Reducing Groundwater Nitrogen Input into Poxabogue Pond

2. Priority Area

Poxabogue Pond, owned by Southampton Town, is a coastal plain pond within the Long Island Greenbelt region which is considered a high priority area according to the Water Quality Improvement Project Plan (WQIPP). Poxabogue Pond and Sagaponack Pond are within the same subwatershed, thus are hydraulically connected. Sagaponack Pond is within a high priority area and is considered a NYS 303d impaired waterbody for fecal coliform pollution. Collectively Suffolk County, Southampton Town, Southampton Board of Trustees, The Nature Conservancy, the Friends of Long Pond Greenbelt, the Peconic Land Trust (PLT), and community members have played a role in preserving and managing Poxabogue Pond and nearby land. Safeguarding the natural habitat, preserving the aesthetic value, and maintaining the agricultural heritage of the area is of primary importance to the residents and local organizations such as the PLT.

The Long Island Greenbelt is a New York State Significant Coastal Fish and Wildlife Habitat which is home to globally rare species. The pond is situated between Poxabogue Pond Park owned by Suffolk County and Sagg Swamp which is managed by the Nature Conservancy. Additionally, some of the land surrounding the pond is residential or Town-owned property, some of which is part of the purchase of development rights (PDR) program. Over time, land use surrounding the pond has shifted from agricultural towards a combination of residential, agricultural, and preserved woodlands and freshwater wetlands.

A wetland buffer of varying thickness surrounds the pond and supports the shoreline habitat. However, native shoreline vegetation, such as cattails, have been replaced by the invasive species *Phragmites australis*. Although the Long Island Greenbelt still contains a vibrant habitat including some rare flora and fauna, environmental stressors are a major issue. Land use change and population increase in the region has culminated in increased environmental stressors such as fecal coliform bacteria, herbicides, excessive nutrients, and harmful algae blooms. According to the Suffolk County Subwatershed Wastewater Plan (SCSWP) (pg. 2-186), 52% of nitrogen inputs to Sagaponack Pond and Poxabogue Pond subwatershed are septic derived and 48% of nitrogen inputs are collectively from fertilizer, atmospheric deposition, and pet waste. The pond is fed below by groundwater and above by precipitation, thus seasonal variability in groundwater table height and rainfall determines the water level in the pond and the nutrient inputs from both stormwater runoff and groundwater seepage.

3a. Existing Conditions

In 2021 the PLT contracted Cornell Cooperative Extension of Suffolk County (CCE) to implement a remediation siting strategy at Sagaponack Pond with a focus on the Smith Corner Preserve shoreline and in areas downgradient from where the PLT holds easements. This effort led to a remediation project funded through the Community Preservation Fund (CPF) for the site characterization, and future design and installation of a nitrogen remediation approach such as a permeable reactive barrier (PRB) to intercept and treat contaminated groundwater before it seeps into Sagaponack Pond. In fact, five shoreline areas were identified as high nitrogen loading zones and potential remediation sites, and site characterization at the Smith Corner Preserve is currently underway. The siting strategy revealed that groundwater seepage rates were highest in the northern half and on the western shoreline of Sagaponack Pond. In addition, seepage rates on the southern shoreline were very low or negative indicating groundwater recharge. It is hypothesized that a similar groundwater flow pattern holds true for Poxabogue Pond. However, quantifying seepage rates directly and measuring water table elevation over multiple seasons will provide data to test the hypothesis.

Harmful algae blooms have been detected in Poxabogue in prior years and recently two surface water grab samples collected from different sides of the pond in March 2022 had 1.7 and 2.1 mg N/L as TKN. Exactly where groundwater nitrogen loading to the pond is highest is still an open question. To the best of our knowledge, this project would provide the first direct measurements of groundwater derived nutrient loads to Poxabogue Pond. The current project builds upon model outputs and regional waterbody prioritization from the SCSWP by providing the locally collected data necessary to take actionable steps towards protection and remediation. Moreover, there is interest in understanding groundwater discharge and nitrogen loading specifically in the southeastern region of Poxabogue Pond where the Town of Southampton owns land adjacent to the pond and this project will provide data to inform land use practices there. Overall, it is critical to “ground-truth” modeled data, evaluate seasonal water table fluctuation, and monitor groundwater seepage rates and nutrient loading under water table elevation extremes to effectively, and economically, apply management and remediation measures intended to control nutrient sources. Poxabogue Pond and Sagaponack Pond are within the same subwaterhed, thus are hydraulically connected, and funding this project is another step towards improving water quality in the region.

3b. How the Proposed Solution Addresses Nitrogen Remediation

The PLT in collaboration with CCE are seeking funds to implement the proven remediation siting strategy which includes creating a groundwater seepage and nitrogen loading map and performing site characterization at Poxabogue Pond to inform remediation design, such as a native vegetation buffer, a PRB, or a combination of approaches if needed. PRBs have been used extensively in the midwest United States and Canada to treat agricultural and septic derived nitrate plumes (Robertson et al. 2000, Schipper et al. 2010, Christianson et al. 2020) and have recently been installed near impaired waterbodies in Suffolk County and on Cape Cod as an approach to mitigate surface water nitrogen pollution (Graffam et al. 2020, Hiller et al. 2015). PRBs support a natural microbial community for nitrate removal through a series of reactions called denitrification. After installation they are subsurface and require no aboveground structures, they are completely passive with no moving parts, and continue to provide passive nitrogen removal with no maintenance for decades. In fact, one of the longest PRB studies available found that after 15 years 80% of carbon remained, so less than 1.5% of carbon was used per year (Robertson et al. 2008). Assuming half of the total carbon was available to microbes, the life of the PRB would exceed 30 years without maintenance.

Most importantly, PRBs can treat all nitrates regardless of the source, and have the potential to provide rapid relief from excess nitrogen. This type of treatment is ideal for Poxabogue because nitrogen loading to the pond is a combination of septic, fertilizer, and atmospheric deposition, and PRBs can treat nitrate from all these sources while improvements to fertilization practices and septic upgrades are implemented over time. After PRB installation, nitrogen reduction measures will involve sampling upgradient (pre-treatment), within the barrier, and downgradient (post-treatment) of the barrier to determine nitrogen removal as percent N removed and the pounds of nitrogen removed per year. Calculating the pounds of nitrogen removed requires knowledge of the volume of water treated per day which will be determined during the site characterization and PRB design process.

Specifically, the remediation siting strategy involves multiple phases. Phase 1 Step 1 includes deploying a patented porewater evaluation instrument to locate and map groundwater discharge zones using conductivity and temperature contrast between the porewater at 1 foot into the pond bottom and surface water 1 foot above the bottom. This will be accomplished by establishing transects starting nearshore and moving offshore (Fig. 1). The porewater evaluation instrument also facilitates sample collection. Samples will be collected at each station and analyzed by an ELAP certified laboratory for the nitrogen series (nitrate, nitrite, ammonium, TKN) and select samples will be analyzed for phosphorous. At each station, coordinates will be recorded using a Wide Area Augmentation System (WAS) locked GPS, an instrument capable of sub-meter accuracy. Porewater field parameters will include temperature, conductivity, total dissolved solids (TDS), pH, oxidation reduction potential (ORP), and dissolved oxygen. Additionally. a qualitative description of the sediment bottom type will be recorded at each

Figure 1: Map of Poxabogue Pond with porewater survey transects shown by the red dotted lines and anticipated shoreline stations for porewater and groundwater seepage measurements shown by light blue triangles.

station and a field log will be maintained. Sediment bottom type is an important indicator of groundwater seepage zones.

In Phase 1 Step 2, stations which have the highest porewater nitrogen concentration, and which show the greatest potential for elevated groundwater seepage rates will be selected for further measurements with groundwater seepage equipment (Paulsen et al. 2001). The groundwater seepage meter will be deployed within the pond bottom for extended periods to determine groundwater seepage rates. By combining seepage rate and porewater nitrogen concentration, a nutrient load to the surface water is calculated. The deliverable for Phase 1 will be a map of nitrogen loading around Poxabogue. Shoreline areas will be ranked according to nitrogen loading which will help target the best location for remediation placement, will ensure that funds are directed towards projects which will have the largest positive impact on pond water quality and this allows for an efficient use of CPF money.

The area(s) with the highest nitrogen loading will be selected for Phase 2 site characterization to determine site suitability and provide critical data for remediation design. Phase 2 will include mobilizing and operating a Geoprobe to install several nearshore shallow profile wells and collect soil borings. Soil borings will be analyzed for grain size analysis and hydraulic conductivity tests will be performed. A survey of well elevations will be performed to determine the hydraulic gradient, groundwater flow direction, and groundwater velocity. Groundwater samples will be collected at 5 to 10 ft intervals below the water table and field parameters will include temperature, conductivity, total dissolved solids (TDS), pH, oxidation reduction potential (ORP), and dissolved oxygen. Samples will be collected and analyzed by an ELAP certified laboratory for the nitrogen series (nitrate, nitrite, ammonium, TKN) and select samples will be analyzed for phosphorous. During site characterization work, environmental disturbances will be minimized whenever possible. This project is highly feasible given that there is access to road right of ways and or private and public property access for machinery along much of the shoreline surrounding the pond.

The deliverables for Phase 2 include a site characterization report which outlines targeted site(s) for remediation, the anticipated pounds of nitrogen removed, site-specific data for remediation design, and recommendations on the nitrogen remediation approach. Although nitrogen is the primary pollutant and nutrient of concern, phosphorous samples will be collected at select stations. Phosphorous is known to play a role in algae bloom formation in freshwater bodies. While PRBs do not treat phosphorous, native vegetated buffers can help with phosphorous removal, thus we feel it is important to know some information about both nitrogen and phosphorous to impart the greatest water quality benefit with the strategic placement of remediation. Additionally, outreach to stakeholders and community members will occur. The goal is to help the community understand the importance of groundwater and surface water quality and provide education on the science and efficacy of the remediation approach.

The integrated remediation siting strategy that CCE implements allows for a comprehensive understanding of the hydrogeologic conditions and the groundwater, porewater, and surface water interactions. The siting strategy also supports a holistic approach to nitrogen remediation because each waterbody is unique and there is not a one-size-fits-all solution. For instance, onsite wastewater improvements are critically important, and the siting strategy can identify areas where septic upgrades are most useful. However, according to the SCSWP septic upgrades alone will not be enough to meet nitrogen load reduction targets in the subwatershed, thus alternative approaches such as PRBs and bio-extraction with a native vegetation buffer can help meet targets.

<u>PROJECT PHASE SUMMARY:</u>

Phase 1: Prioritize and inform the location(s) and design of the nitrogen remediation. Funded through private donations secured by the PLT.

1. Use porewater evaluation equipment to map porewater nitrogen concentrations.
2. Use groundwater seepage equipment to map seepage rates, calculate nitrogen loading to the pond surface water, and rank shoreline areas according to nitrogen loading.

Phase 2: Remediation site characterization. Funded through CPF.

1. Bases on the results of Phase 1, install shoreline groundwater wells at targeted locations and collect hydrogeological data to inform the remediation design.
2. Determine the site suitability for nitrogen remediation technology such as PRBs or native vegetation buffer.
3. Communicate the results in the form of a site characterization report and provide educational outreach to stakeholders and the community.

Phase 3 and Phase 4: *Remediation design and installation (future work not funded with this proposal)*

1. *Design and install the nitrogen remediation based on the results of the site characterization using a cost-effective and appropriate design*

2. *Document the design and installation process and provide a report to the Town*
3. *Monitor the performance of the remediation approach*
4. *Communicate performance results and provide educational outreach to the community*

3c. Technology Efficacy in Similar Settings

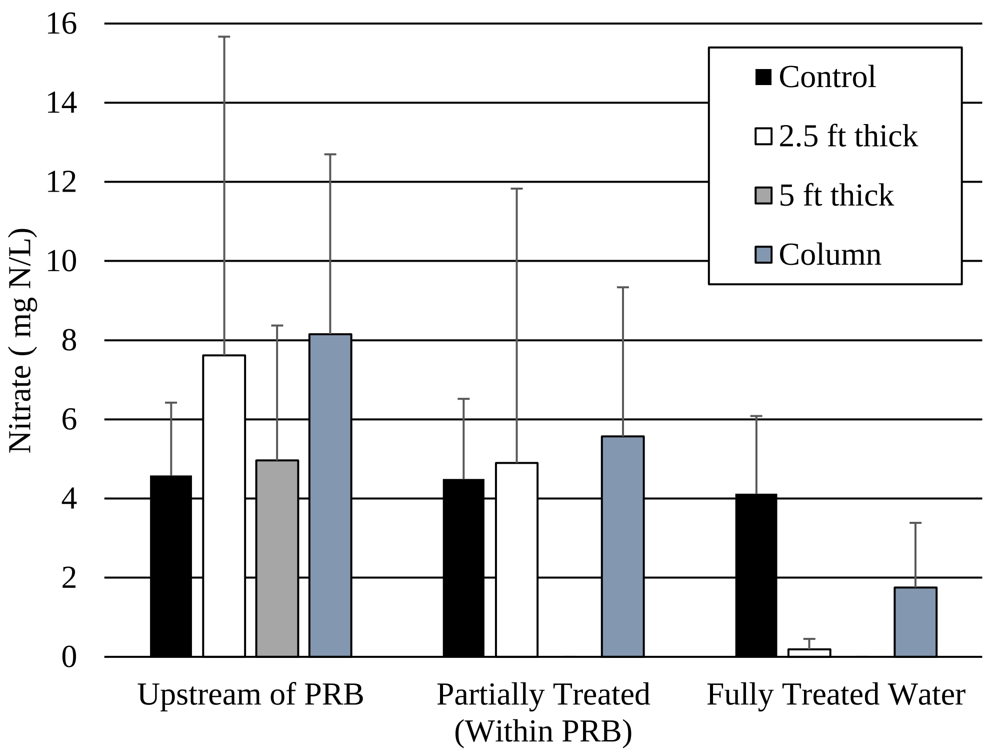

Figure 2: Bulkhead PRB performance data from April 2021. Partially treated and fully treated water is collected from the center and downgradient of the PRB, respectively.

In 2020, a 100 ft. long PRB was installed during scheduled bulkhead replacement to prevent nitrate contaminated groundwater from entering Shinnecock Bay. The installation was funded by the Town of Southampton CPF at the Hampton Hills Association property and consisted of 12 test cells with 4 different design configurations (5 ft thick, 2.5 ft thick, column array, and control test cells without woodchips). Nitrate concentrations upstream of the PRB varied between 0.6 and 18.9 mg N/L in April 2021 with an average of 6.3 mg N/L, and between 1.2 and 33.7 mg N/L in September 2021 with an average of 5.3 mg N/L. In April 2021, percent nitrate removal was 100%, 99%, 84%, and 13% in the 5 ft, 2.5 ft, column array, and control test cells, respectively. In September 2021, percent removal was 94%, 100%, 100%, and -5% in the 5 ft, 2.5 ft, column array, and control test cells, respectively. Control areas do not contain woodchip media and are filled with native sand which does not provide the conditions for nitrate removal to occur. In Figure 1 there is little to no change in groundwater nitrate concentration collected from upgradient, within, and downgradient of control test cells. On the other hand, the PRB test cells provide the conditions for nitrate removal as shown in Figure 1 where nitrate concentrations decreases as water passes through the woodchip media for all PRB design configurations.

3d. How the Project Supports Goals/Policies

This project is anticipated to provide valuable information for the Town and other stakeholders which can be added to the existing collection of data and will complement other ongoing modeling and water quality monitoring efforts in the region. Information and insights gained from this project will be distributed publicly through various forms of media including reports, presentations, and content available on the PLT and CCE webpages. Overall, **this project is aligned with regional water quality goals** because it would reduce the nitrogen load entering Poxabogue Pond and reduce the effects of eutrophication. Providing relief from elevated surface water nitrogen concentrations reduces algae growth and decreases biological oxygen demand. In addition, this project is consistent with goals which seek to enhance natural areas for recreation. The project seeks to help avoid loss of economic, environmental, and aesthetic value by increasing water clarity and providing a healthier habitat for fish and other aquatic life. Specifically, this project is consistent with the following goals and policies important to New York State and the Town of Southampton:

a) Long Island Nitrogen Action Plan Scope (ny.gov)

- Goal #1: Assess nitrogen pollution in Long Island waters (pg. 7)
- Goal #2: Identify sources of nitrogen to impaired and non-impaired water bodies (pg. 7)
- Goal #3: Develop an implementation plan to achieve reductions including action plans which contain near term actions that will reduce nitrogen pollution to groundwater and surface waters (pg. 7)

b) Town of Southampton

- WQIPP Vision Goals for Natural Resources Goal #2: Improve the quality of surface and bay waters by reducing nutrient loading, toxins and sedimentation (pg. 6)
- Coastal Resources and Water Protection Plan

- Policy 5.1 Reduce nutrients to levels necessary to support a healthy ecosystem; one that allows for harvestable, sustainable fish and shellfish populations, healthy submerged aquatic vegetation, and traditional human uses in the Town's waters (pg. 71).
    - a. Reduce the input of nutrients from all sources including human waste, pet waste, storm water, and fertilizers.
    - b. Employ effective means to reduce nutrients such as permeable reactive barriers etc.

5. Cost Factors

Direct Costs	Cost
Salary (includes U/I and W/C)	$26,289
Equipment and supplies	$15,375
Travel	$1,978
Contractor costs (CLEAR)	$26,079
Indirect Administrative Costs	
14.56% Cornell Cooperative Extension	$10,151
CPF Request	**$39,936**
Matching Funds (Peconic Land Trust)	**$39,936**
Total Budget (Phase 1 & 2)	**$79,872**

The current request of $79,872 is for the completion of Phases 1 and 2 of the remediation siting strategy. The work is to be performed by CCE and its associated contractors including CLEAR. The PLT has already secured privately funded donations to support the project, indicating it is a high priority for residents. PLT is prepared to financially support half of the project cost and proposes that the Town CPF matches their contribution which will allow the project to be fully funded. **Since the PLT has already secured approximately $40,000 from private donors, they are prepared to enter into an agreement with CCE to fund the work associated with Phase 1.** The Town's matching contribution would be used to fund Phase 2 which is the site characterization that directly informs remediation design. The Town's commitment to support this effort will provide leverage for the PLT to continue to raise the additional funds necessary to fund future phases. This is truly a unique opportunity for private-public-governmental partnership which will maximize the use of both public and private funds to benefit the community and improve Poxabogue Pond water quality.

The current budget is appropriate and reasonable as it is based on updated quotes for salaries, equipment rental fees, analytical and contractor costs as well as travel/mileage reimbursements. CCE was a leader in the site characterization and installation of the Hampton Bays bulkhead PRB in addition to the site characterization effort for Southampton and East Hampton PRBs which are currently in the design phase. They are experienced in properly budgeting for the work.

Upon completion of Phase 1 and 2, the PLT would likely apply to next year's funding cycle to secure CPF funds to complete the design and installation of the nitrogen remediation. The purpose of this approach is to exercise an appropriate use of funds given the current understanding of the site conditions. Developing a budget for the design and installation is premature since the site characterization will determine the location and size of the remediation strategy.

While there are substantial upfront costs due to site characterization, design, and installation of PRBs, the treatment requires no maintenance or energy input after installation which makes them cost-efficient over their lifespan. According to multiple sources, the cost effectiveness of PRBs is similar to other nitrogen removing technologies (Schipper et al. 2010, SCSWP pg. 2-117, Fig. 2-54). Funds for performance monitoring will be secured through private donations and will be used as a match in a subsequent proposal. After installation of the nitrogen remediation technology, maintenance and monitoring will be performed quarterly and will include sampling upgradient, within, and downgradient of the treatment area to determine nitrogen removal as percent N removed and pounds of nitrogen removed per year. Surface water conditions downgradient of the treatment area will also be monitored quarterly. Performance results will be provided to the Town in a report.

8a. Anticipated Project Timeline

The anticipated timelines are provided to show that the PLT, CCE, and associated contractors are highly motivated to begin the project upon securing funds. Timelines are contingent upon contract approvals and fund dispersal, and thus need to be flexible.

Funding Request	Description	Summer 2022	Fall 2022	Winter 2022	Spring 2023	Summer 2023
Current 2022	Planning and management	x				
	Implement Phase 1 of remediation siting strategy	x	x			
	Implement Phase 2 of remediation siting strategy			x	x	
	Data analysis and final report preparation				x	x
	Outreach and recommendations			x	x	x

Funding Request	Description	Fall 2023	Winter 2023	Spring 2024+
Anticipated 2023	Remediation Design	x		
	Remediation Installation		x	
	Performance Monitoring			x

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Photos of Existing Conditions at Poxabogue Pond March 2022

Photos of Existing Conditions at Poxabogue Pond March 2022