



# Strategies for Meeting the Extreme Effluent Phosphorus Limits at New Hampshire Fish & Game Fish Hatcheries

NE-NYWEA Spring Technical Conference and Exhibition  
June 8, 2023



# AGENDA

- 01 – Overview of Fish Hatcheries
- 02 – Fish Hatchery Effluent Treatment Concerns
- 03 – New Hampshire Fish & Game Case Study



**01**

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# **Overview of Fish Hatcheries**

# Importance of Hatcheries

- Fishing Opportunities
- Conservation
- Protection
- Mitigation of Habitat Loss



# Fisheries by the Numbers



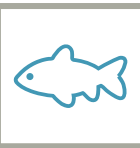
100+

Staff who Interact with Fisheries Projects



120+

Aquatic Species HDR has Worked With



3

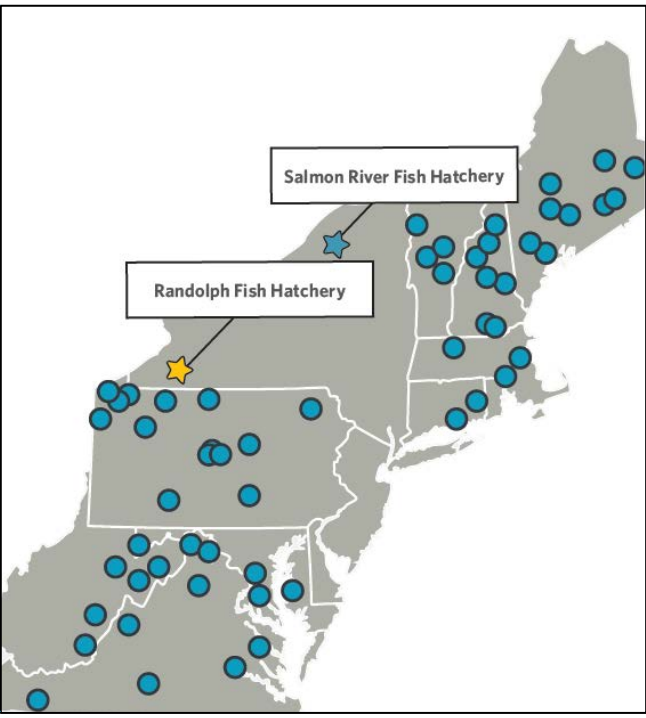
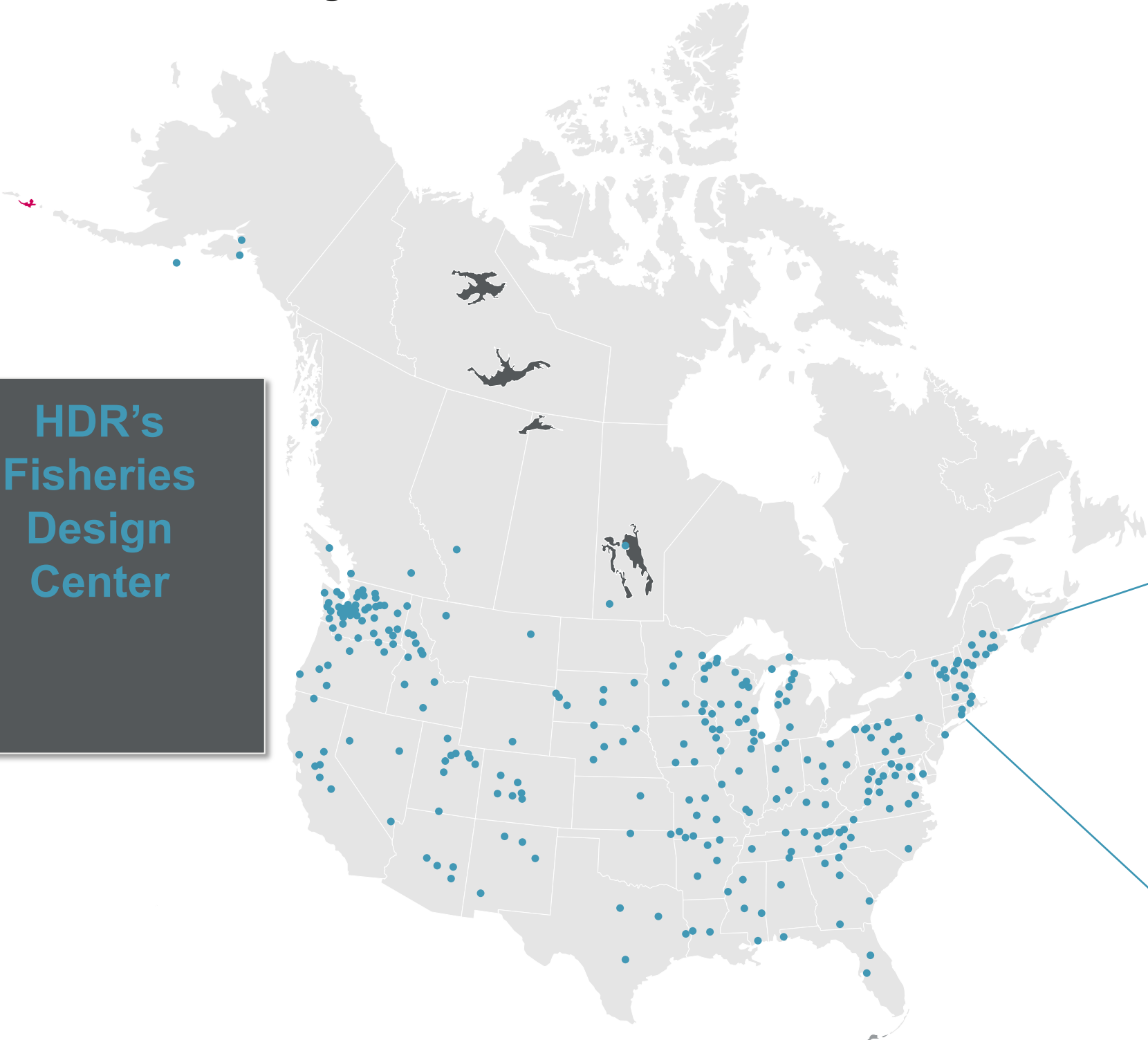
Technical Service Areas



56+

Northeast Fisheries Design Center Project Locations

HDR's Fisheries Design Center



# HDR Hatchery Effluent Practice

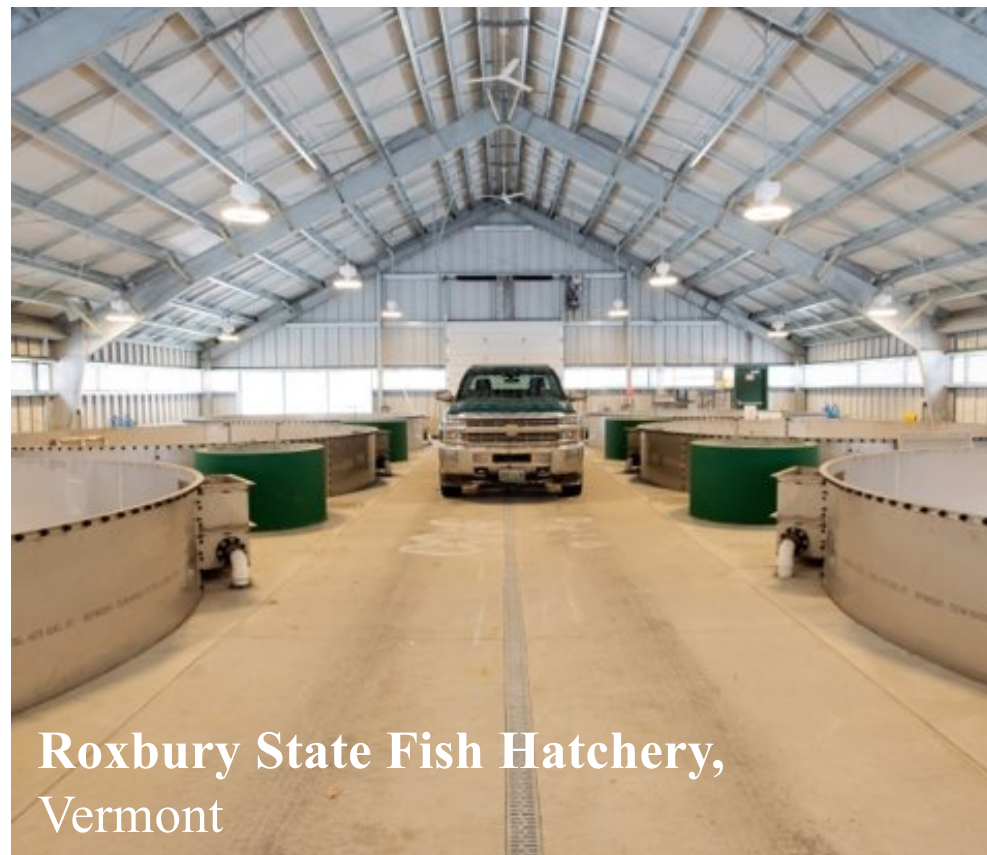
- Fish Culture
- Water Quality Modeling
- Wastewater Treatment
- Water Quality Monitoring



**Powder Mill Fish Hatchery,  
New Hampshire**



**Powder Mill Fish Hatchery,  
New Hampshire**



**Roxbury State Fish Hatchery,  
Vermont**



**Twin Mountain Fish Hatchery,  
New Hampshire**

02

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# **Fish Hatchery Effluent Treatment Concerns**

# Regulatory Compliance Drivers

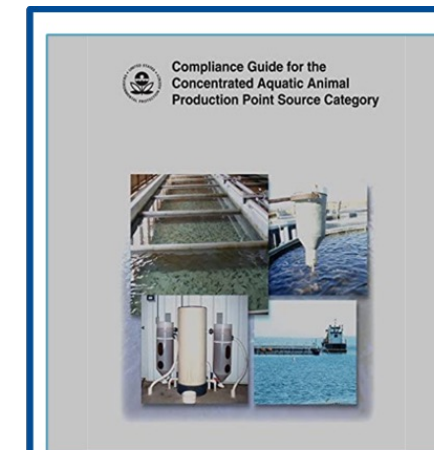
- Hatcheries are point source dischargers.
- Effluent treatment requirement is typically solids removal through settling or screening.
- When discharging to impaired waters, hatcheries are increasingly required to limit phosphorus and nitrogen discharges to very small daily mass loadings.
- Hatcheries need specialized assistance with this new requirement!



**Federal Water  
Pollution Control  
Act  
1948**



**Clean Water Act &  
NPDES  
1972**



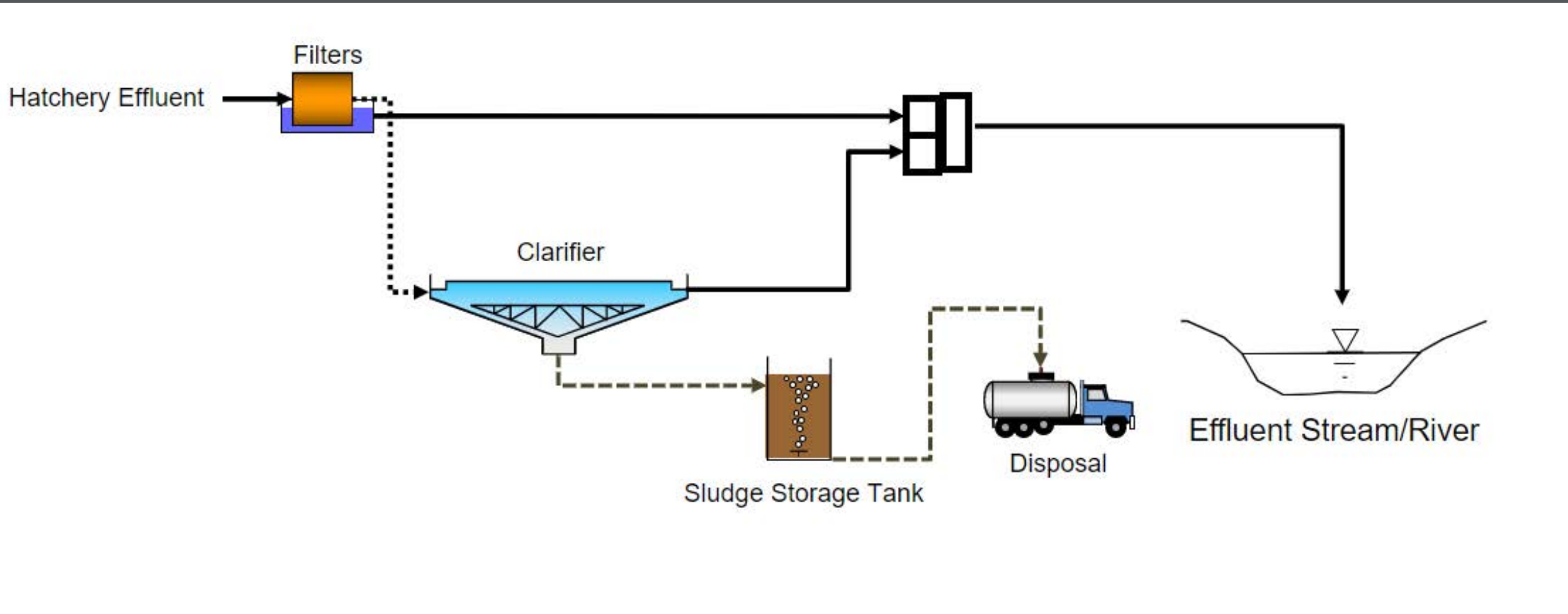
**Concentrated Aquatic  
Animal Production  
(CAAP)  
2004**



**Total Maximum Daily  
Load (TMDL)  
Current**



# Modern Hatchery Effluent Treatment Flow Diagram



Roxbury State Fish Hatchery, Vermont



## **Fish Hatchery Effluent Treatment**

- Simple settling ponds to advanced treatment systems
- Enhanced treatment - nutrient removal or recovery for beneficial reuse

# How Does Phosphorus Get Into The Hatchery Effluent?



Feed

- Fecal Settleable Solids
- BOD
- **Total Phosphorus (TP)**

- $\text{CO}_2$
- $\text{NH}_3$

$\text{O}_2$  Consumption

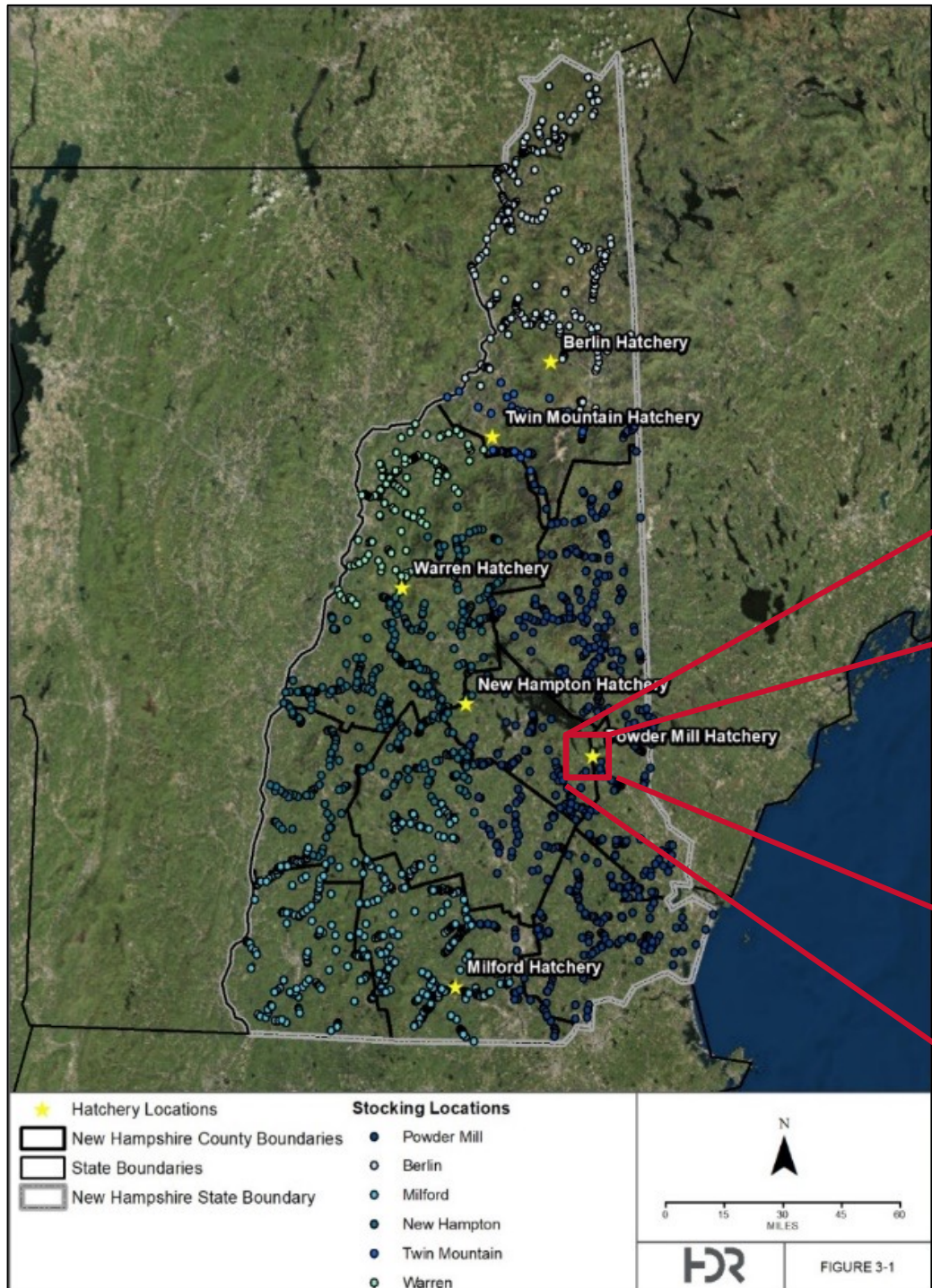
03

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# **New Hampshire Fish & Game Case Study**

# Powder Mill Fish Hatchery

- Located in New Durham, NH
- Production: Brook Trout, Rainbow Trout, Brown Trout
- Average Influent Flow Rate: 5 mgd



# Powder Mill Hatchery

## New NPDES Phosphorus Limits

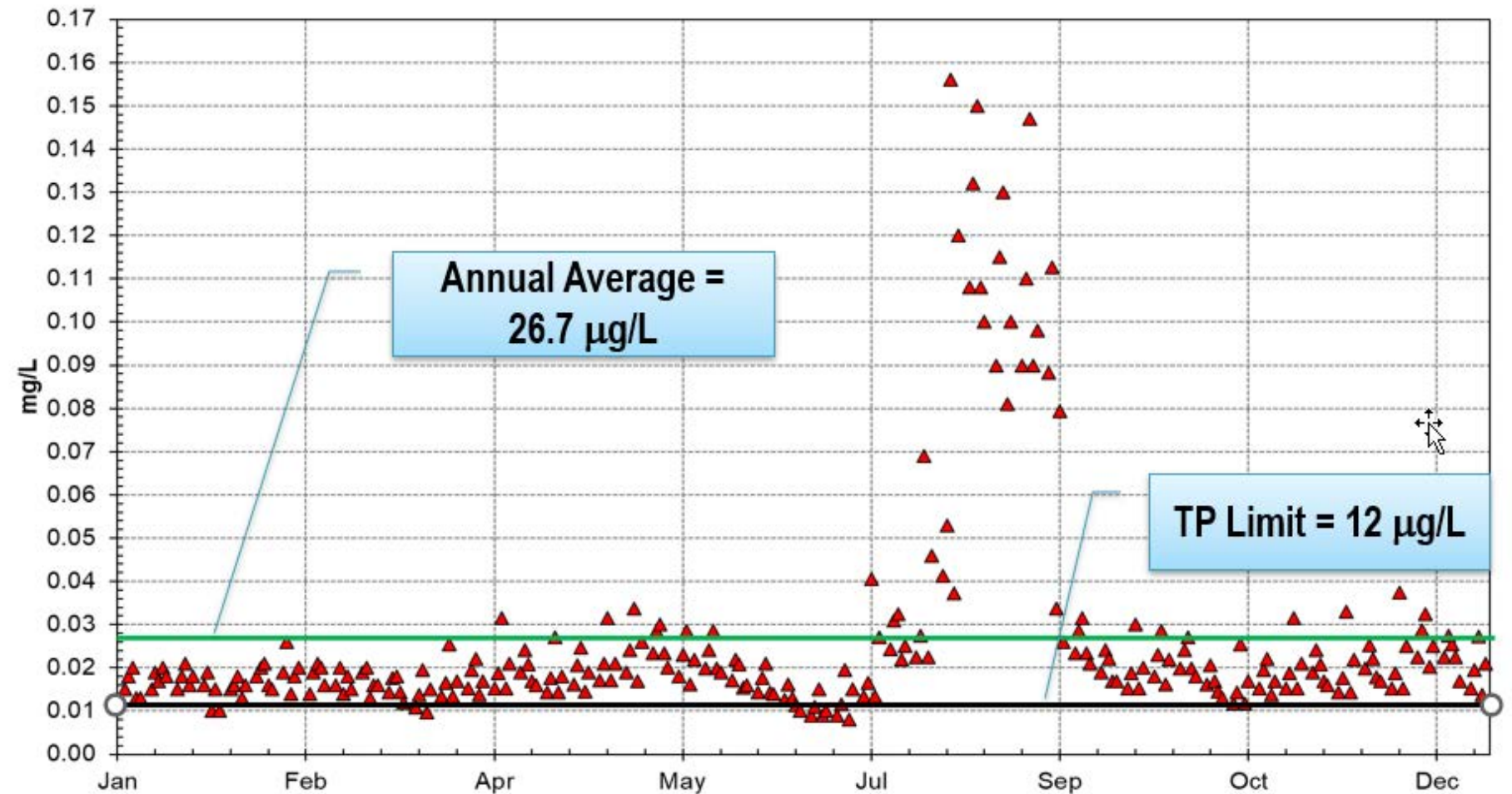
- An average monthly TP discharge concentration limit of 12  $\mu\text{g}/\text{L}$



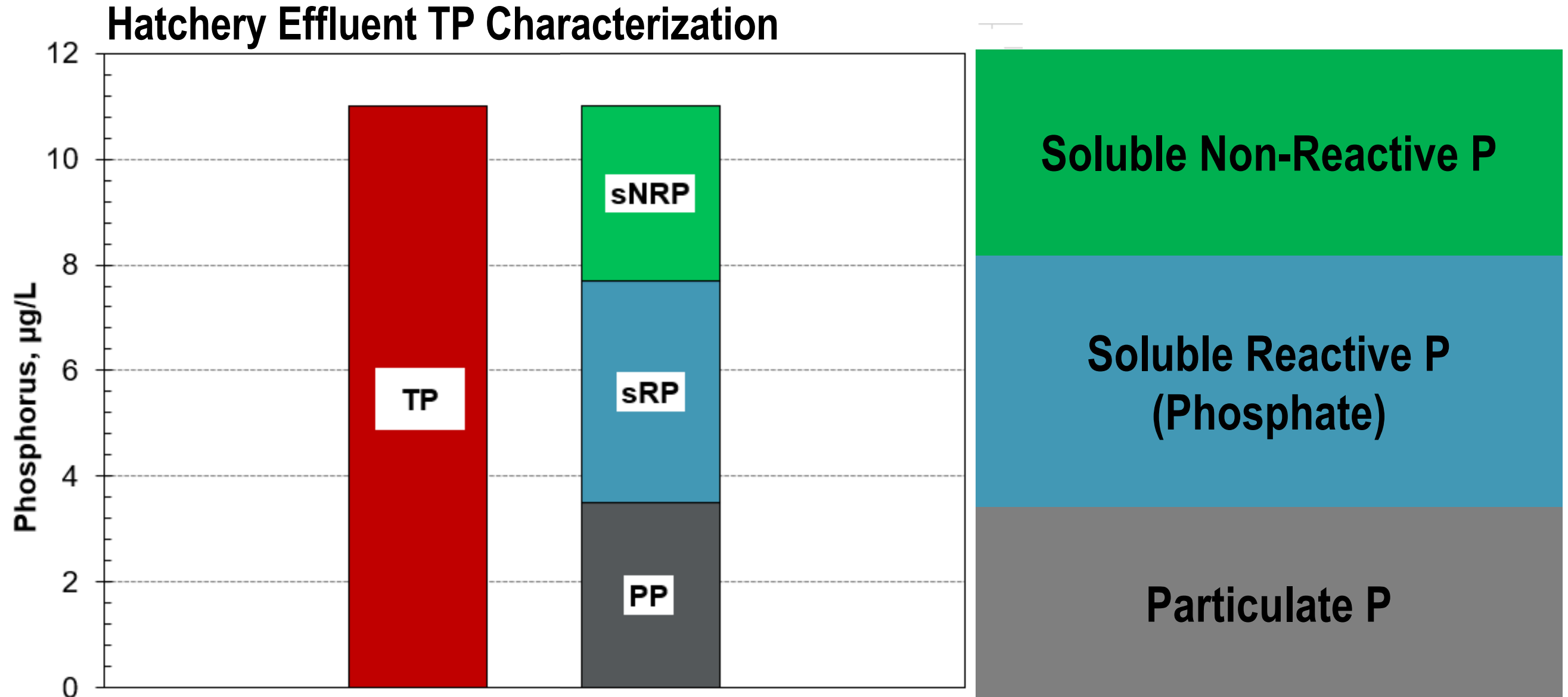
# Case Study Purpose

## To Meet the Limit

- 50% TP removal on average
- More than 90% removal in peak loading summer months



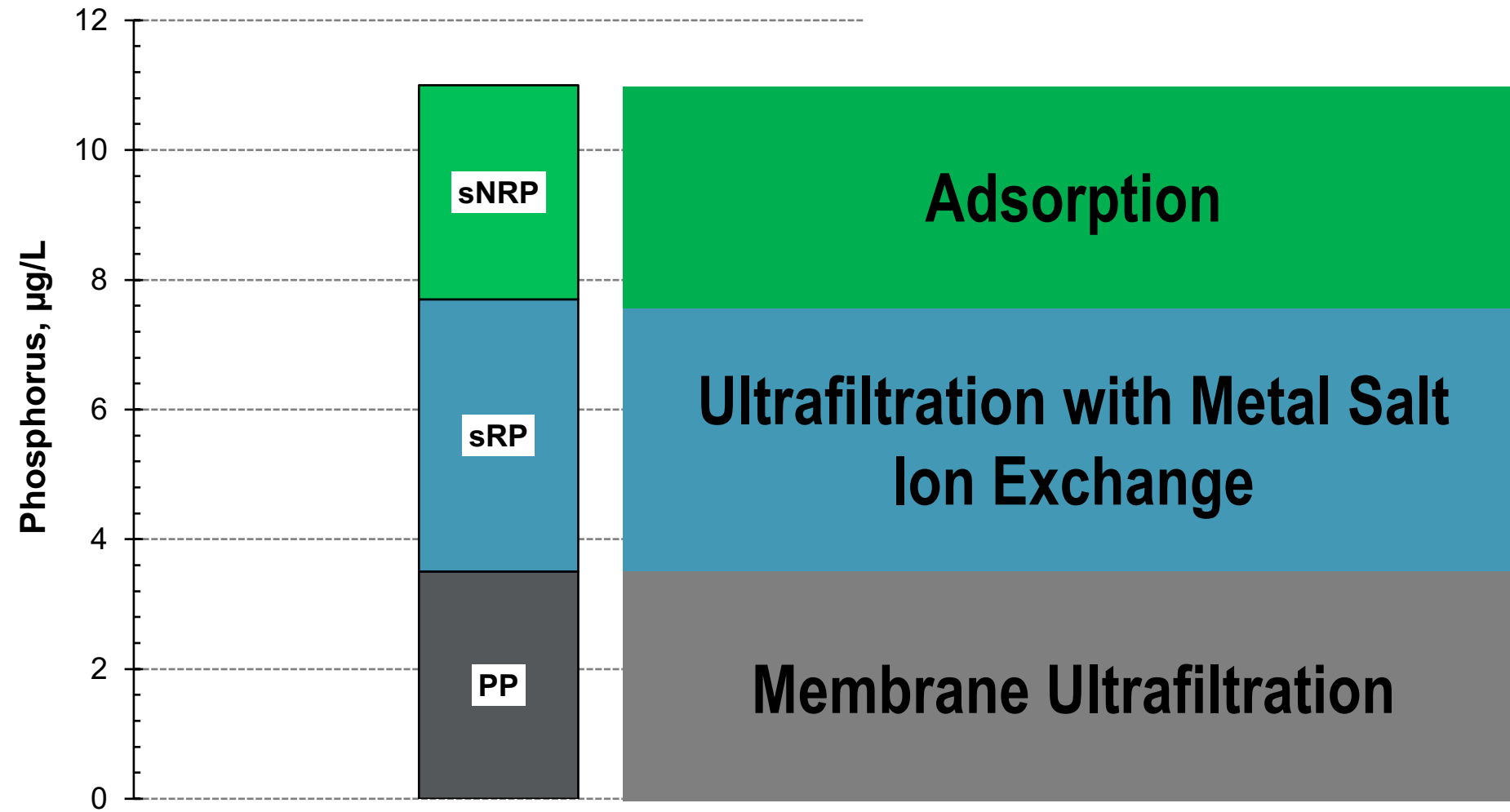
# The Challenge- TP Species in Hatchery Effluent



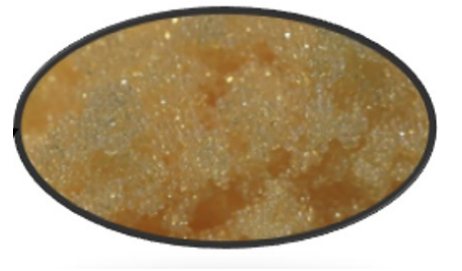
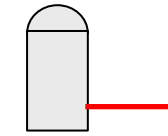


# Treatment Technology Selection

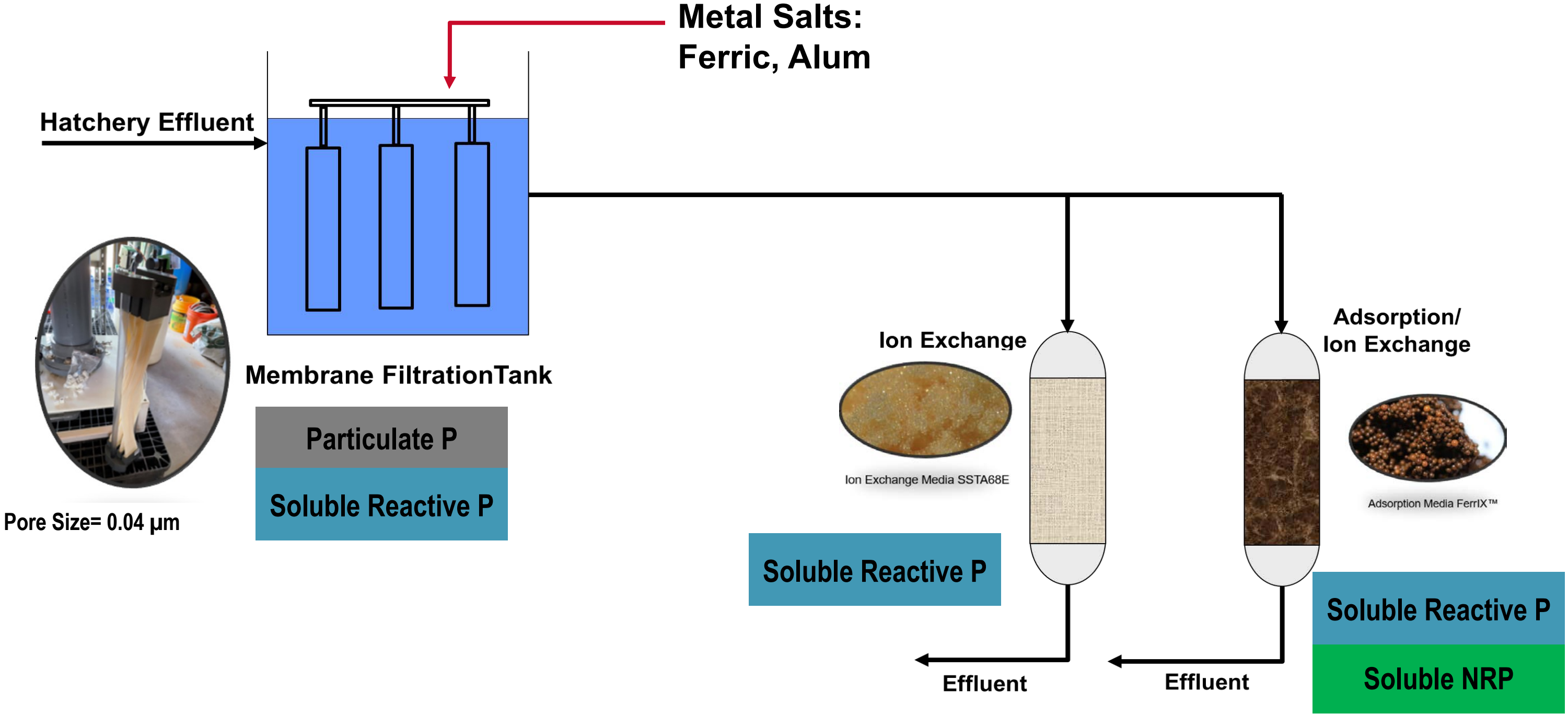
## Hatchery Effluent TP Characterization



Metal Salt Addition



# Powder Mill Pilot Schematic



Metal Salt Addition

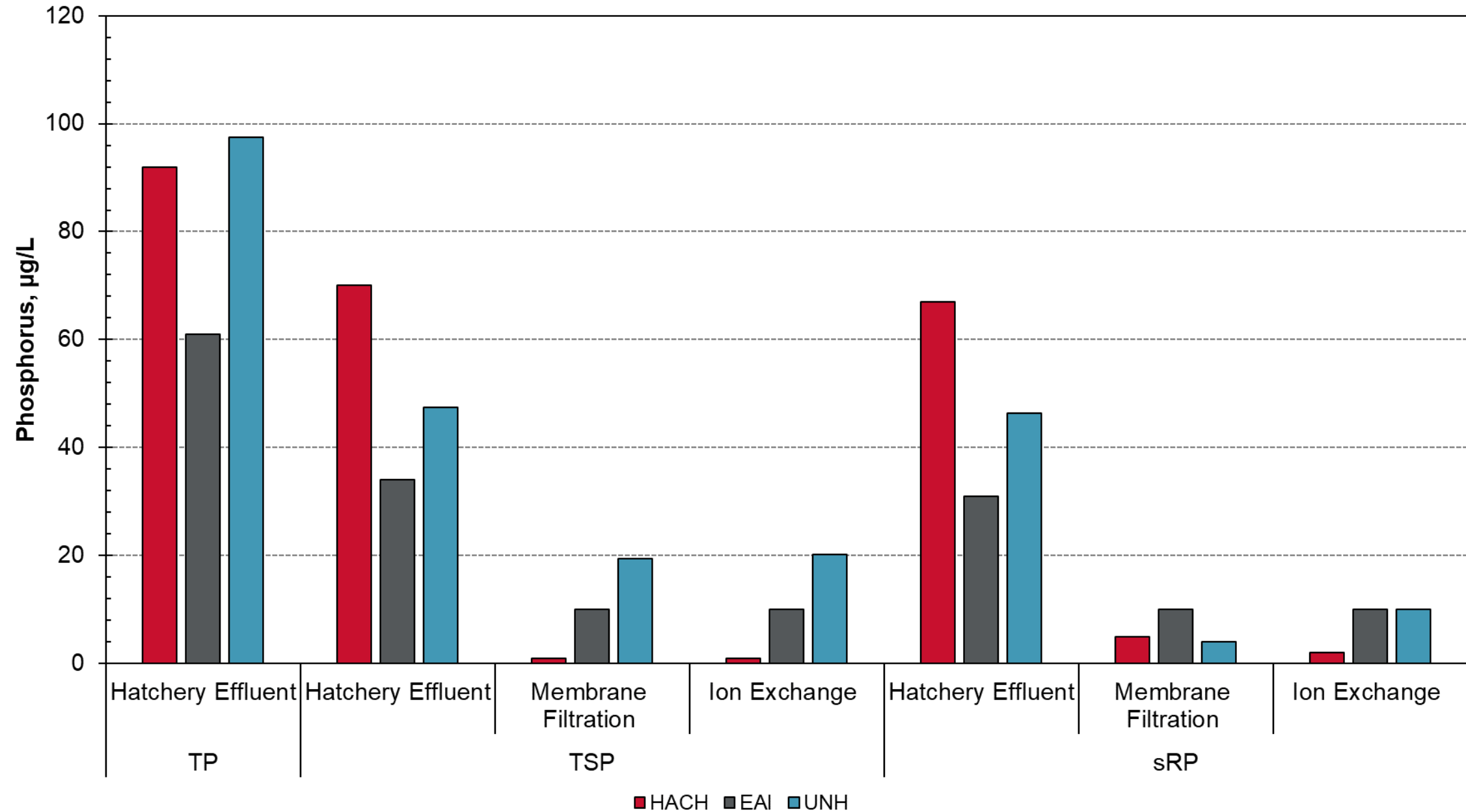
Membrane Ultrafiltration

Adsorption and Ion Exchange



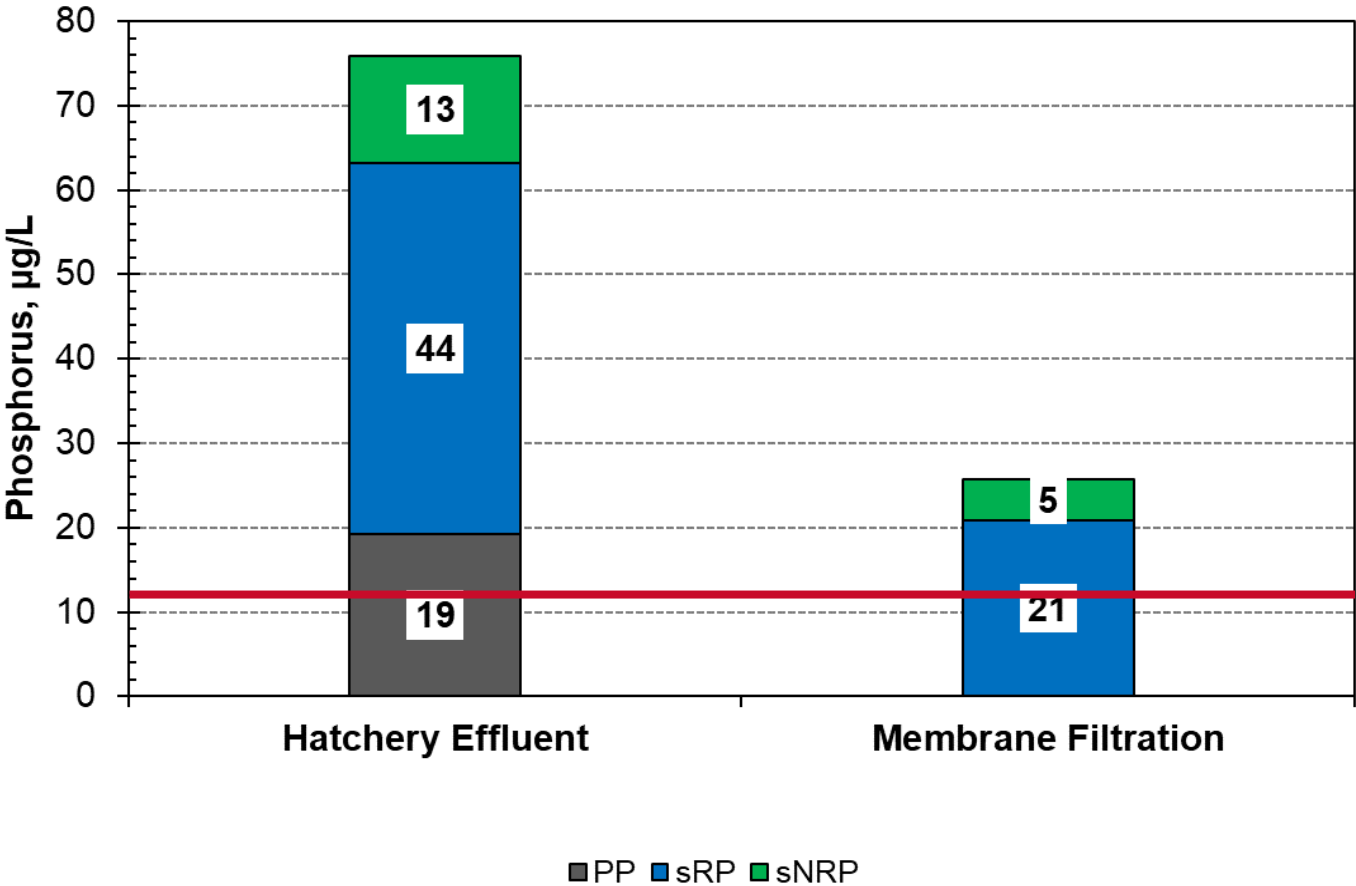
# Pilot Testing- The Challenge of Measuring Ultra-low P Concentration

## Comparison of Phosphorus Speciation Analytical Methods

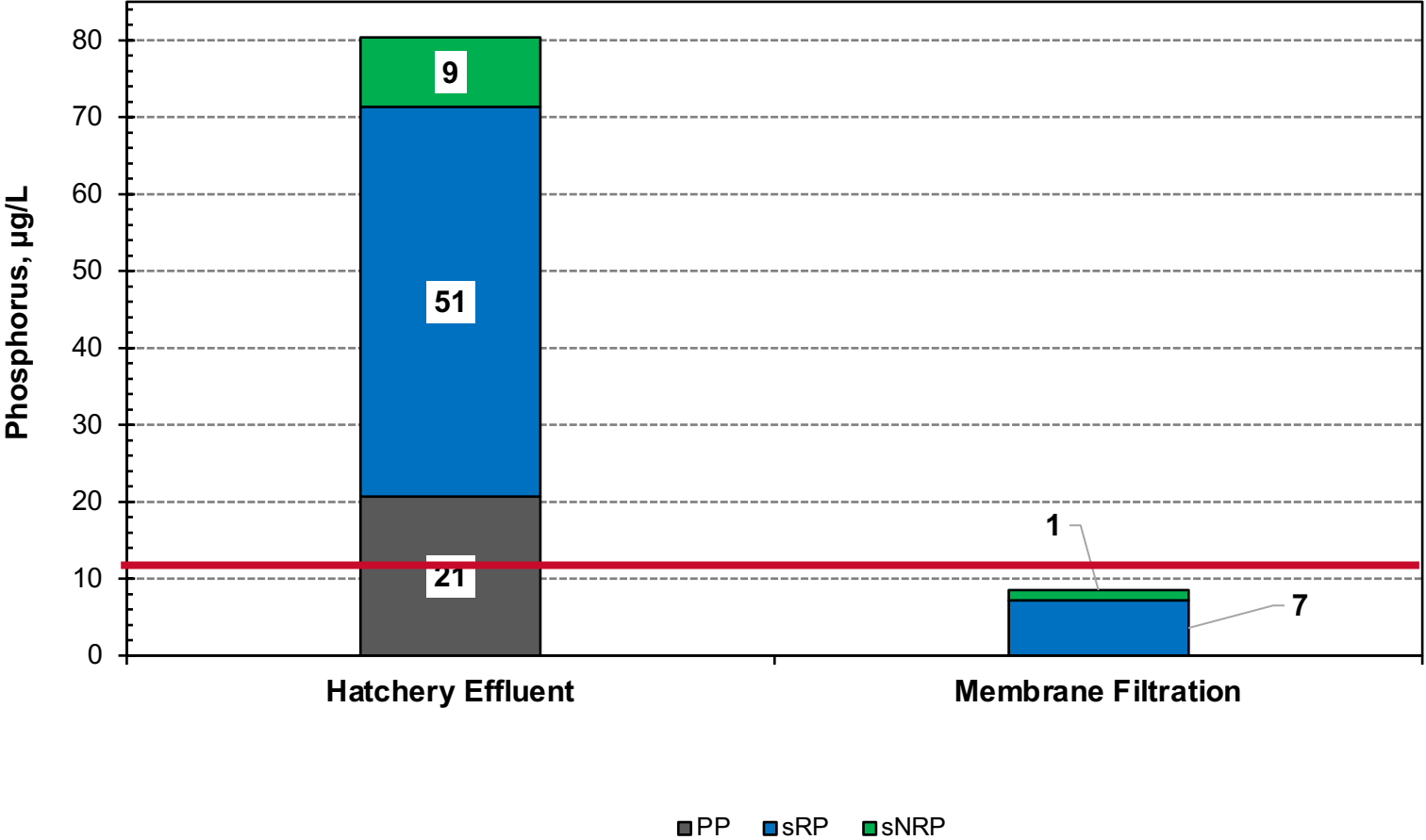


# Pilot Testing- Membrane Filtration

### Membrane Filtration Only



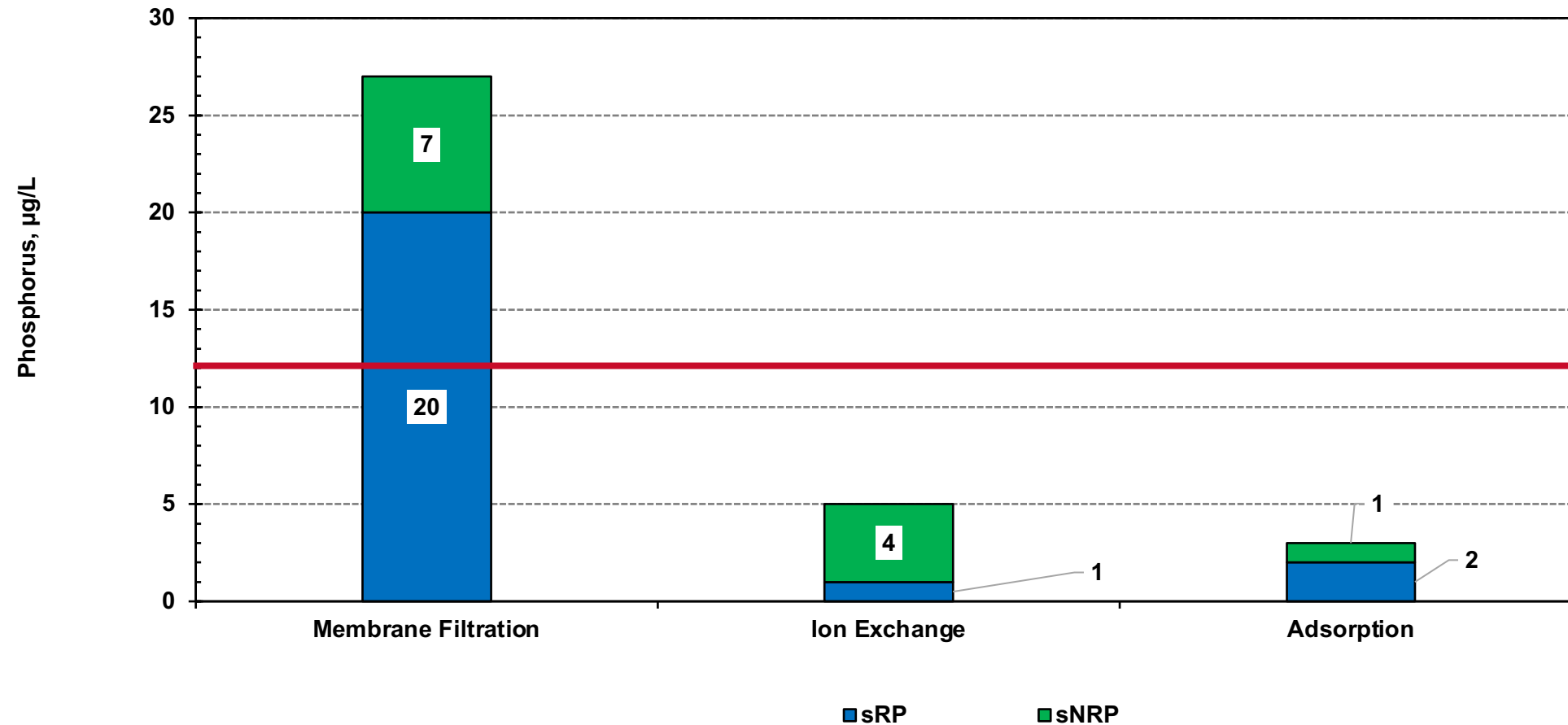
### Membrane Filtration with Metal Salt Addition



- Membrane Filtration only could not meet the 12 µg/L limit.
- Ferric and Alum were tested as the metal salts.
- Membrane Filtration with Metal Salt Addition successfully met the 12 µg/L limit.

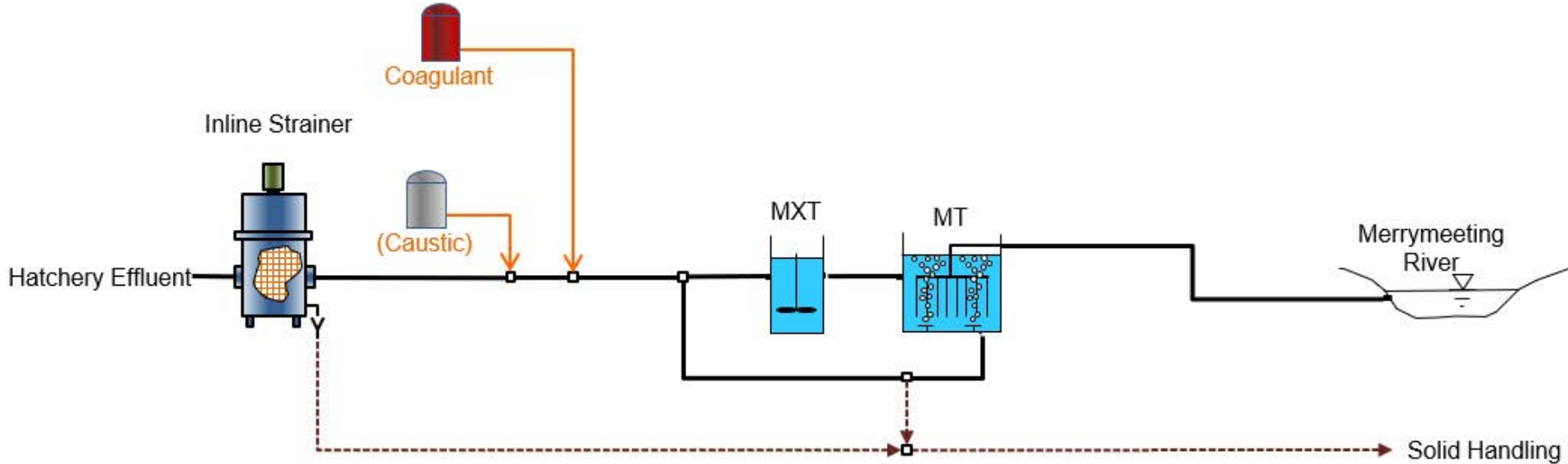
# Ion Exchange and Adsorption Performance

Membrane Permeate TP > 12  $\mu\text{g/L}$

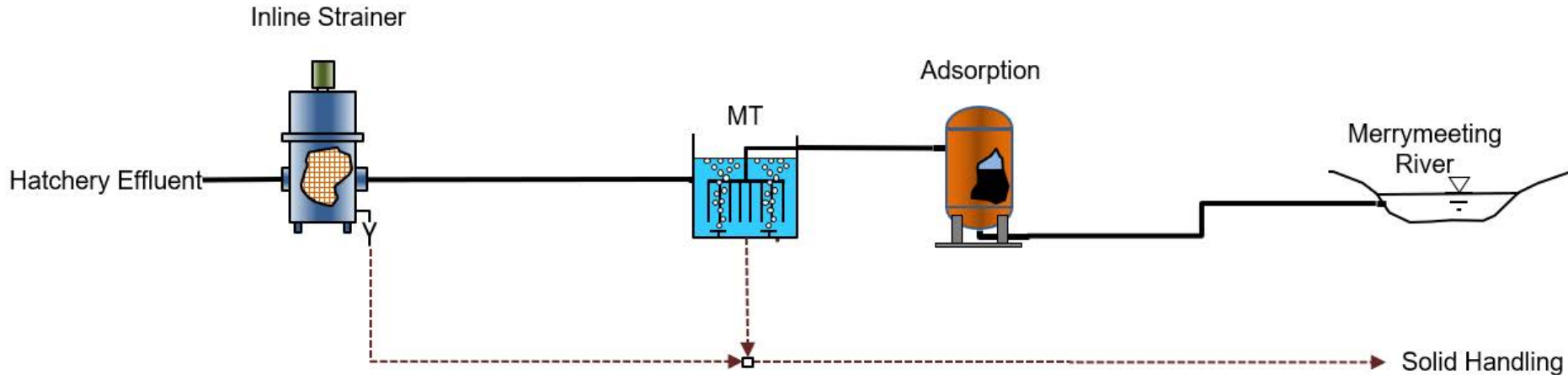


- Ion Exchange effluent sRP concentration remained less than 5  $\mu\text{g/L}$ .
- Adsorption effluent TP concentration remained less than 12  $\mu\text{g/L}$ .
- No breakthrough was observed in adsorption column.

# Alt A: Membrane Filtration with Metal Salt Addition



# Alt B: Membrane Filtration followed by Adsorption



# Modernization Alternatives

## Hatchery Modernization Alternatives:

## Effluent Treatment Alternatives:

1. Existing Rearing Units with Aquaculture Upgrades

A – Membrane Filtration with Chemical Dosing

B – Membrane Filtration with Adsorption

2. Circular Rearing Tanks with 75% Recirculation (RAS)

A – Membrane Filtration with Chemical Dosing

B – Membrane Filtration with Adsorption

3. Circular Rearing Tanks with 95% Recirculation (RAS)

A – Membrane Filtration with Chemical Dosing

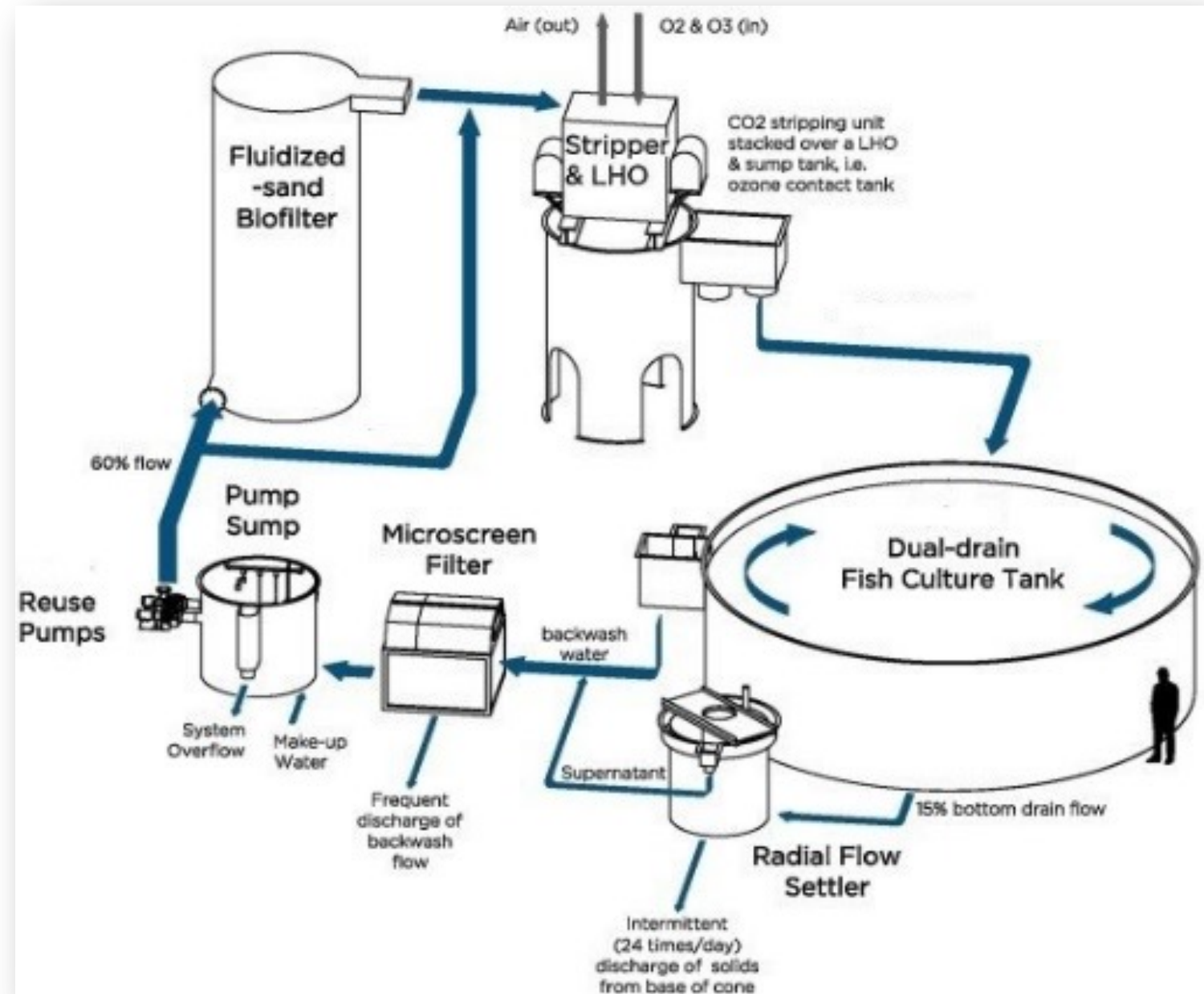
B – Membrane Filtration with Adsorption



# 95% Recirculating Aquaculture System (RAS) Facility

## Proposed Modernization:

- New 95% RAS
- Supply Water Disinfection (Intake Building)
- Effluent Solids Handling
- New Outfall Location

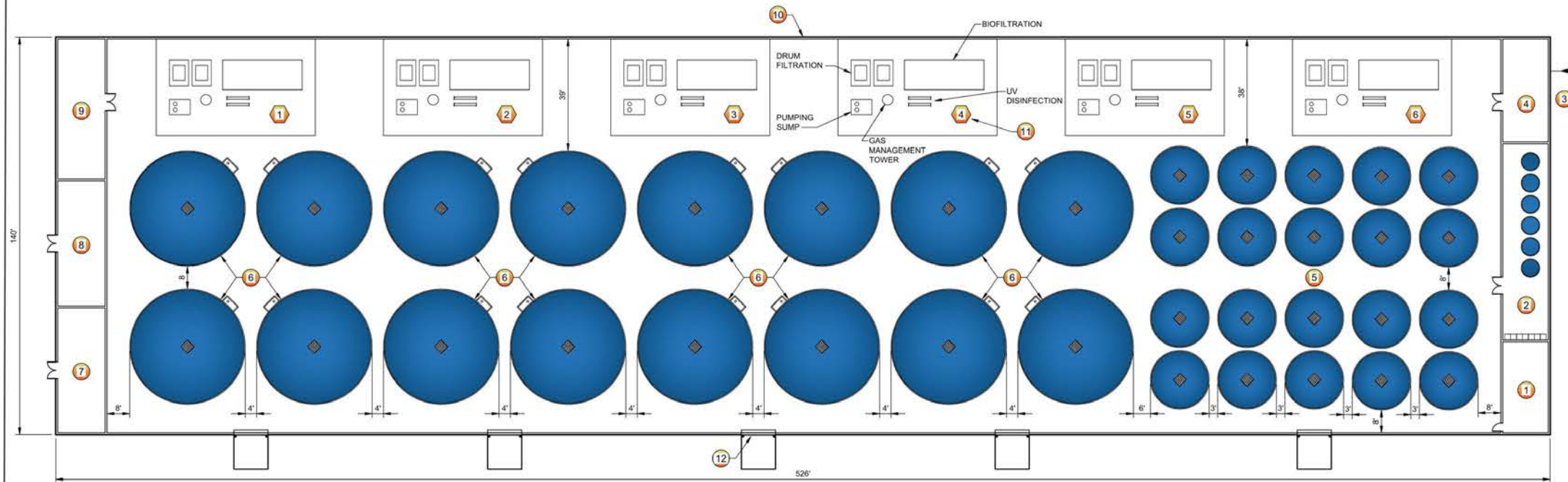


# 95% RAS Facility Concept

- Each module of four tanks = 32,000 lbs of production
- Total Building Flow = 13,868 gpm
- Recirculation Flow = 13,175 gpm
- Makeup Water = 693 gpm

### KEYED NOTES:

- OFFICES AND STAFF SUPPORT SPACES IN INSULATED POWDER MILL RAS PRE-ENGINEERED BUILDING.
- EGG INCUBATION ROOM INCLUDING BIOSECURITY EGG WASH AREA, VERTICAL FLOW EGG INCUBATORS AND CIRCULAR FEED TRAINING TANKS. THIS ROOM ON FLOW THROUGH WATER USE ONLY (NOT RAS).
- SHALLOW AND DEEP LAKE WATER SUPPLY LINES FOR MAKEUP WATER TO RAS SYSTEM.
- PROCESS MECHANICAL ROOM. LAKE WATER FILTRATION, UV DISINFECTION AND MAKE-UP WATER DE-GASSING/AERATION. SPACE INCLUDES PROCESS WATER HEATING SYSTEMS.
- 20 FT DIAMETER INTERMEDIATE REARING TANKS WITH MODULAR RAS TREATMENT COMPONENTS. TWO (2) RAS MODULES WITH 10 TANKS PER MODULE. TANKS ARE DUAL DRAIN DESIGN.
- 40 FT DIAMETER FINAL GROW-OUT TANKS WITH MODULAR RAS TREATMENT COMPONENTS. FOUR (4) RAS MODULES WITH 4 TANKS PER MODULE. TANKS ARE DUAL DRAIN DESIGN.
- GENERAL EQUIPMENT STORAGE SPACE.
- FEED STORAGE SPACE (AIR CONDITIONED).
- ELECTRICAL EQUIPMENT ROOM. ELECTRICAL PANELS AND EMERGENCY ELECTRICAL GENERATOR. PROCESS MONITORING AND INSTRUMENTATION SYSTEM FOR ALL RAS MODULES PROVIDED.
- PRE-ENGINEERED INSULATED METAL BUILDING WITH HVAC SYSTEMS. BUILDING SIZE IS APPROXIMATELY 65,745 SQUARE FEET.
- RAS MODULES 6 PROVIDED. EACH MODULE INCLUDES DUAL DRAIN CULTURE TANKS, MICROSCREEN, CIRCULATION PUMPS, BIOFILTRATION TOWER, GAS MANAGEMENT TOWER WITH CO2 & DO GAS MANAGEMENT, UV DISINFECTION, OZONE AND SYSTEM PIPING. SYSTEM IS 95% RECIRCULATION / 5% MAKE-UP BY RATE OF FLOW RAS DESIGN. RAS MODULES CAN OPERATE AS STAND-ALONE INDEPENDENT SYSTEMS.
- 12' HEAD DOOR, TYP. FOR 5 LOCATIONS



ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	R. ELWOOD
PROJECT NUMBER	10331124



POWDER MILL FISH HATCHERY  
FEASIBILITY STUDY

PROPOSED RAS BUILDING



FILENAME NH CONCEPT.DWG  
SCALE 1"=20'

SHEET  
1

# Modernized Powder Mill Effluent Treatment Alternatives

**Alt. 1B - 124,000 lbs production & 3,500 gpm  
(5 MGD) makeup water**

Note:

- 50% contingency- Class 4 AACE
- Effluent Treatment
  - \$35M



**Alt. 3B - 130,000 lbs production & 693 gpm  
(1 MGD) makeup water**

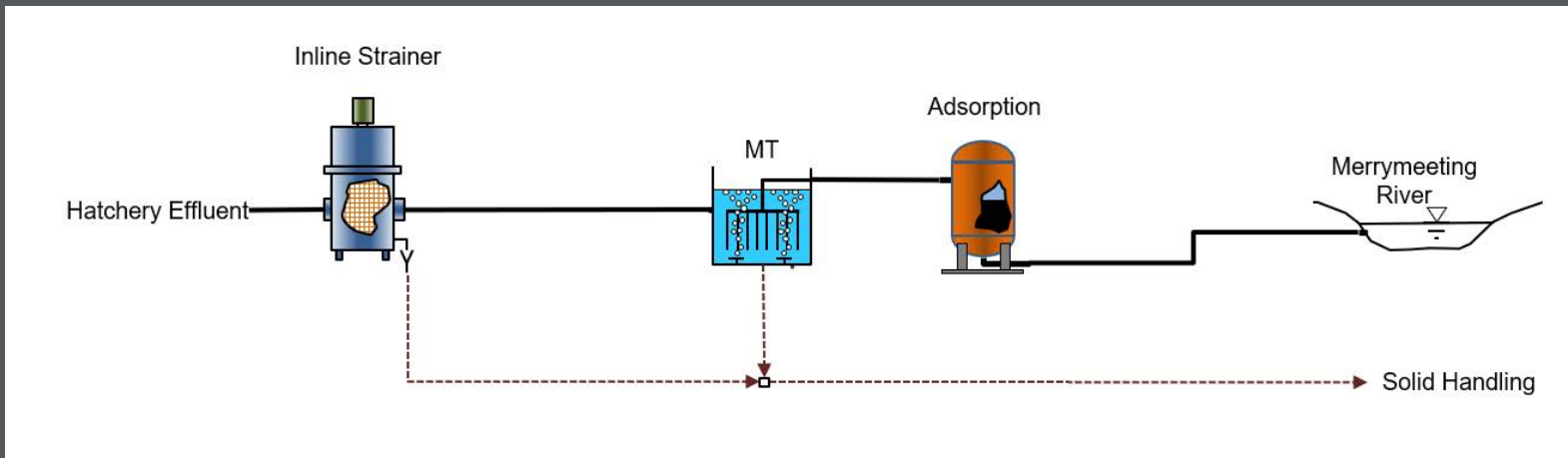
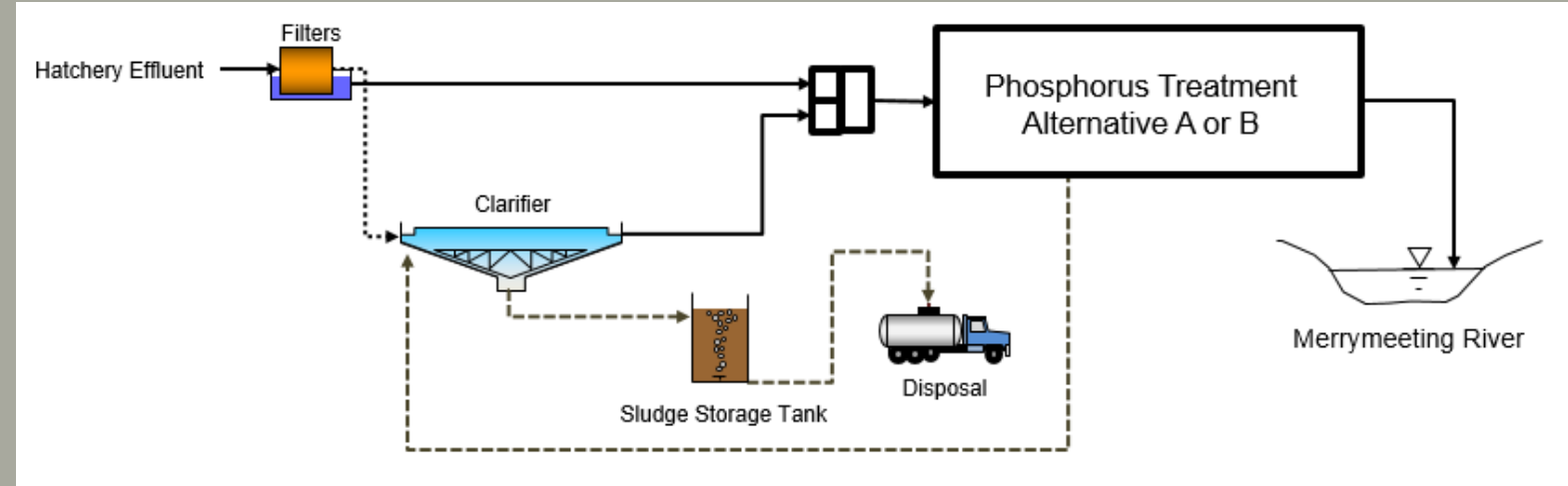
Note:

- 50% contingency- Class 4 AACE
- Effluent Treatment
  - \$14M

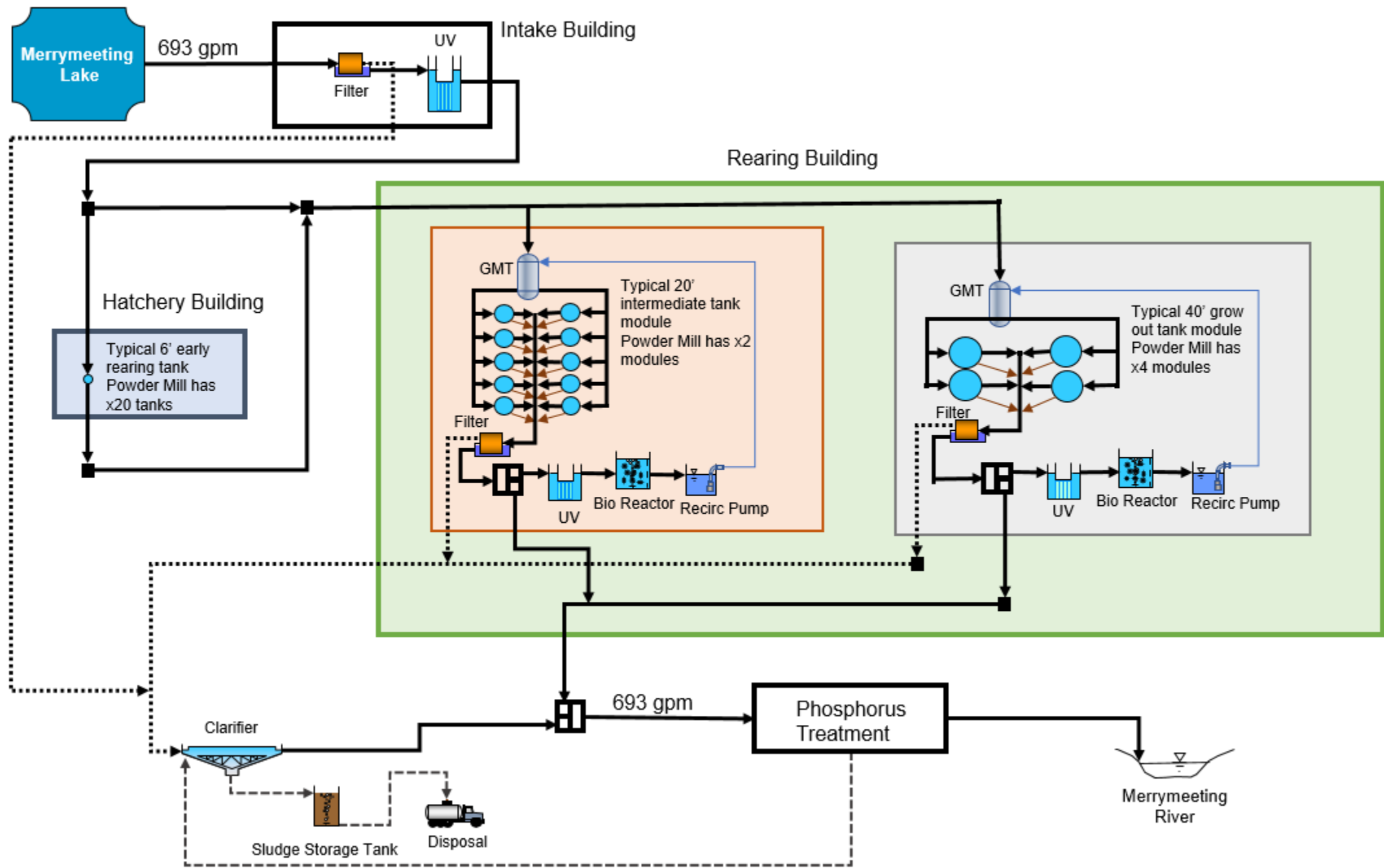


# Powder Mill Effluent Treatment

- Solids Handling
  - Drum Filters
  - Clarifier
  - Sludge Storage Tank
- Phosphorus Treatment
  - Membrane Ultrafiltration
  - Adsorption Columns



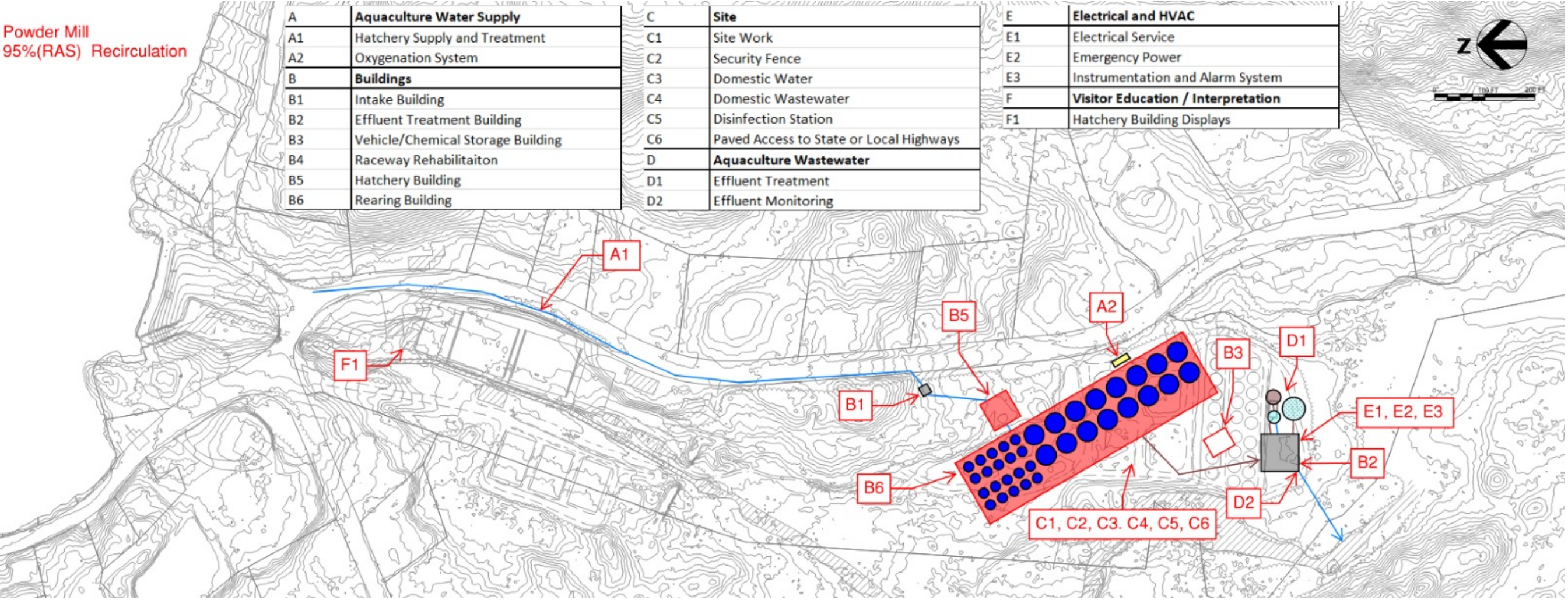
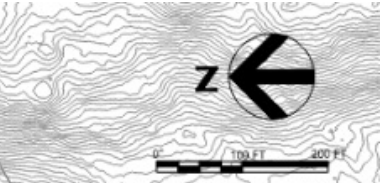
# Powder Mill Hatchery Modernization and Effluent Treatment



# Powder Mill Fish Hatchery Site Plan

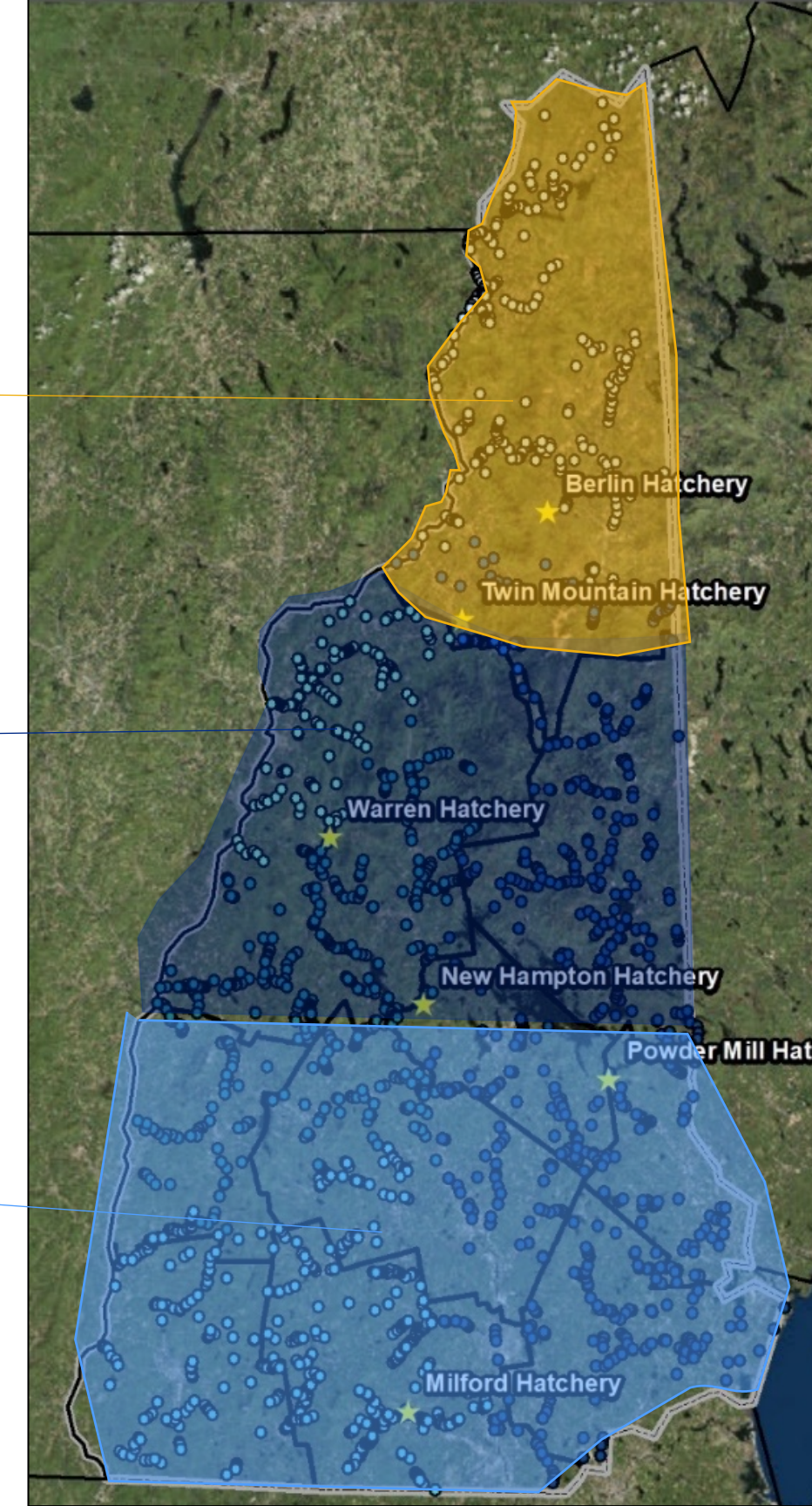
Powder Mill  
95%(RAS) Recirculation

A	Aquaculture Water Supply	C	Site	E	Electrical and HVAC
A1	Hatchery Supply and Treatment	C1	Site Work	E1	Electrical Service
A2	Oxygenation System	C2	Security Fence	E2	Emergency Power
B	Buildings	C3	Domestic Water	E3	Instrumentation and Alarm System
B1	Intake Building	C4	Domestic Wastewater	F	Visitor Education / Interpretation
B2	Effluent Treatment Building	C5	Disinfection Station	F1	Hatchery Building Displays
B3	Vehicle/Chemical Storage Building	C6	Paved Access to State or Local Highways		
B4	Raceway Rehabilitaiton	D	Aquaculture Wastewater		
B5	Hatchery Building	D1	Effluent Treatment		
B6	Rearing Building	D2	Effluent Monitoring		



# Future Statewide Production Plan

- North ~25,000 lbs of fish
  - ~6% of statewide production
  - ~17% of statewide waterbodies stocked
- Central ~275,000 lbs of fish
  - ~69% of statewide production
  - ~62% of statewide waterbodies stocked
- South ~98,000 lbs of fish
  - ~25% of statewide production
  - ~15% of statewide waterbodies stocked





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Water/Wastewater  
Engineer



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Water/Wastewater  
Engineer



HDR