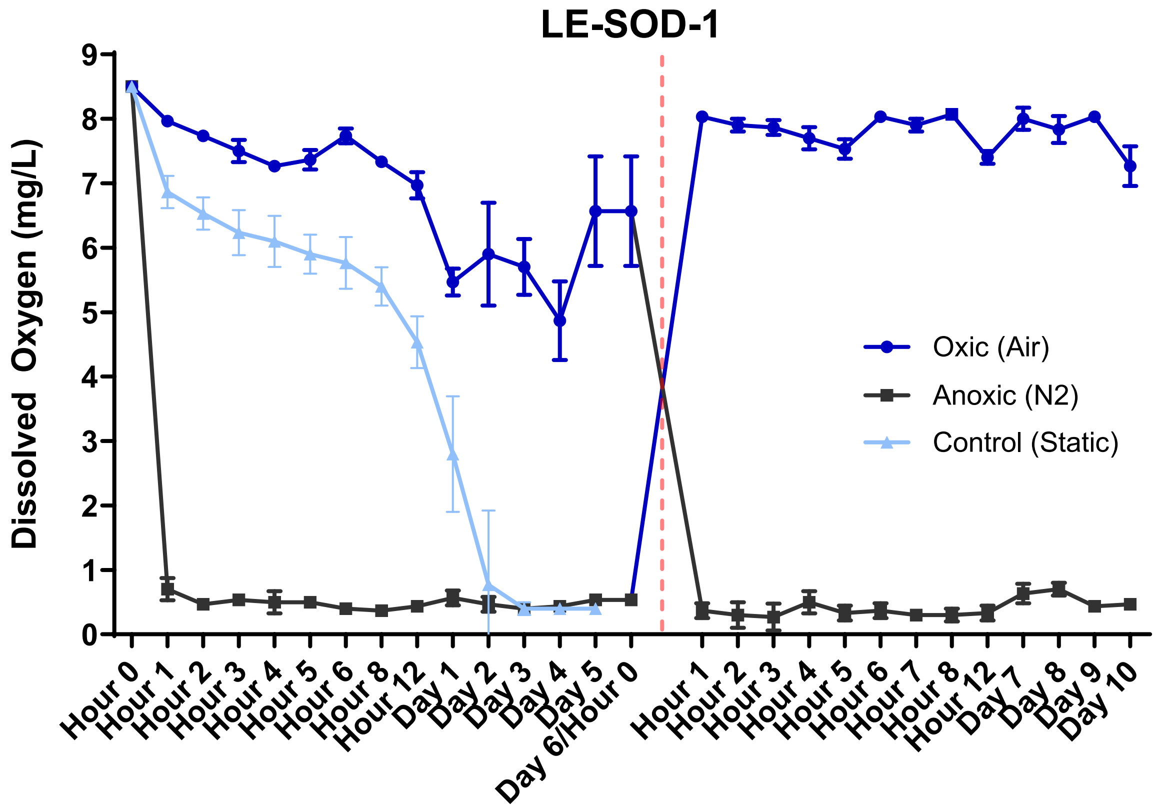
Nutrient Flux

- Treatment DO responded as expected

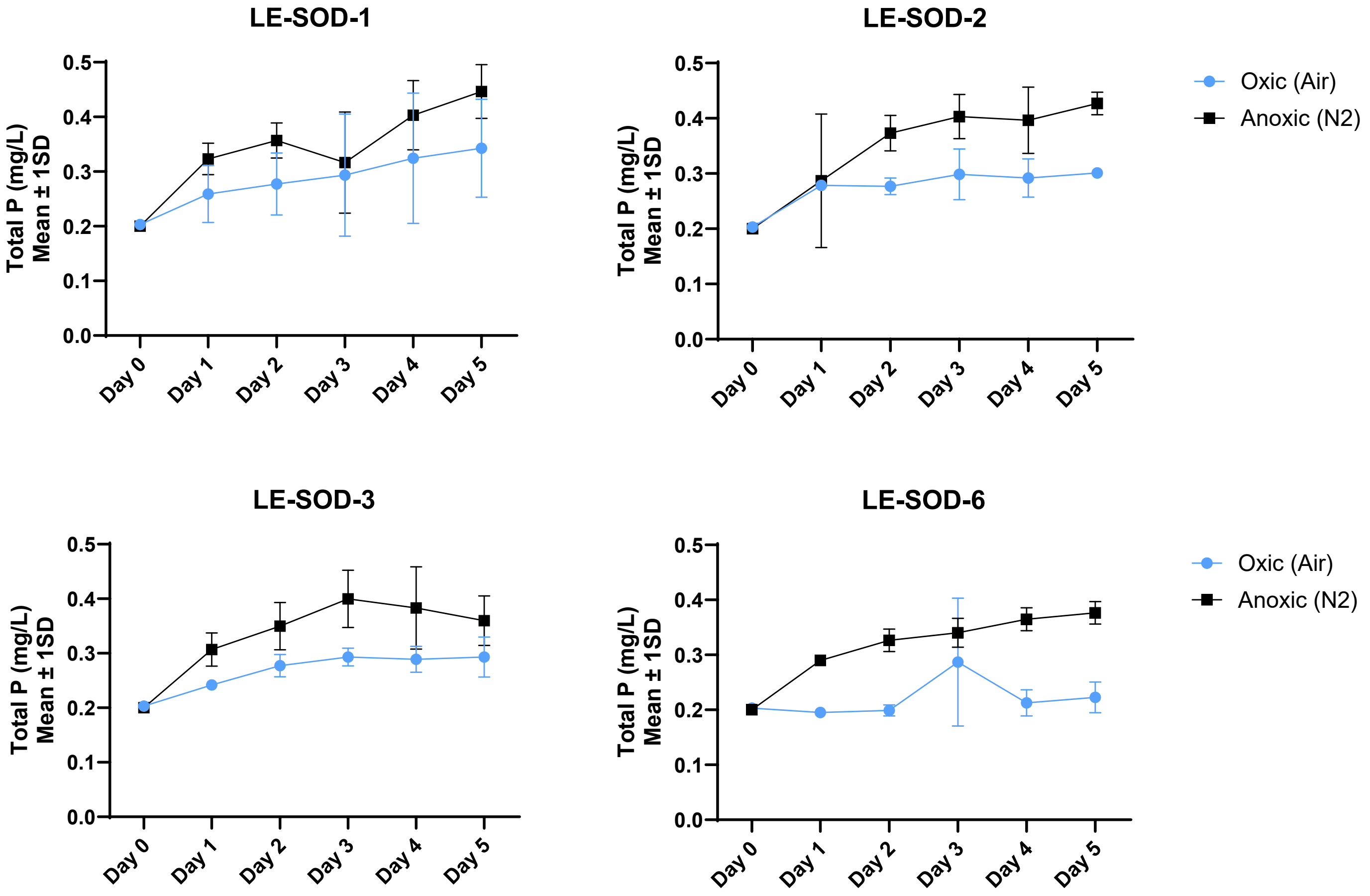
Dissolved Oxygen Concentrations
During the 10-Day Nutrient Flux Study



Nutrient Flux

- Treatment DO responded as expected
- Initial Day 0-5 period - All sites exhibited increased overlying water concentrations for all nutrients under anoxic conditions relative to oxic cores

Overlying Water **Total Phosphorus** Concentrations for Days 0 - 5 Nutrient Flux



Nutrient Flux

- Treatment DO responded as expected
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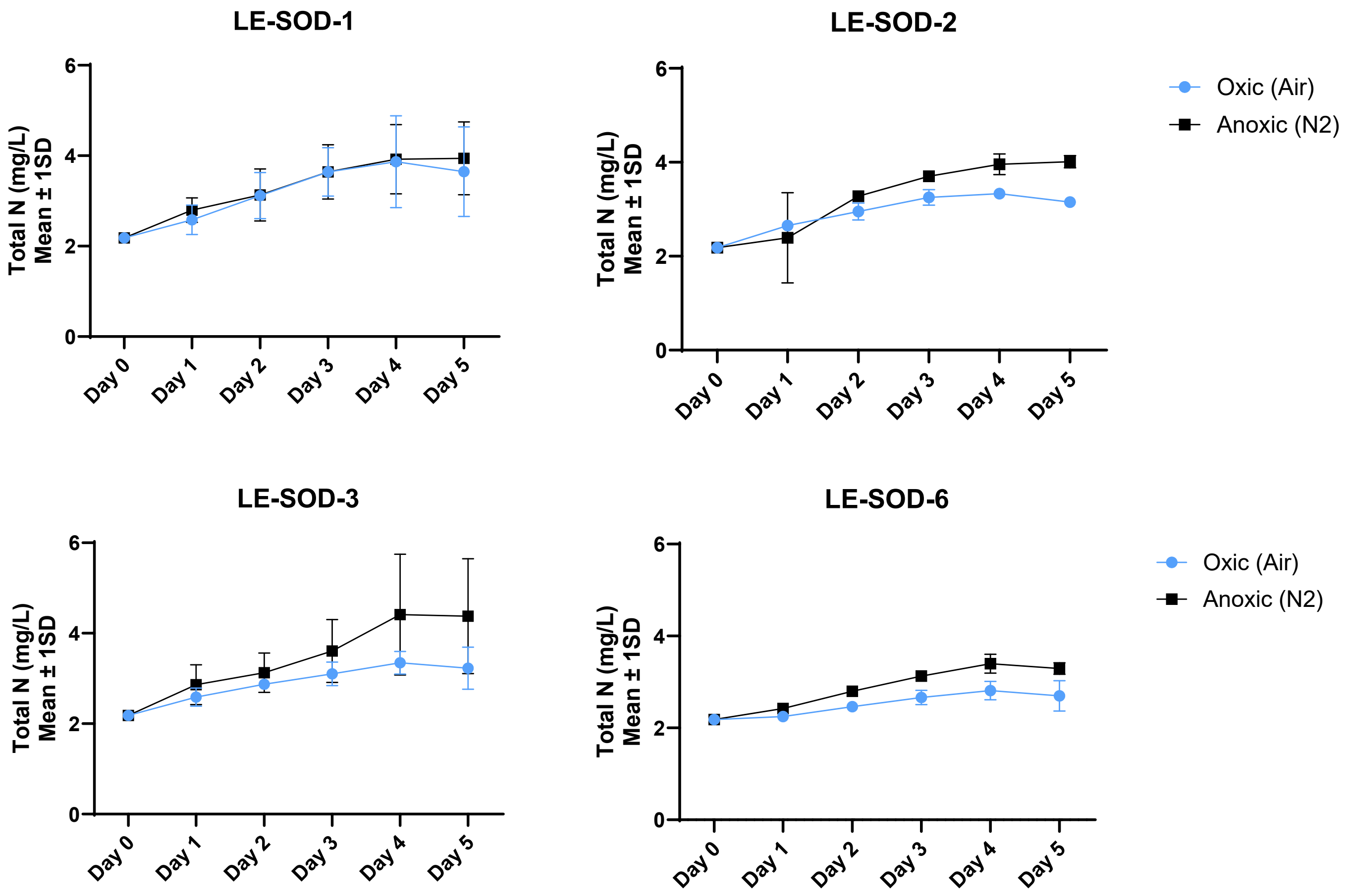
Overlying Water **Total Nitrogen**
Concentrations for Days 0 - 5 Nutrient Flux



Nutrient Flux

- Treatment DO responded as expected
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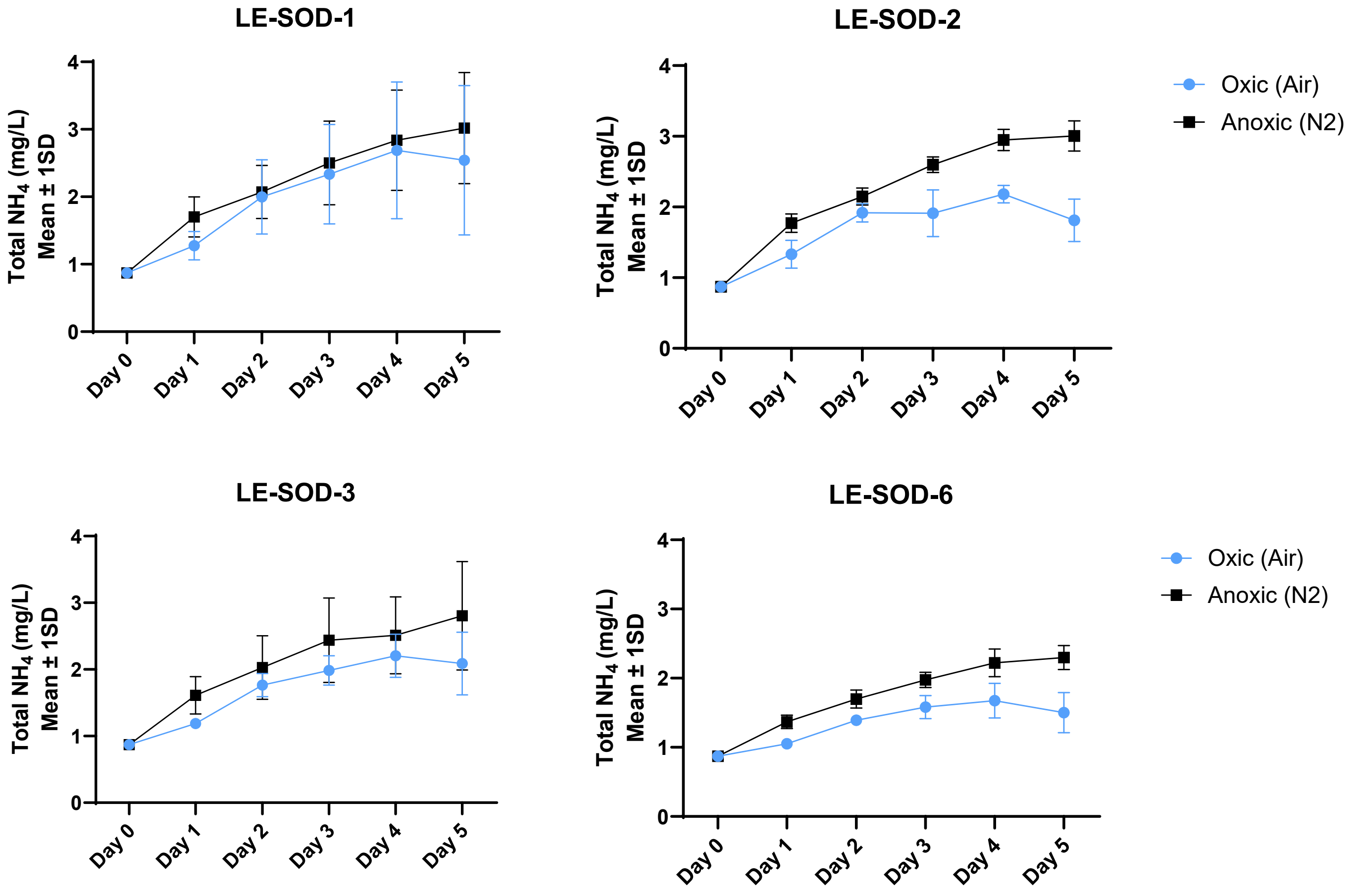
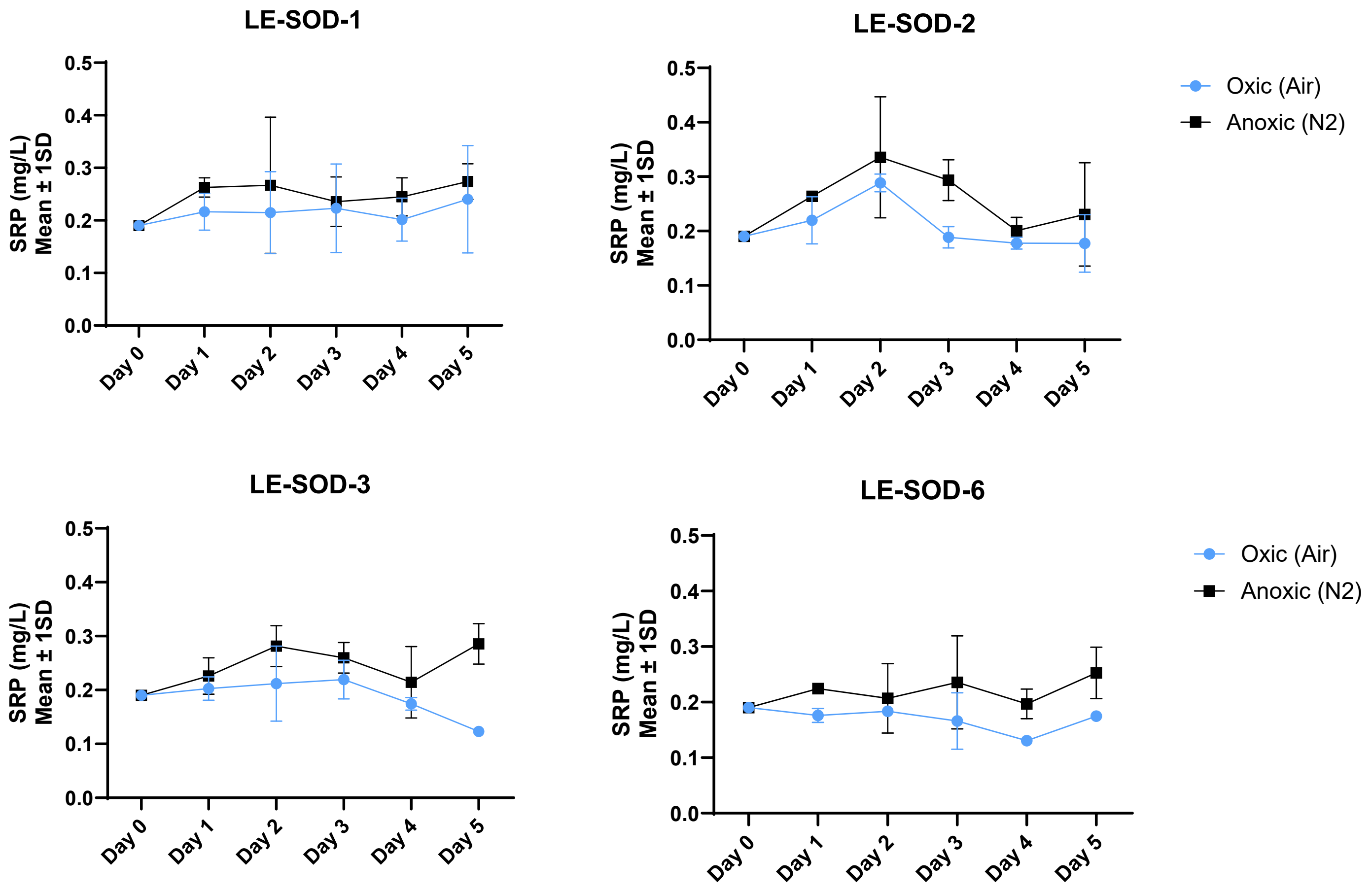
Overlying Water **Total Ammonia**
Concentrations for Days 0 - 5 Nutrient Flux



Nutrient Flux

- Treatment DO responded as expected
- Initial Day 0-5 period - All sites exhibited increased overlying water concentrations for all nutrients under anoxic conditions relative to oxic cores

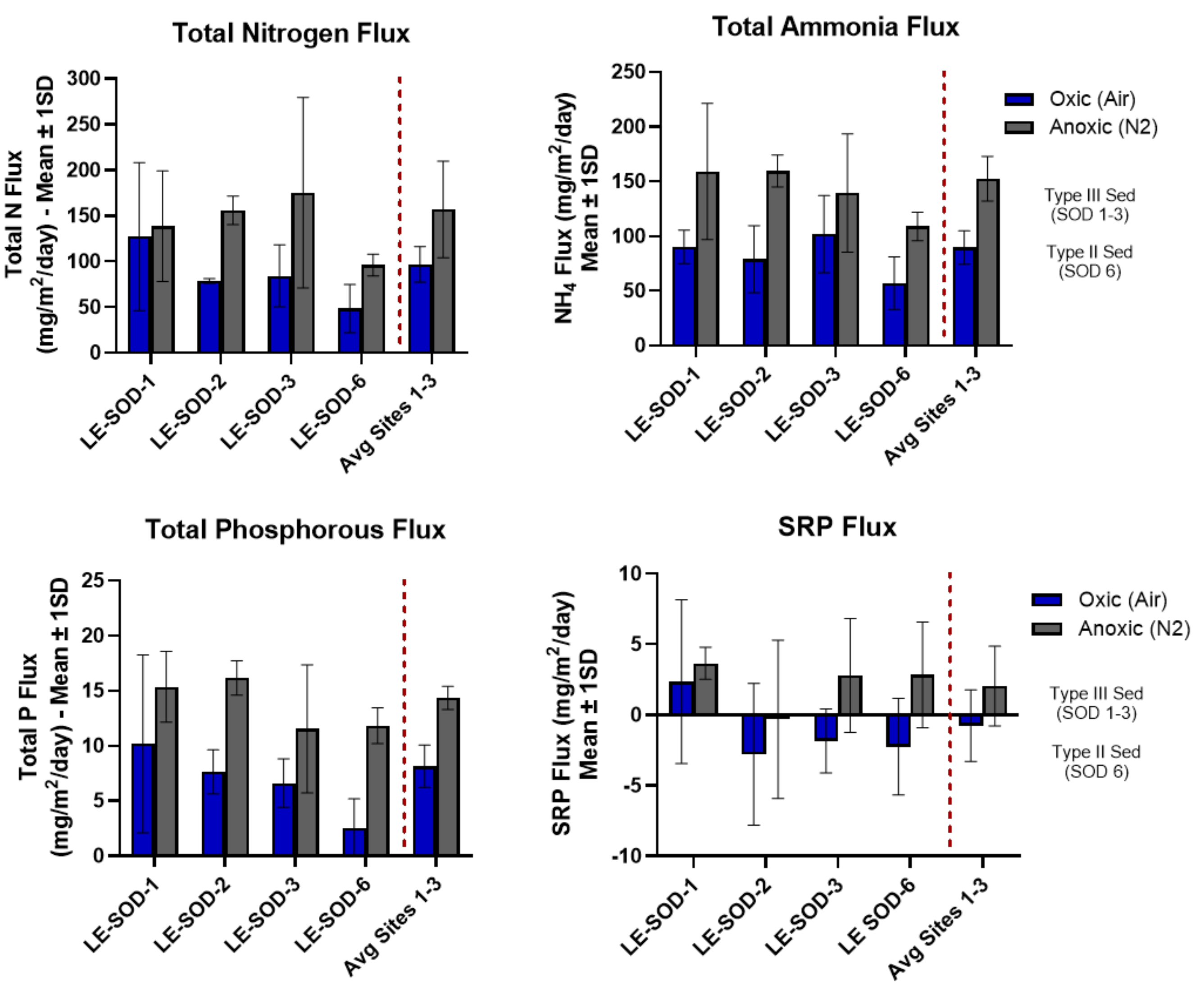
Overlying Water **SRP** Concentrations for Days 0 - 5 Nutrient Flux



Nutrient Flux

- Treatment DO responded as expected
- Initial Day 0-5 period - All sites exhibited increased overlying water concentrations for all nutrients under anoxic conditions relative to oxic cores
- Mean flux rate in both Type II and III sediments was less than or negative in oxic cores relative to anoxic cores

Total Mass Flux from Sediments Days 0-5



Conclusions

- Results support conceptual model
- Four sediments exhibited similar rates of oxygen consumption with a mean WOD-corrected SOD rate of 0.84 $g/m^2/day$
- Relative to sediments held under anoxic conditions, Lake Elsinore sediments that are well oxygenated exhibited a reduction in nutrient flux
- Large number of replicates and agreement among sites gives us confidence in study results
- High confidence in quantitative estimate of the potential benefit of oxygenation

% Reduction in Nutrient Flux from Sediments Held Under Oxic Conditions Relative to those Under Anoxic Conditions

	Sediment Type	
	II	**III**
Total Phosphorus	**78.6**	**43.5**
Soluble Reactive Phosphorus	**179.9**	**137.3**
Total Nitrogen	**49.5**	**38.3**
Total Ammonia	**47.5**	**42.1**

Questions

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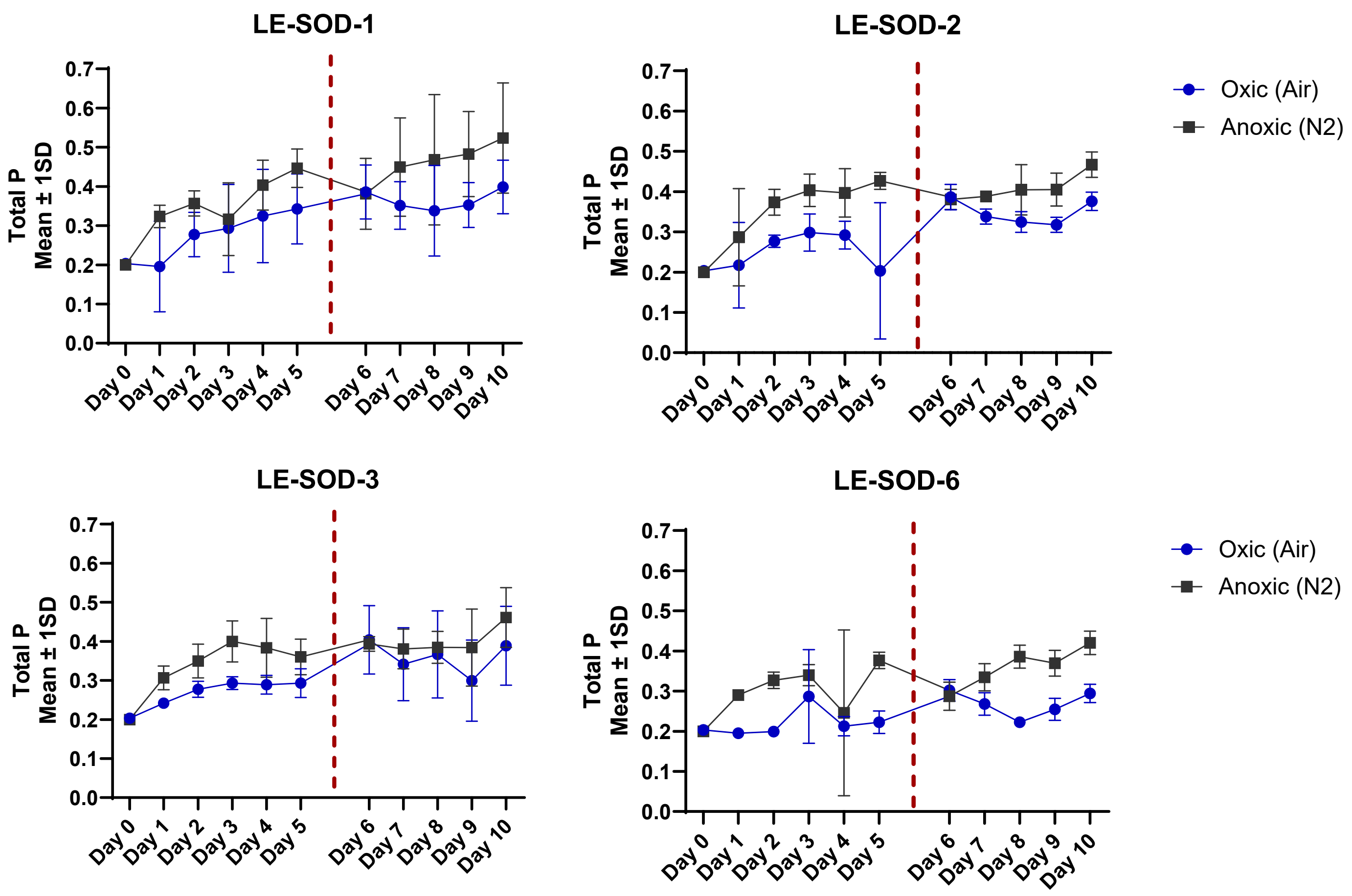
Back Up Slides

Nutrient Flux Days 6-10

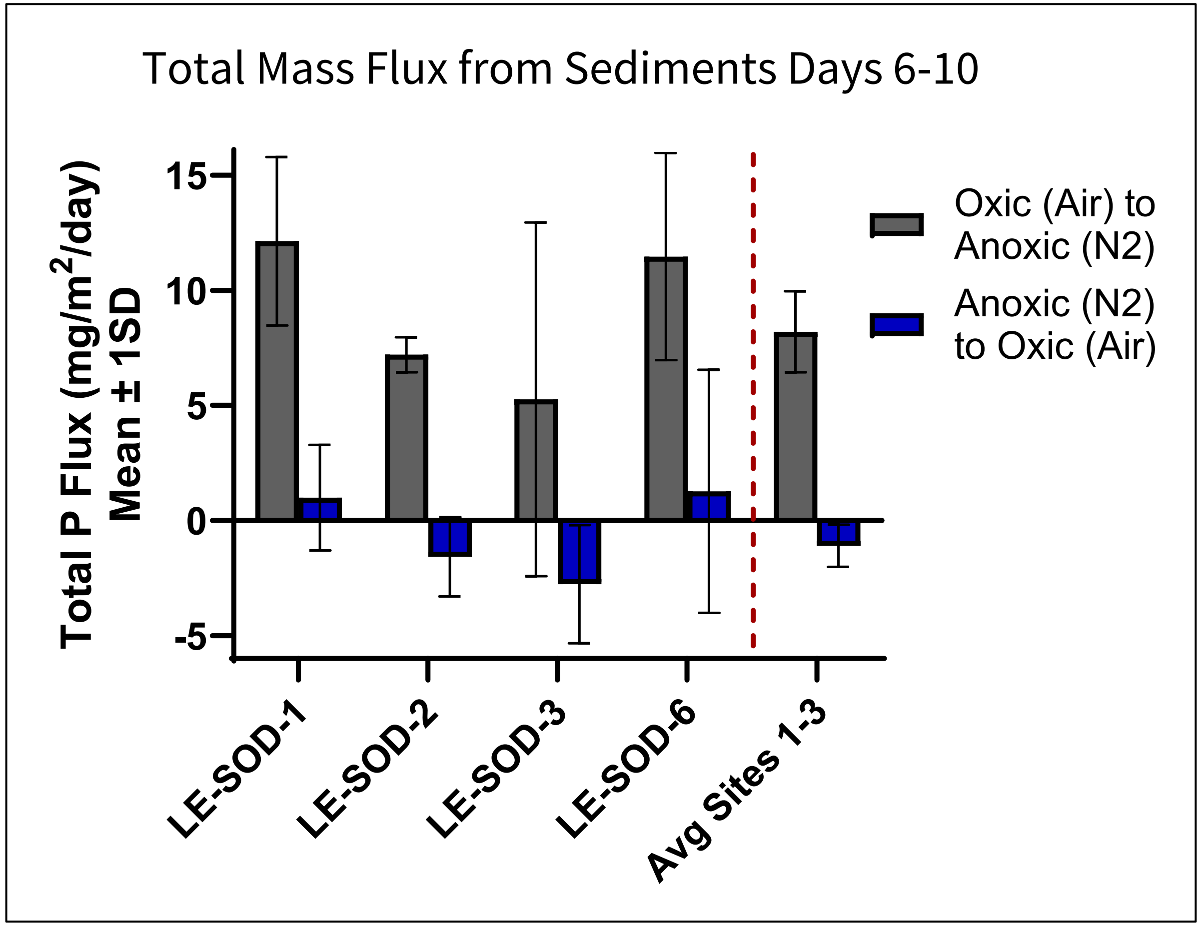
- Moving from anoxic to oxic conditions at Day 6, TP concentrations in the overlying water decreased in all four sites

Total Phosphorus Overlying Water Concentrations (mg/L) During the 10-Day Nutrient Flux Study



Nutrient Flux Days 6-10

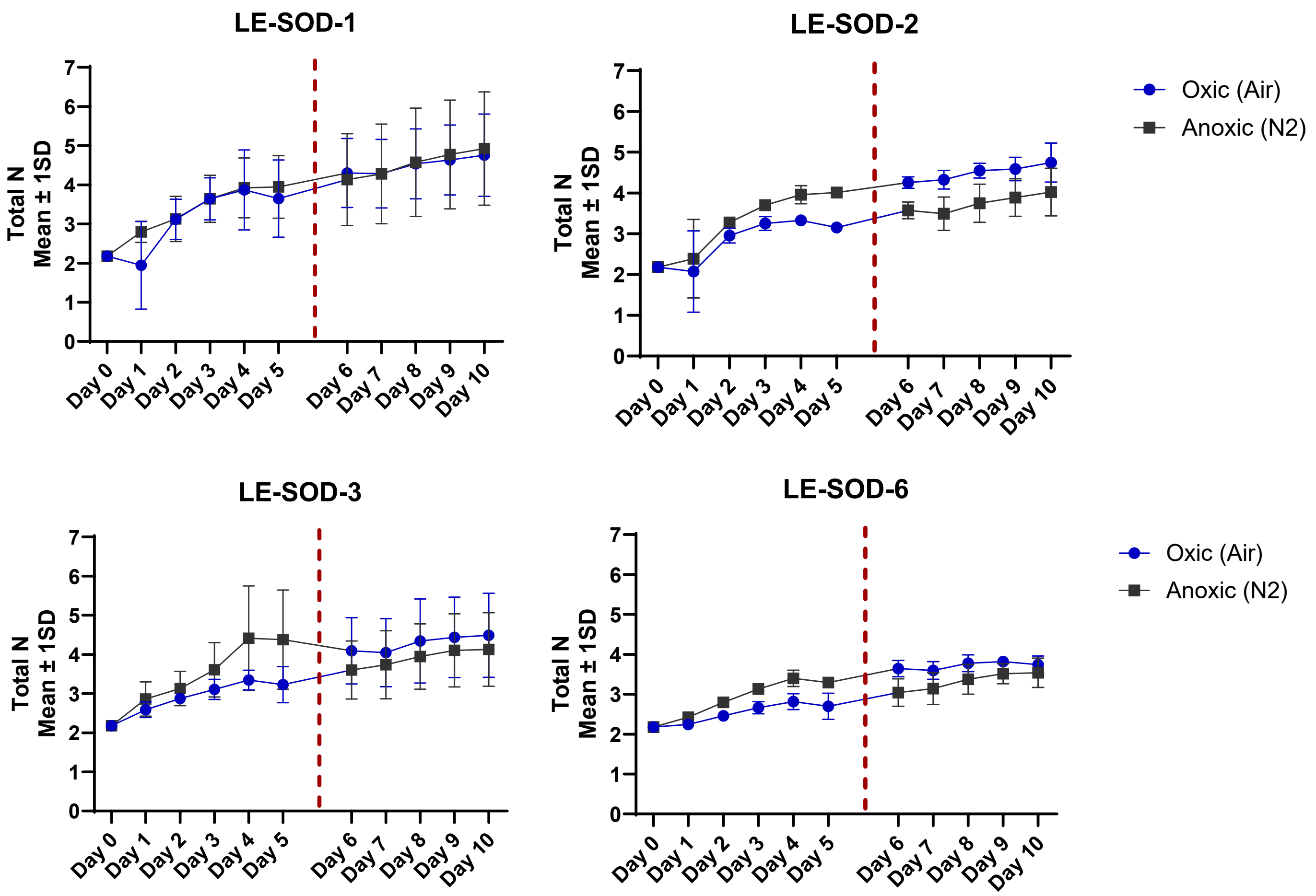
- Moving from anoxic to oxic conditions at Day 6, TP concentrations in the overlying water decreased in all four sites
- Sediments transitioned from releasing phosphorus to phosphorus uptake



Nutrient Flux Days 6-10

- TN concentrations continued to increase under both oxic and anoxic conditions after treatment switch

Total Nitrogen Overlying Water Concentrations (mg/L) During the 10-Day Nutrient Flux Study



Nutrient Flux Days 6-10

- TN concentrations continued to increase under both oxic and anoxic conditions after treatment switch
- But NH_4 began to decrease under oxic conditions

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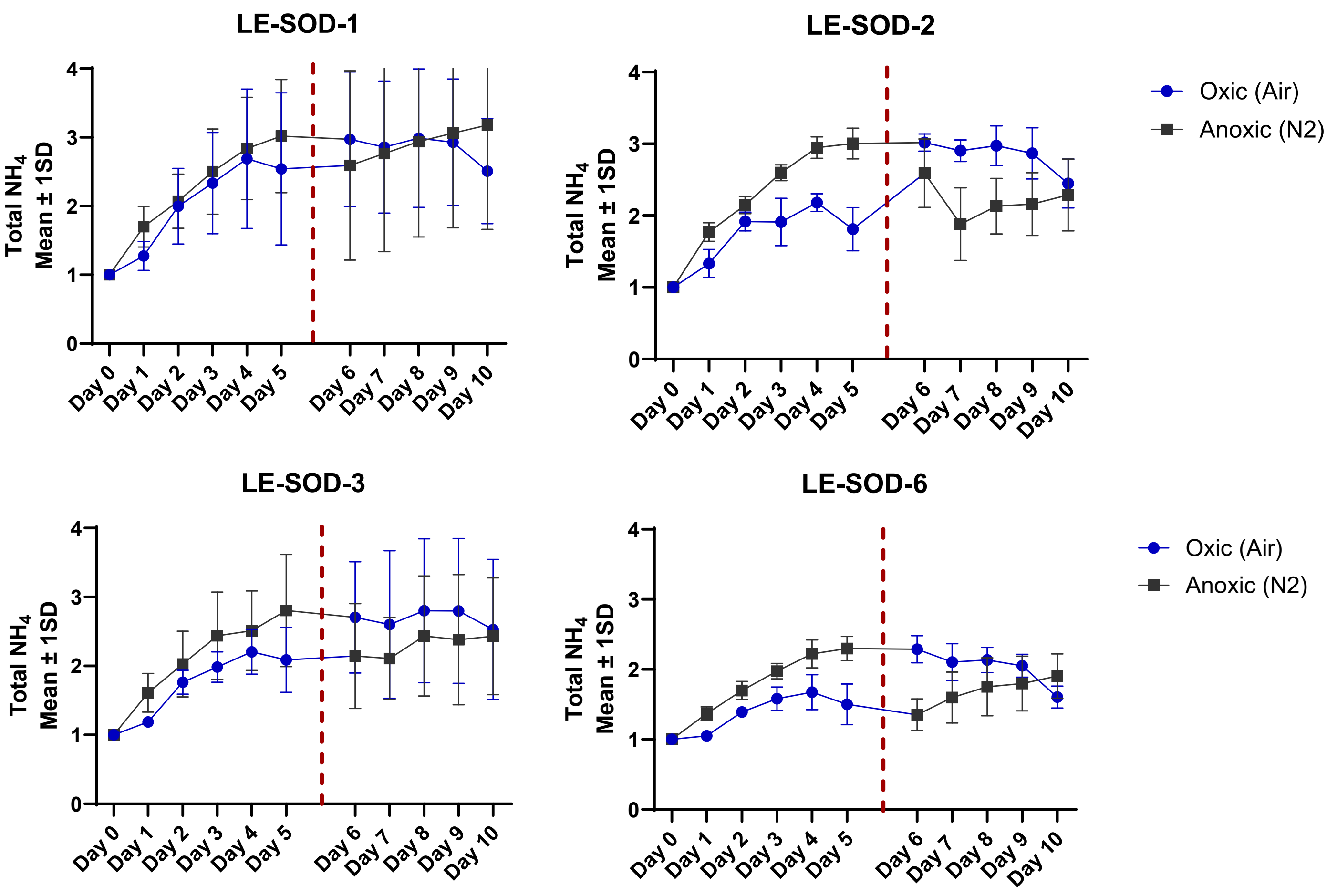
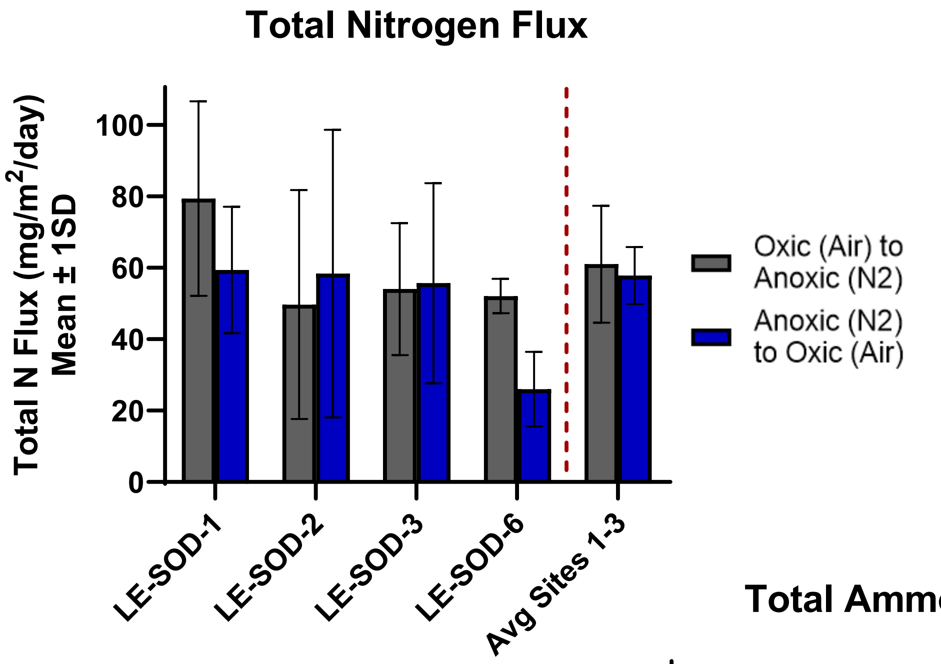
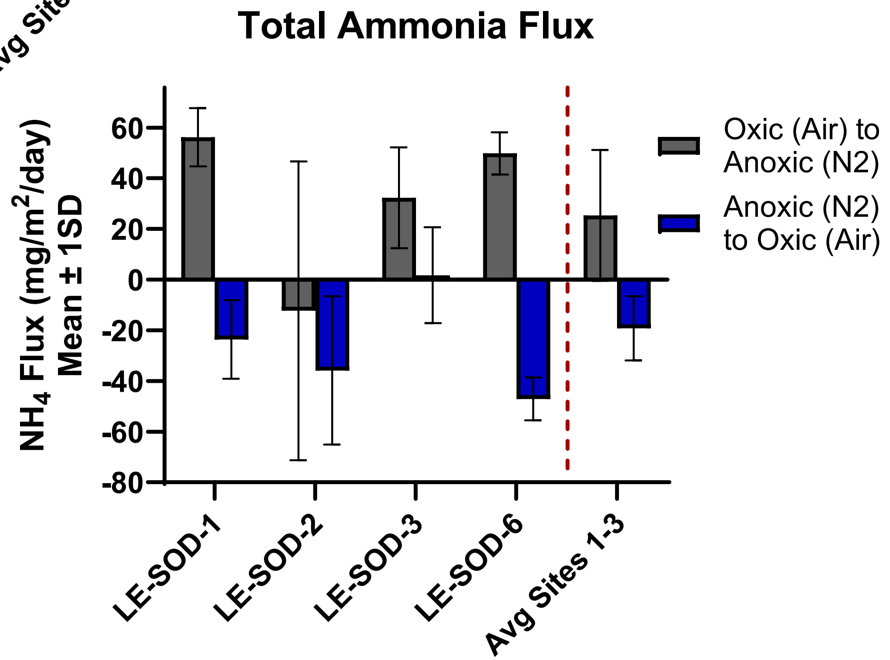


Nutrient Flux Days 6-10

- TN concentrations continued to increase under both oxic and anoxic conditions after treatment switch
- But NH_4 began to decrease under oxic conditions
- Similar TN flux, but negative NH_4 flux after switch in treatment



Total Mass Flux from Sediments Days 6-10



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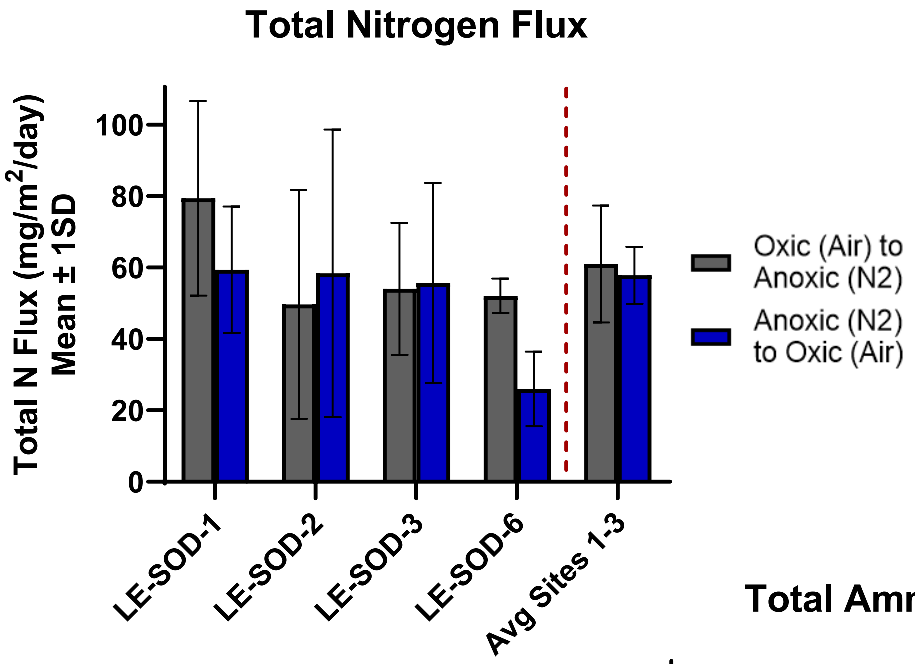
Nutrient Flux Days 6-10

- TN concentrations continued to increase under both oxic and anoxic conditions after treatment switch
- But NH_4 began to decrease under oxic conditions
- Similar TN flux, but negative NH_4 flux after switch in treatment
- Nitrification of ammonia being converted to nitrate



Total Mass Flux from Sediments Days 6-10