Powder Mill Fish Hatchery Recirculating Retrofit Design

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Introduction

The Powder Mill State Fish Hatchery in New Durham, NH was constructed in 1947 and is currently the largest fish hatchery in the state, providing over 30% of recreational fish stock to over 150 waterbodies (NH Fish Stocking Database, 2023). The hatchery is located along the Merrymeeting River on state-owned land and produces rainbow, brook, and brown trout. The hatchery utilizes flow from Merrymeeting Lake and discharges 4-6 million gallons per day (MGD) into the Merrymeeting River.

In 2021, the Powder Mill fish hatchery was given an National Pollutant Discharge Elimination System (NPDES) permit that puts the facility under the most stringent concentration-based phosphorus discharge limits in the nation for a hatchery. The facility has aging infrastructure, high water flow, and influent water quality variations that make it difficult to isolate and remove nutrients from its waters, and it sometimes surpasses its phosphorus limit. This project aimed to design a solution to these challenges.

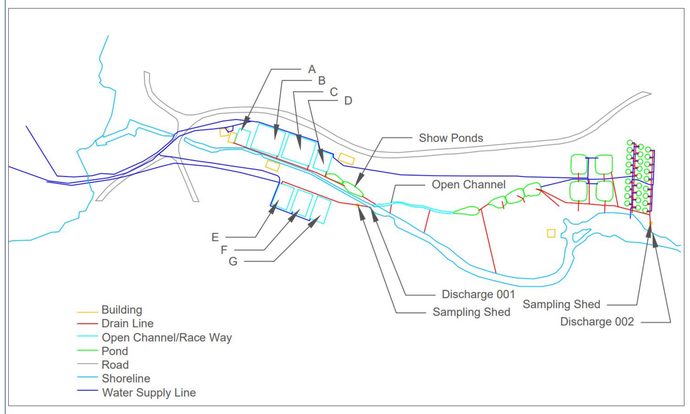

Fig. 1: Existing conditions plan view and locus map

Objectives & Outcomes

The scope of the project was to:

1. Complete an alternatives analysis for three conceptual designs
2. Choose one alternative using a decision matrix
3. Develop one preliminary design that will include conceptual details of the aquaponics and aquaculture operations shown through an engineering process flow diagram
4. Prepare a projected 1-year operation and maintenance cost estimate (OPEX) and capital cost estimate (CAPEX) for the selected alternative

It was important that the design:

- Be able to support the same stocking density of fish as the facility currently produces
- Be financially and technically feasible
- Meet permit requirements and address nutrient effluent concerns
- Meet hatchery needs as defined by the sponsor

Acknowledgements

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References

NH Fish Stocking. New Hampshire Fish and Game. ArcGIS Database. (2023). Retrieved from https://nhfg.maps.arcgis.com/apps/webappviewer/index.html?id=ce89fbd1ba0c4205ae6794dfb4c9f088.

Design book:
Timmons, M. B., & Ebeling, J. M. (2010). *Recirculating aquaculture* (2. ed). Cayuga Aqua Ventures.

Alternatives Analysis

Three possible design alternatives were considered: a solution utilizing existing infrastructure, a partially recirculating aquaponics system, and a fully recirculating aquaponics system. A decision matrix was used to evaluate the three alternatives. The decision matrix criteria were chosen to represent the cost, intensity, social factors, and environmental factors of each design and to evaluate whether they met the required design objectives.

The criteria and scores for each alternative design is provided in **Table 1**. Parameters and weight values were determined through sponsor feedback and project objectives. Higher weights mean the category has more importance. Higher scores mean the alternative is less favorable.

The fully recirculating alternative had the lowest and therefore best score, and thus was chosen for the final design.

Parameter:	Weight	Existing Infrastructure	1 MGD Flow Through	Fully Recirculating
Regulation Compliance	4	1	1	1
%R Phosphorus Required	3	3	2	1
%R Nitrogen Required	3	3	2	1
Renovation Size (% hatchery operations area that will be changed)	2	3	2	2
Predation	2	3	2	1
Social Impact	2	2	1	1
Operations Cost	1	2	3	3
Oxygen Requirements	1	1	2	3
Energy Usage	1	1	2	3
		42	34	27

Table 1: Alternatives analysis weighting and scores

Retrofit Design

To accomplish the project objectives, a fully recirculating aquaponics facility was designed. A maximum feed rate of 186 kg/day was used to determine the design flow and size of the water treatment processes. Dissolved oxygen and carbon dioxide control was the limiting water quality parameter and designated a design flow of 6 MGD for fish health. A hydraulic analysis was done for this design flow and the retrofit design was created. In understanding the design, it can be visualized as having an existing 'use' section and a new 'treatment' section. After flowing through the fish culture tanks, water will be pumped uphill from the old Discharge 002 near the circular tanks to a hydroponic greenhouse built on former raceways E, F, and G (**Fig 3**). The greenhouse will contain 25,000 ft² of hydroponic grow space laid out as shown in **Fig. 4**. Other water processes include a settling tank, biofilters, submerged aeration, and a UV system to remove contaminants from the water before it is returned to the fish tanks (**Fig. 2**).

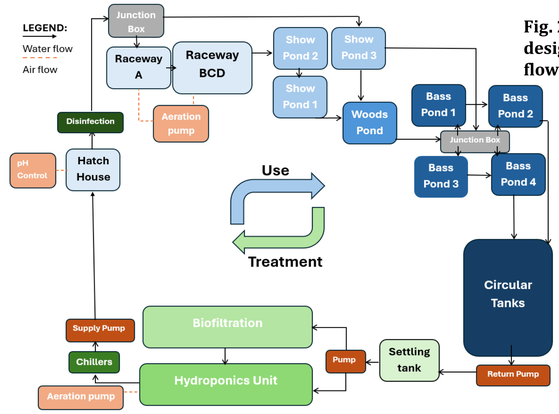


Fig. 2: Retrofit design process flow diagram

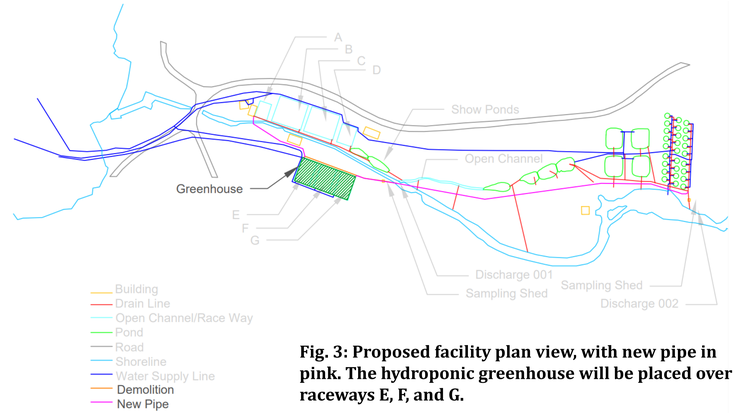
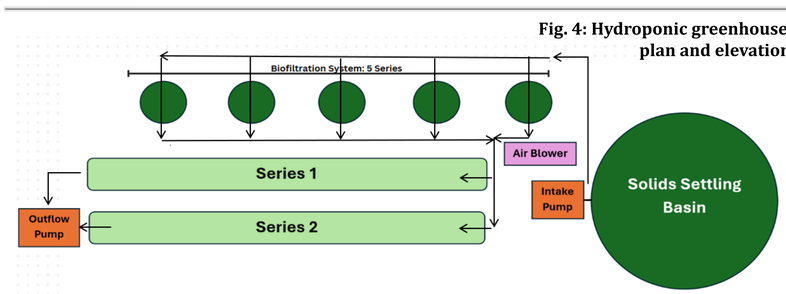


Fig. 3: Proposed facility plan view, with new pipe in pink. The hydroponic greenhouse will be placed over raceways E, F, and G.



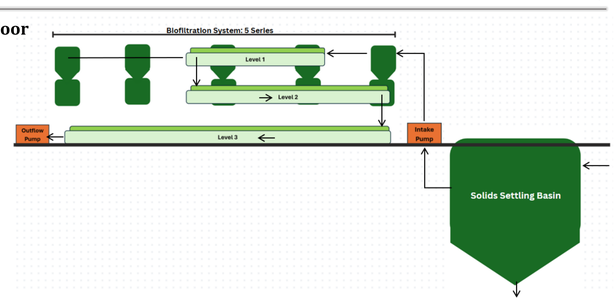


Fig. 4: Hydroponic greenhouse layout; floor plan and elevation

Next Steps

Before the presentation and report on this project is finalized, an initial cost estimation and a 1-year operation and maintenance cost estimate will be completed. There is potential to utilize solar power and existing infrastructure at the site to decrease the initial and overall operations and maintenance costs for the design, but a conservative estimate will be provided to the Sponsor with the suggestion of these options rather than an augmented design that includes them. If time allows, potential funding resources will be researched to help the fishery implement a retrofit or a different remodel to comply with their discharge permit. It is hoped that this project may show a new way forward for the Powder Mill Fish Hatchery, as they serve an important role in New Hampshire's economy.