Hazen



THE VOICE OF THE RIVER
SINCE 1984
HENRY'S FORK FOUNDATION

Protecting Fisheries: Addressing Low Dissolved Oxygen and Algal Blooms in Island Park Reservoir

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Agenda

- Project Background
- Addressing Dissolved Oxygen
  - In-Reservoir Data
  - Oxygenation Systems: Alternatives Analysis
- Addressing Eutrophication
  - In-Reservoir Data
  - Management Strategies
- Conclusions

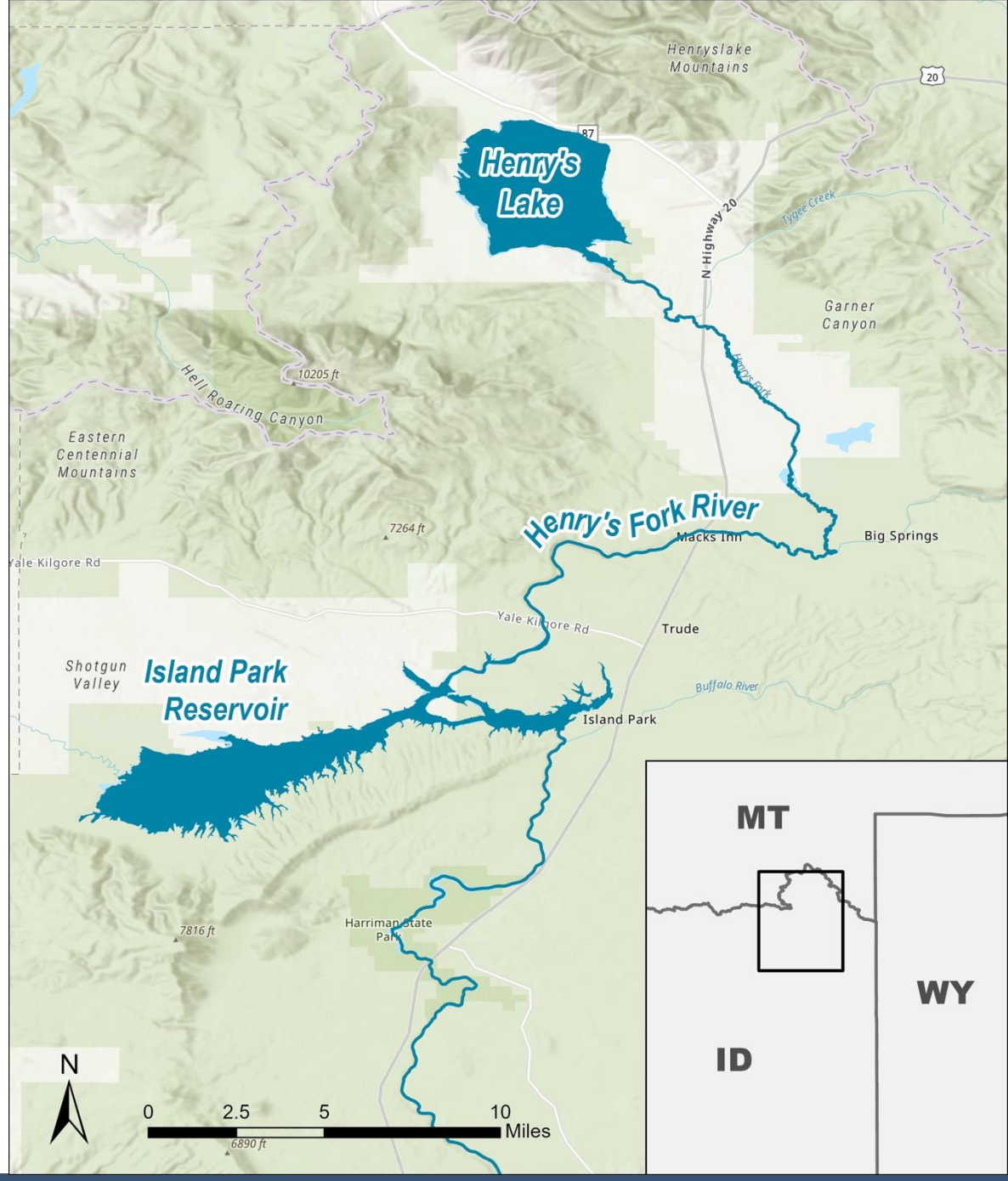


Project Background

Overview

- The Henry's Fork River is a premier destination for fishing
- Regional economy is tied to recreation and tourism
- Henry's Fork Foundation is a nonprofit dedicated to studying and maintaining fisheries on the Henry's Fork River
- Reservoirs such as Island Park Reservoir present challenges for managing fisheries

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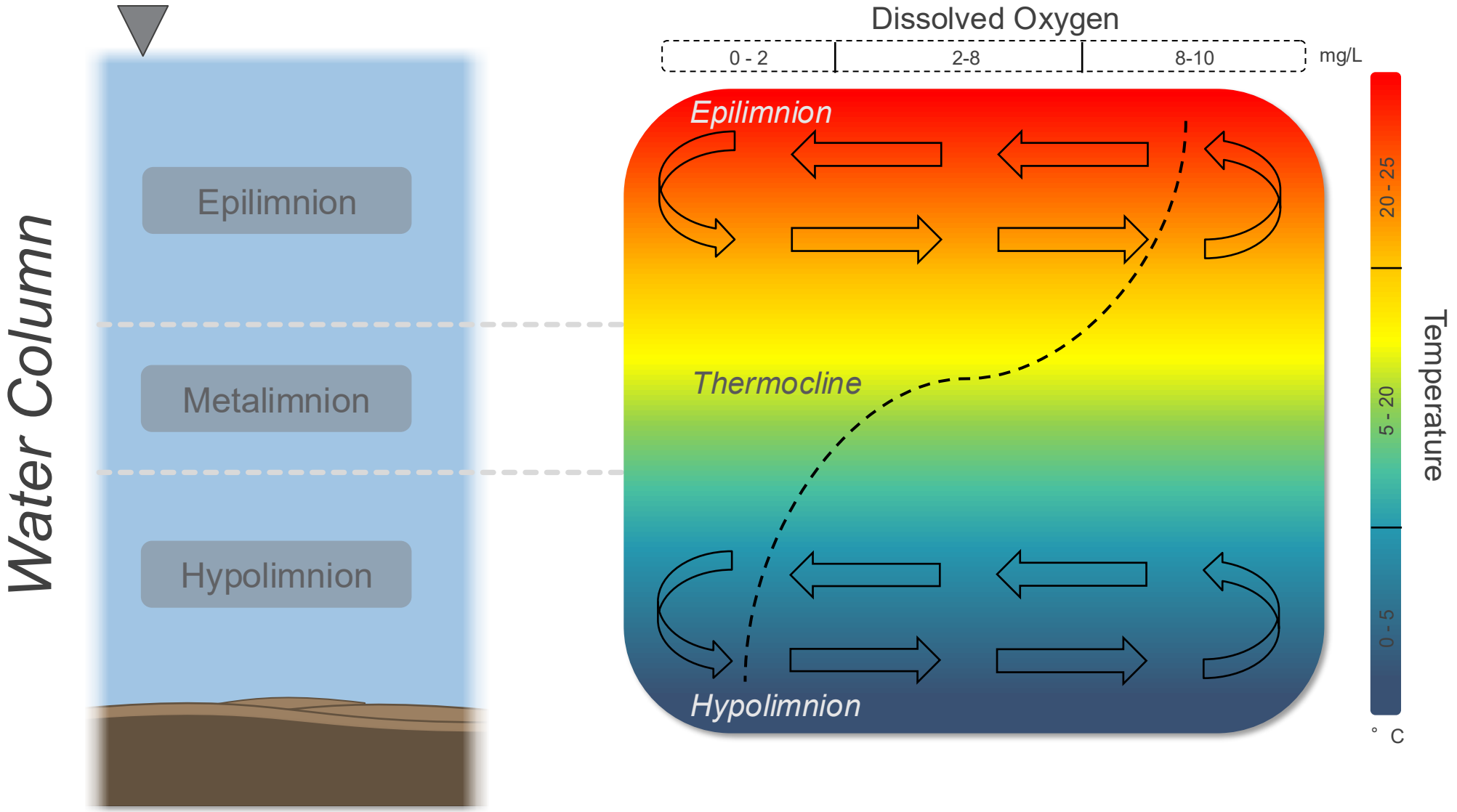


Fisheries and Habitat

- Primary fish species of concern are salmonids
  - **Rainbow Trout**
  - **Cutthroat Trout**
  - **Brook Trout**
  - **Kokanee Salmon**
- Habitat requirements are highly specific
  - **Cold Water (< 23 Celsius)**
  - **High Dissolved Oxygen (> 5 mg/L)**
  - **Low turbidity**
  - **Healthy food chain (plankton, aquatic plants, invertebrates, fish)**
- Conditions are even more critical during certain life cycle stages (spawning, egg, alevin, fry)



Overview: Lake and Reservoir Stratification



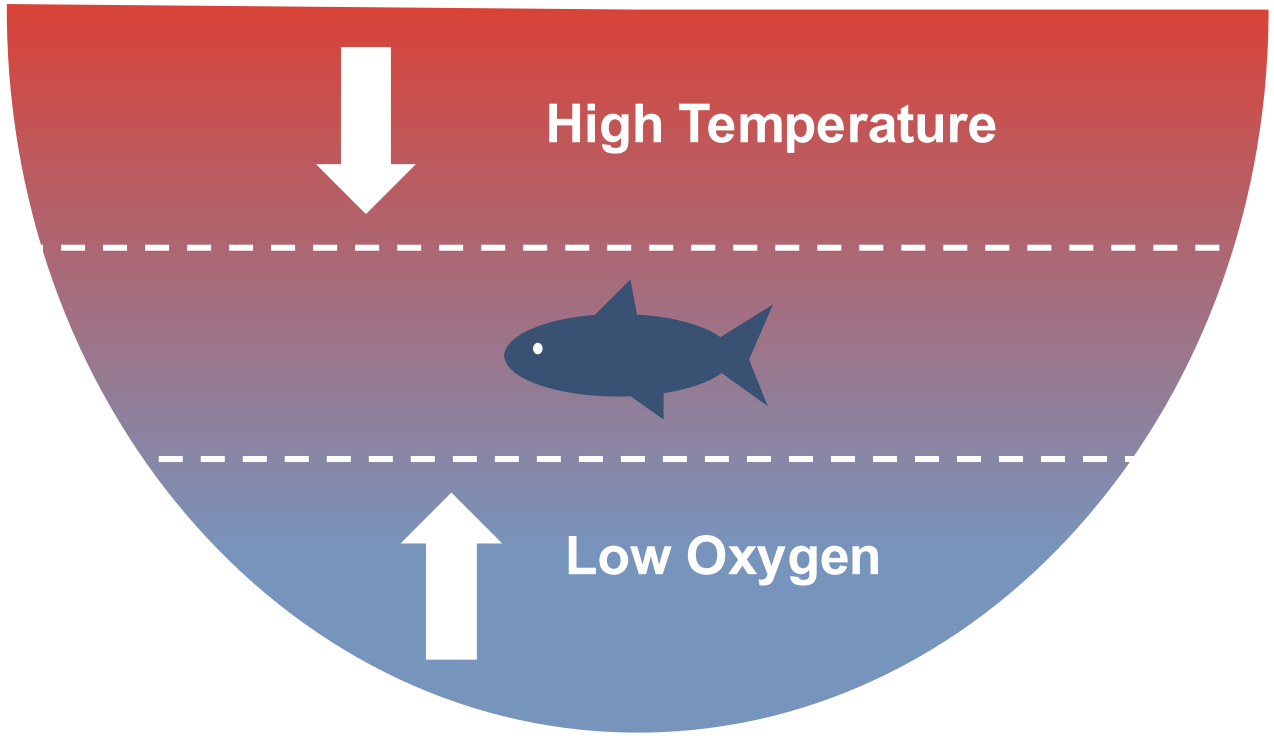
Hypoxia:
DO < 3 mg/L

Anoxia:
DO < 0.2 mg/L

Water Quality in Island Park Reservoir

Two primary concerns:

- Small oxythermal area for fish to occupy
  - Surface is too hot
  - Hypolimnion is too low-oxygen
- Eutrophication
  - Toxic cyanobacteria blooms
  - Disrupted food web
  - Increased oxygen demand



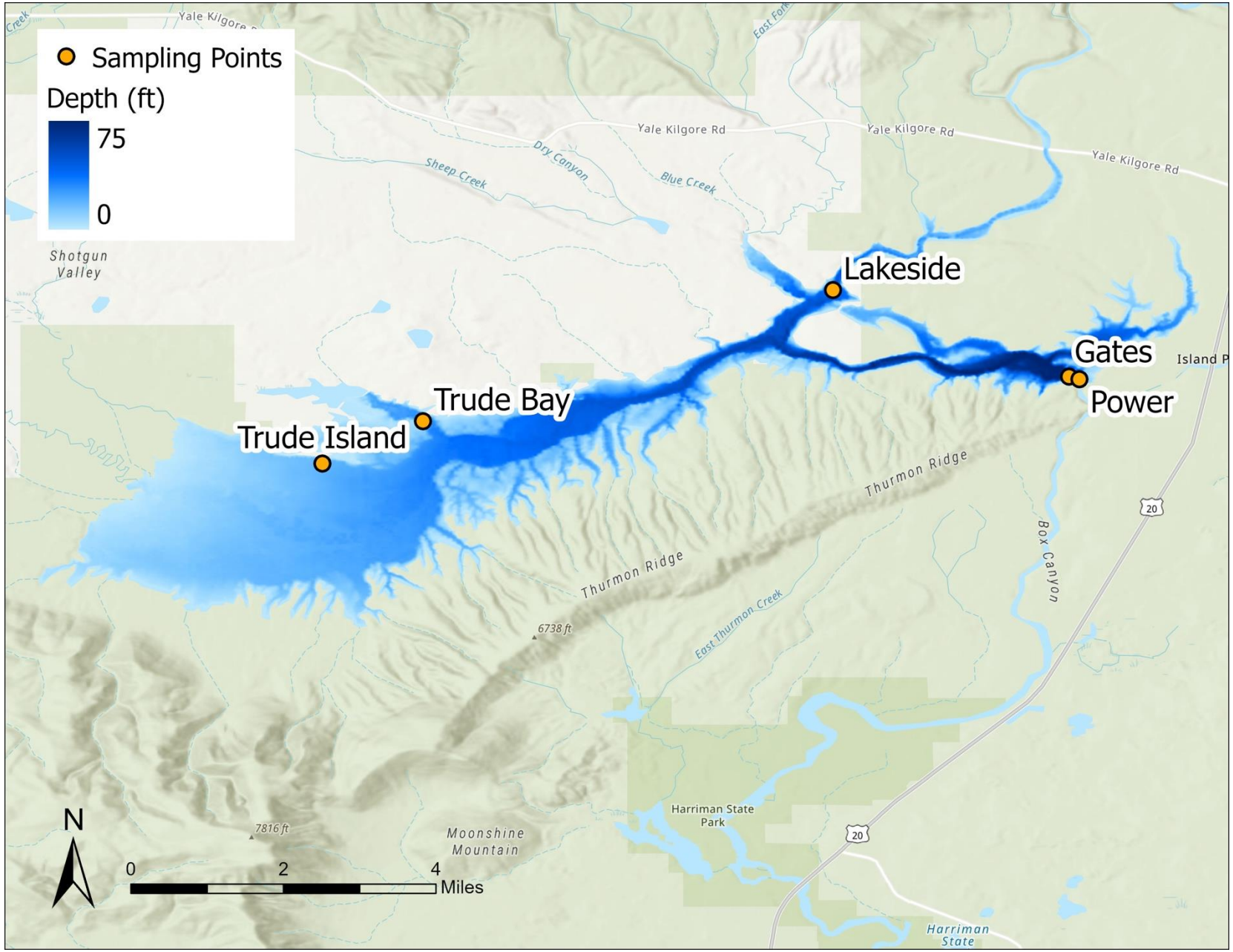
- Oxygenation addresses habitat concerns and can help restore proper ecology through top-down control
- Eutrophication may require additional strategies to address

Addressing Dissolved Oxygen

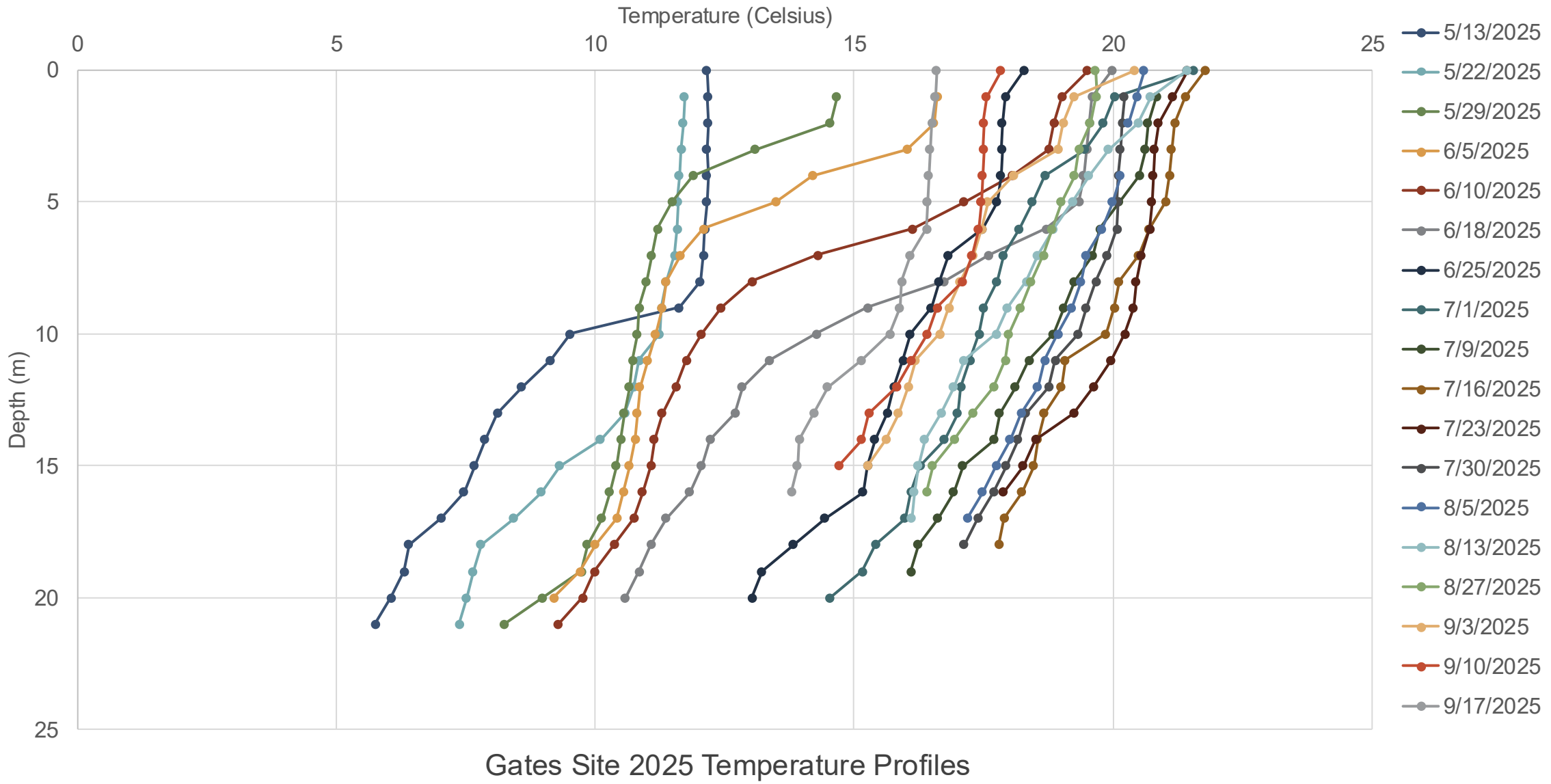
In-Reservoir Data

Weekly Sampling

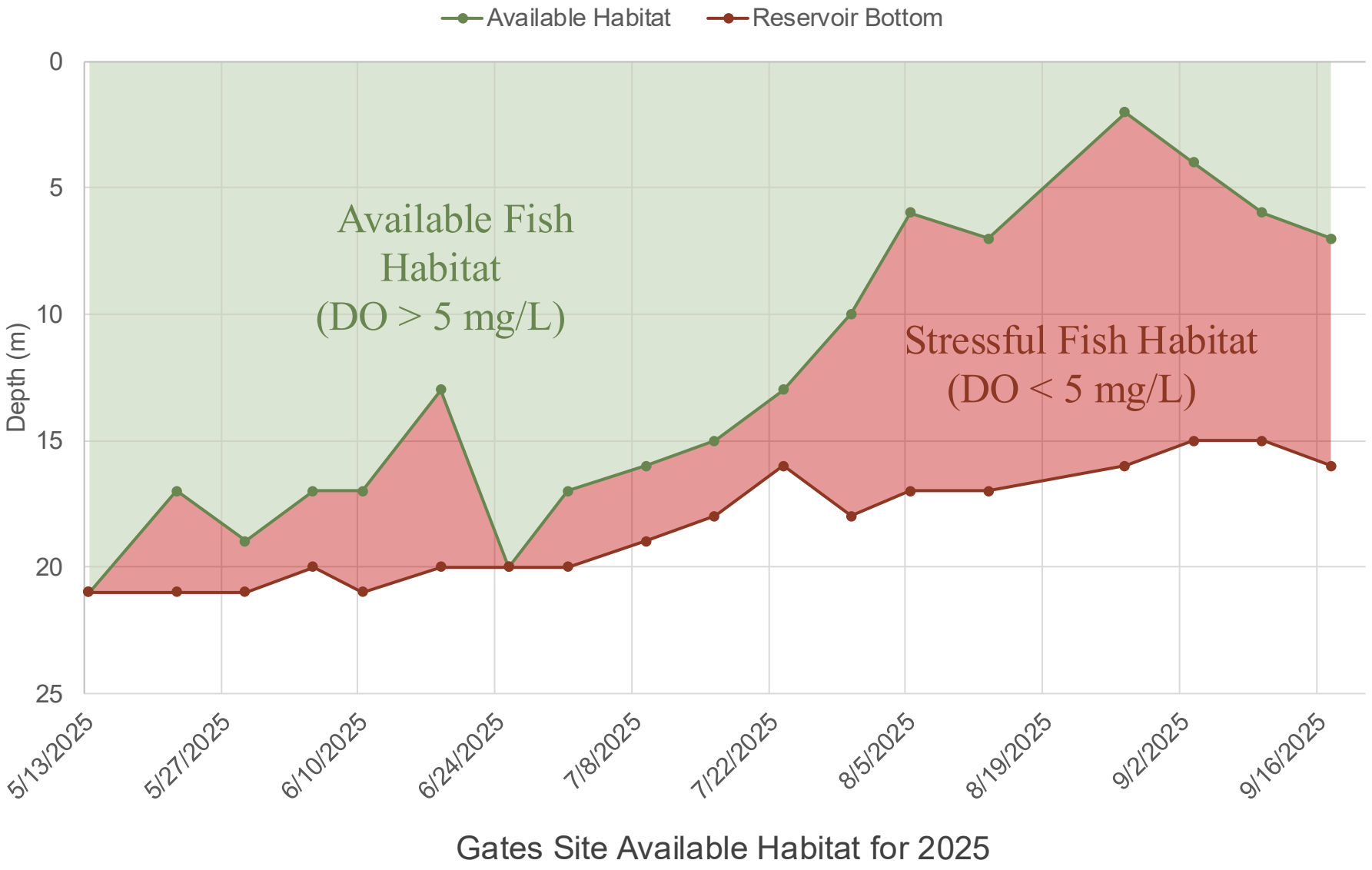
- Water Quality Profiles
  - **Dissolved Oxygen**
  - **Temperature**
  - **Chl-*a* and Phycocyanin**
  - **Conductivity**
  - **pH**
  - **Turbidity**
- Algal Enumerations
- Cyanotoxin Test Strips
- Nutrients
  - **Top and Bottom**



Profiles: Temperature



Profiles: Dissolved Oxygen



Gates Site Available Habitat for 2025

Oxygenation System: Alternatives Analysis

Overview of Alternatives Considered



Diffused Air / Destratification

- Aeration
- Uses high and low flux sections to provide direct and indirect DO infusion
- Destratifies



Speece Cone

- Oxygenation
- 2 options: submerged or on shore application
- Utilizes a chamber to produce oxygenated water that is then reintroduced to the lake
- Maintains stratification



Free Bubble Oxygenation

- Oxygenation
- Utilizes linear micropore hose diffuser to introduce DO into the hypolimnion
- Maintains stratification



Oxygen Saturation Technology

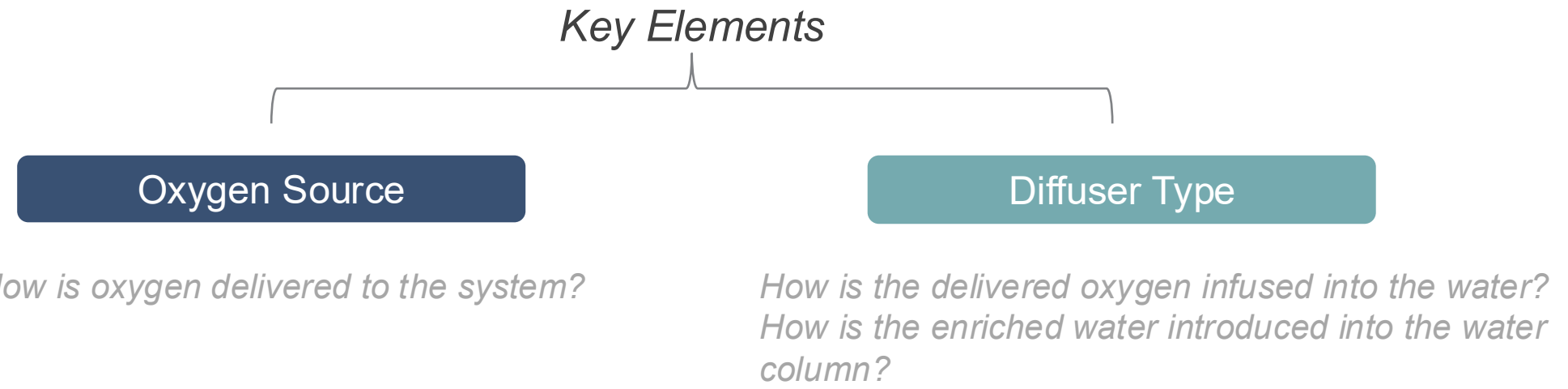
- Oxygenation
- New technology with limited field applications
- Modular submerged chambers that generate supersaturated water that is then reintroduced to the lake
- Maintains stratification

Basis of Design

- Hydrologic Flows dominate oxygen depletion in preliminary analysis
- Effect of DO concentration on maximum delivery is substantial
- Sediment Oxygen Demand was nearly negligible for this analysis
  - **Further study is recommended**

Parameter	Average Outflow (650 cfs)	Maximum Outflow (1,660 cfs)
Oxygen Depletion from SOD (kg/day)	439	439
Oxygen Depletion from Outflow (kg/day)	7,951	20,309
Total Oxygen Delivery Rate (kg/day)	**8,391**	**20,748**

Key Elements of Alternatives Considered



Combating Anoxia Requires the Infusion of Dissolved Oxygen

Key Elements

Oxygen Source

How is oxygen delivered to the system?

Pure Oxygen

FBO
Speece Cone

Compressed Air



DA/D

Liquid Oxygen (LOX)



Onsite Generation (PSA)



OST

Lease

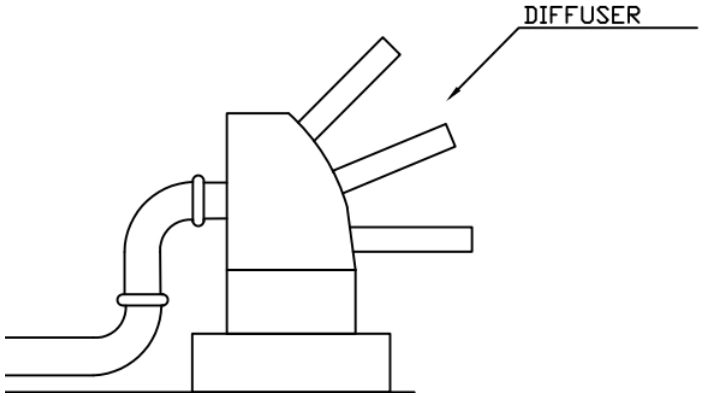
Own

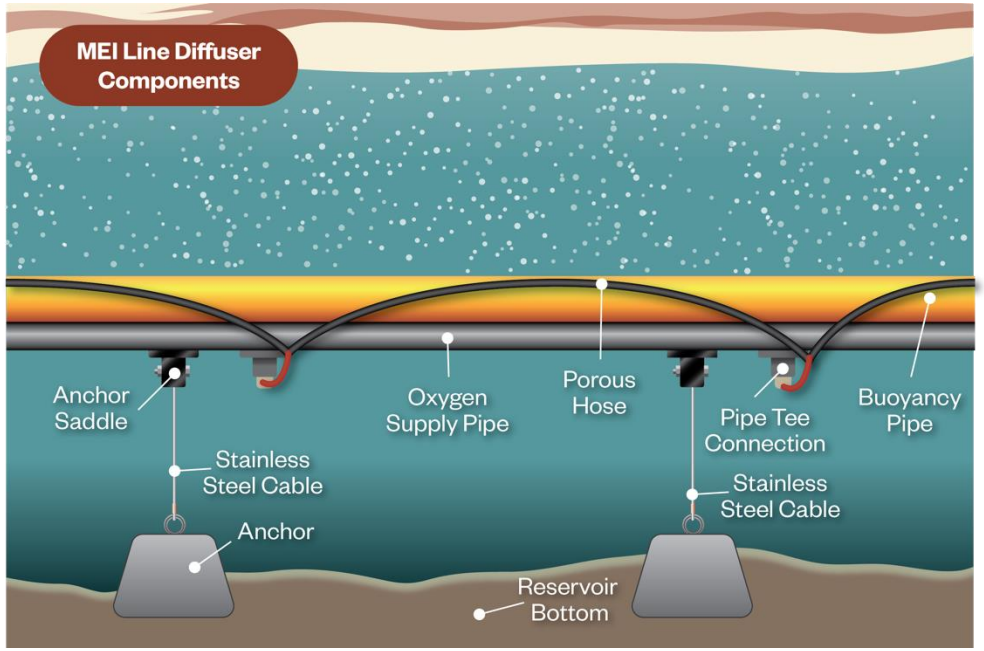
Combating Anoxia Requires the Infusion of Dissolved Oxygen

Key Elements:

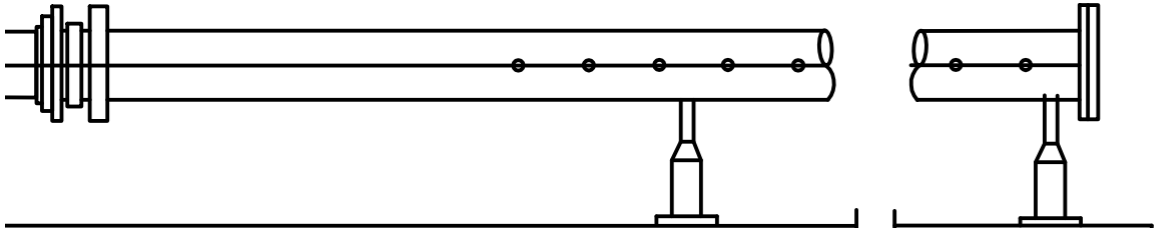
Diffuser Type

- **Linear hose diffuser line (micropore)**
  - *DA/D, FBO*
- **Effluent canon (multi-port diffuser)**
  - *SC*
- **Engineered slotted pipe (multi-port diffuser)**
  - *SC, OST*





TYPICAL DIFFUSER PIPE LENGTH: 100 FT – 150 FT



Overview of Alternatives Considered: Oxygen Supply

Technology	Vendor	Type of System	Oxygen Supply	Diffuser Type
Diffused Air / Destratification (DA/D)	Mobley Engineering Inc. (MEI)	Aeration	Compressed Air	Linear hose diffuser line
Free Bubble Oxygenation (FBO)	Mobley Engineering Inc. (MEI)	Oxygenation	LOX*	Linear hose diffuser line
Speece Cone	ECO_2	Oxygenation	LOX*	Slotted Pipe or Effluent Canon
Oxygen Saturation Technology (OST)	Clarity Resources Group	Oxygenation	PSA	Slotted pipe

**Lease LOX equipment*

Recommended Alternative

Free Bubble Oxygenation (FBO)

- Designed for larger, deeper systems and hydropower facilitation
- Directly oxygenates target area (does not vertically mix)
- Use of LOX and buoyancy line reduced maintenance costs

Unselected Alternatives:

- Speece Cone: Potentially viable, but higher maintenance costs, lower delivery rate, and smaller spatial extent
- Oxygen Saturation Technology (OST): Less field-verified applications, not practical for large delivery rates
- Diffused Air/Destratification (DA/D): Not feasible for reservoir size and depth



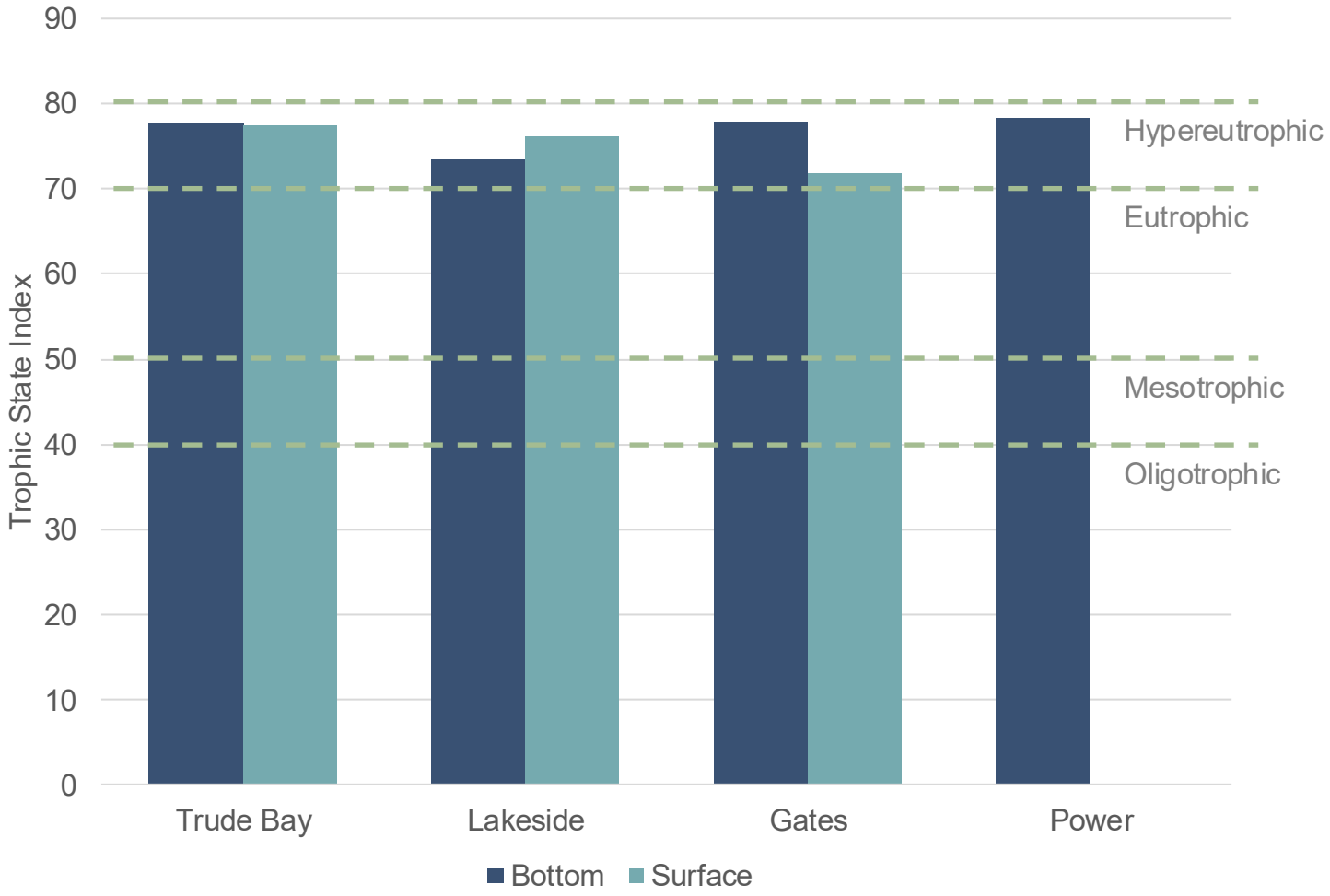
Addressing Eutrophication

In-Reservoir Data

Trophic State Index: TP

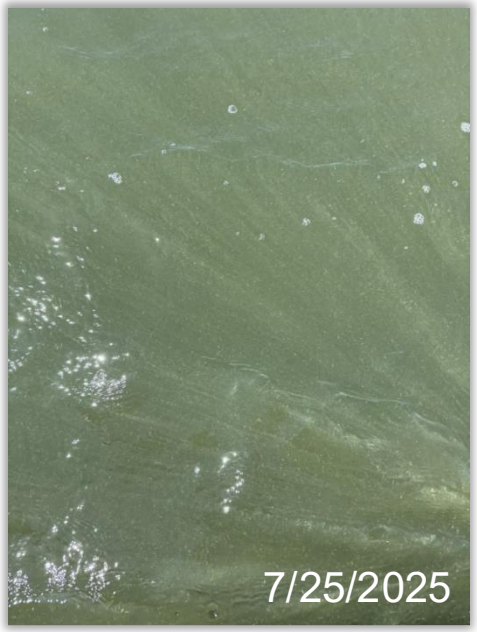
- TSI in Island Park Reservoir is ***hypereutrophic*** using total phosphorus
- High phytoplankton growth, likely causing oxygen depletion and other ecological impacts

$$TSI_{TP} = 14.42 \ln TP + 4.15$$



Overview of Nutrients

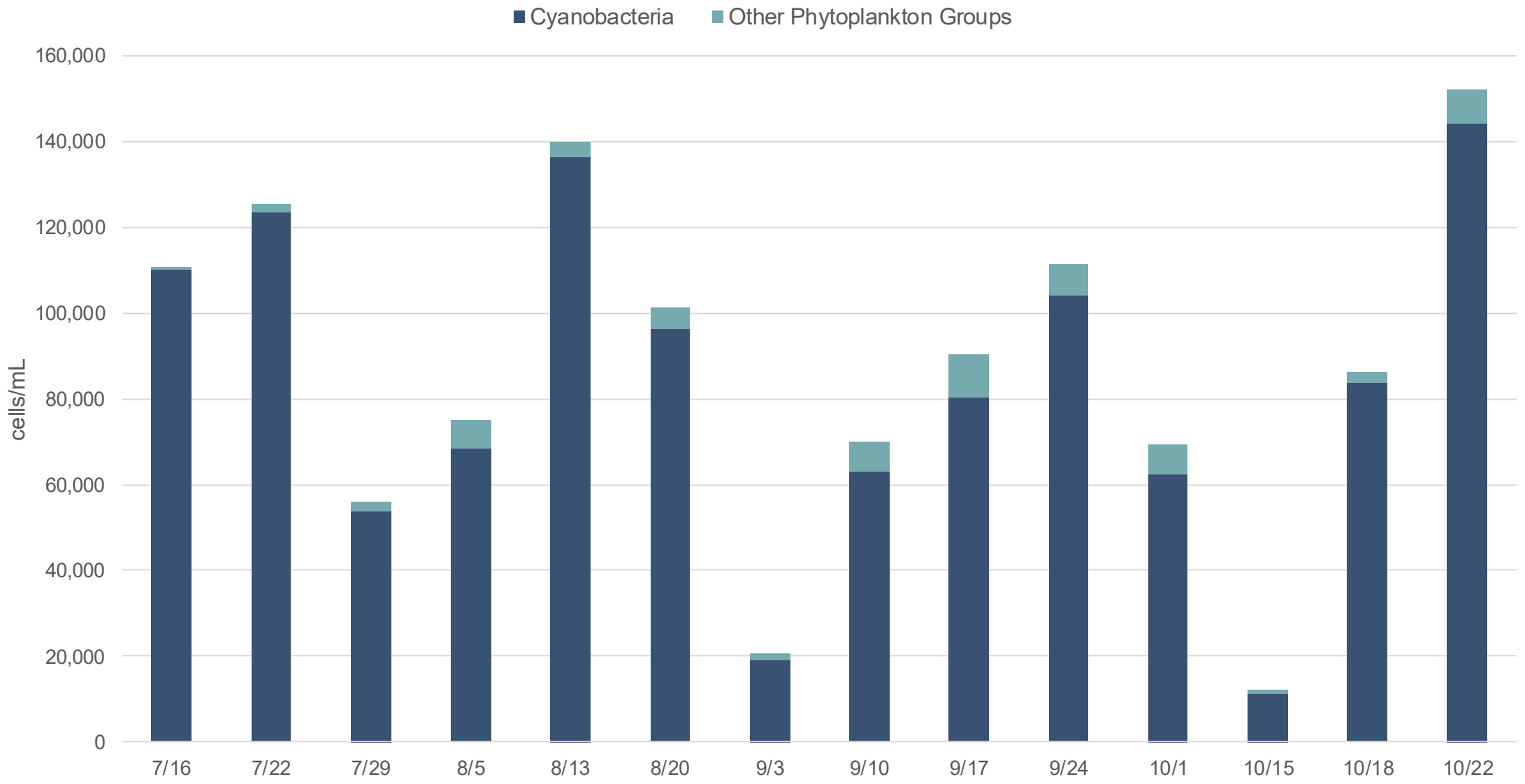
- TP very high throughout water column
  - **Key macronutrient for phytoplankton growth**
- TN:TP Ratio < 16
  - **Indicates nitrogen-limited growth**
  - **Favors nitrogen-fixing cyanobacteria**





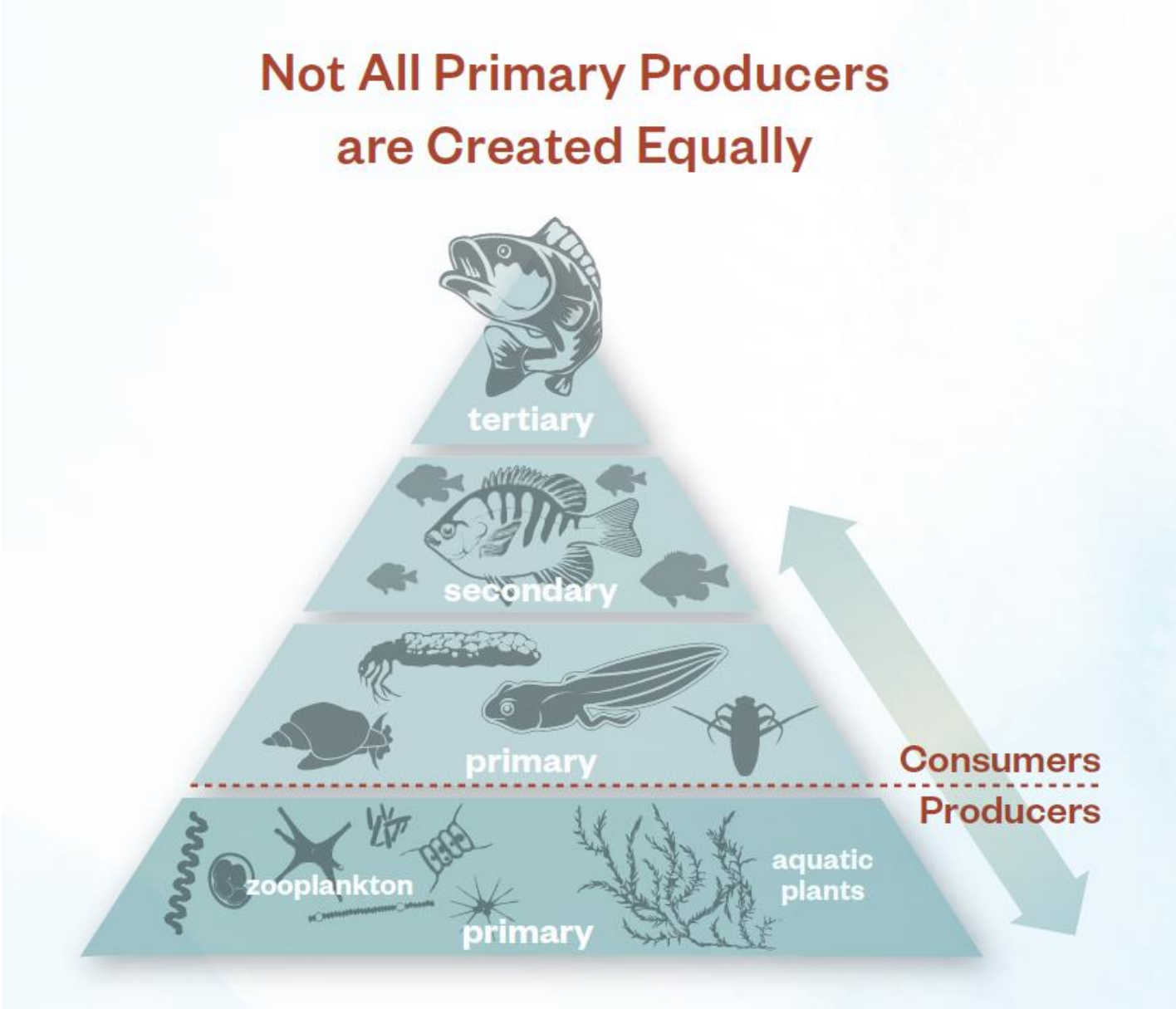
Parameter	2025 Seasonal Average
Total Phosphorus (mg/L)	0.171
Total Nitrogen (mg/L)	0.30
Ammonia (mg/L)	0.110
Nitrate & Nitrite (mg/L)	0.035
TKN (mg/L)	0.26
Orthophosphate (mg/L)	0.015

Phytoplankton Enumerations – Cyanobacteria Dominance



Impacts of Eutrophication

- Oxygen depletion via respiration
  - Diurnal cycle can cause fish kills
- Toxicity
  - Cyanotoxins exert a direct pressure on fish populations
- Disrupted food web
  - Reduced macrophytes, invertebrates, and fish populations
  - Turbidity reduced sunlight penetration
  - Altered nutrient cycling
- Risk to recreators



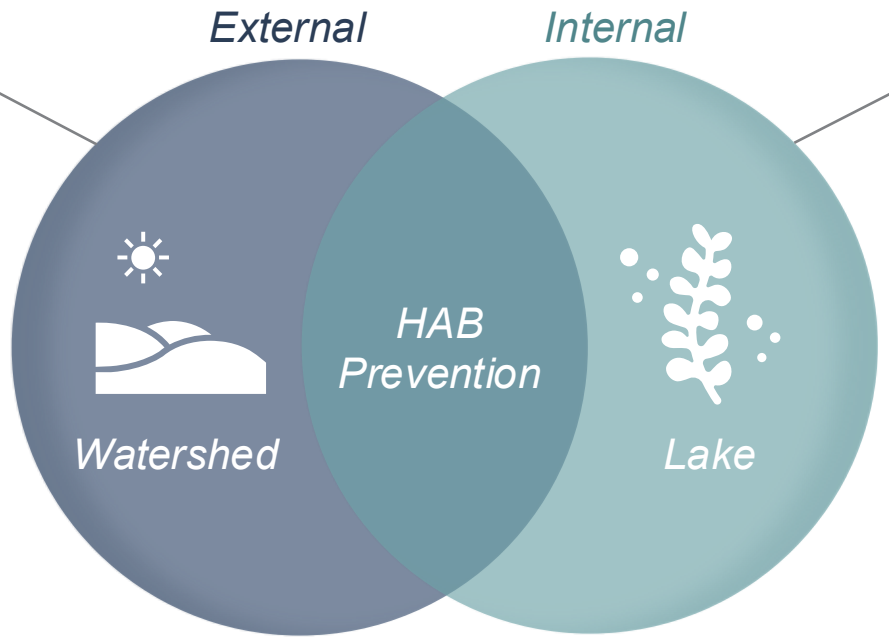
Management Strategies

Core Components of Source Water Protection and Management

No one "Silver Bullet" Solution

Source Water Protection

- Maintain quality of receiving waters
- Offset anthropogenic impact
- Watershed based



Source Water Management

- Restore or maintain quality of source water
- Buffer impact of external influences
- In situ management

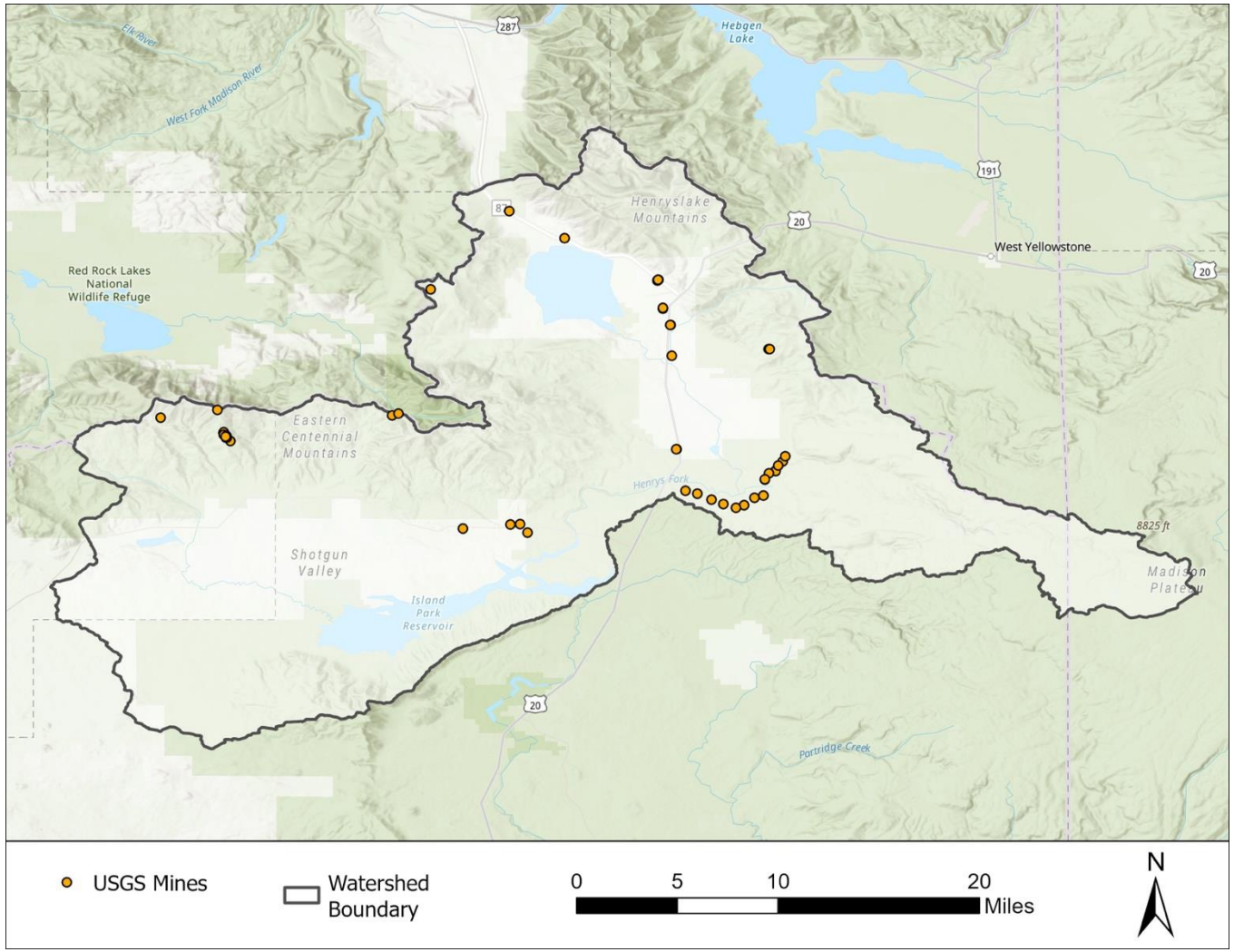
Protection ≠ Management

Source Water Protection: Watershed Nutrient Sources

Potential Sources

- Naturally occurring in surrounding geologic formations
- Septic systems
- Cattle ranching
- Phosphorus mines

Targeted watershed monitoring is recommended to determine sources



Watershed Phosphorus Mines (USGS)

Source Water Management: In-Reservoir Strategies

- Continued Routine Monitoring
  - **Establishes the basis for long-term management**
- Address impacts of motorized watercraft
- Algaecide
  - **Hydrogen peroxide**
- Littoral Zone Restoration



Conclusions

Conclusions

- Recommended Alternative: Free-Bubble Oxygenation (MEI)
- Oxygenation will have the best impact on water quality and fish habitat when paired with other strategies
- Nutrient concentrations in Island Park Reservoir are very high
- Overall ecological parameters indicate cyanobacteria dominance and loss of macrophyte habitat
- Strategies to address ecological regime and nutrient loads are recommended



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