Tanbark Creek Long Term
PRB Performance Monitoring

Submitted to:

Peconic Estuary Partnership
Director Joyce Novak, PhD

Town of East Hampton
Water Quality Technical Advisory Committee

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Introduction:

In 2015 the Town of East Hampton in collaboration with CDM Smith engineering and Cornell Cooperative Extension (CCE) received a NYS DEC Water Quality Improvement Program grant to perform site characterization, installation, and monitoring of an innovative method to treat groundwater nitrate entering Three Mile Harbor using a pilot Permeable Reactive Barrier (PRB) installed via carbon emulsion injections. The theory behind this approach is that the proprietary emulsified soybean oil (Environmental Protection Agency approved EOS-100 amendment) injected below ground adheres to the soil, acts as a carbon source for microbes, promotes aerobic respiration to drive down oxygen concentration and creates the geochemical conditions required to denitrify the intercepted groundwater.

CCE initially performed an offshore porewater investigation along Gann Road adjacent to Three Mile Harbor to determine whether the hydrologic and geochemical conditions would be suitable for the pilot PRB. Despite groundwater model projections indicating Gann Road would be a target for groundwater nitrate reduction, the offshore porewater investigation and groundwater well data indicated there was not enough nitrate to warrant PRB installation at that location. Additional site characterization was performed in the headwaters of Three Mile Harbor along Tanbark Creek. CCE measured elevated groundwater nitrogen concentration (up to 20 mg N/L), with nitrogen primarily in the forms of ammonia and nitrate, which likely originates from conventional septic systems along the creek and further inland within the subwatershed. The Town of East Hampton, CDM Smith engineering and CCE agreed to pursue PRB pilot installation at Tanbark Creek.

In 2022 Quarter 2, the Town of East Hampton received a tidal wetland permit from NYS DEC to proceed with installation of the pilot PRB at Tanbark Creek. The final PRB design was determined by CDM Smith engineering firm. The final PRB design included 6 injection well clusters (TCINJ 1-6) consisting of three 2-inch diameter wells per cluster (shallow, intermediate, and deep) screened at 5-15, 15-25, and 25-35 ft below ground surface (BGS). A conservative target amendment concentration (1% EOS-100) was chosen to minimize the chance of 1) clogging around the injection wells and 2) reduced hydraulic conductivity within the treatment zone which could lead to groundwater flow diversion. PRB performance monitoring wells consist of 8 clusters including 4 upgradient (TCMWC1-4) and 4 downgradient (TCMWC5-8). The upgradient monitoring wells were installed outside of the anticipated range of influence of the injection so that future samples would not be influenced by carbon amendment and could be used to calculate percent nitrate removal. The performance monitoring well clusters consist of two 1-inch diameter wells screened at 10-15 and 20-25 ft below grade. Monitoring well clusters were installed approximately 20 ft upgradient and downgradient of TCINJ 2, TCINJ 3, TCINJ 4, and TCINJ 5.

The Tanbark Creek PRB is a pilot project intended to demonstrate the use of carbon emulsion injection for groundwater nitrate reduction. To the best of our knowledge this is a first-of-its kind system in New York State. The installation of injection wells and the injection of the carbon emulsion was successful. However, there is a significant amount of post-installation research to determine the effectiveness of the current design and to improve upon it. The current design assumed a radius of influence of 15 feet and the amendment was diluted to 1% solution prior to injection. Future research on the effectiveness of this technology will involve increasing the strength of the carbon emulsion since the EOS-100 amendment is used in environmental applications at up to 20% concentration.

This project will add to a repository of PRB performance data and inform several long-term goals for PRB implementation and specifically the carbon injection installation approach. Goals include relating inland PRB performance to offshore porewater and surface water quality, optimizing the effectiveness of the injection approach including varying the carbon amendment solution strength to minimize the installation time, maximizing the PRB longevity, maximizing nitrate reduction by potentially including other environmentally approved amendments with the EOS-100 to support the proper microbial community. For example, modifying the solution pH with bicarbonate or seeding the emulsion with the proper bacteria could influence performance. Furthermore, achieving the forementioned performance aspects without clogging or diverting groundwater flow will be important. Ultimately a comparison of the cost-effectiveness of the injection approach to other passive nitrogen removal technology or other PRB installation methods will support stakeholders as they make long term plans for water quality improvements.

One objective is to relate inland PRB performance to offshore porewater and surface water quality. In theory, a decline in the porewater nitrate concentration discharging into the surface water after PRB installation can provide additional evidence of PRB function. This type of monitoring has the potential to directly relate PRB performance to water quality benefit to the waterbody. However, a complicating factor at this site is that the groundwater nitrogen plume is a combination of ammonia and nitrate. When interpreting the water quality results it will be important to tease apart the details related to ammonia and nitrate transformation. Additional downgradient monitoring wells may provide insight into the nitrogen plume transformations at this site.

Methods:

A. PRB performance monitoring

PRB performance monitoring wells are purged of three well volumes prior to sampling using a peristaltic pump running at approximately 500 mL/min. Samples are collected for laboratory analysis when field parameters including conductivity, total dissolved solids (TDS), oxidation reduction potential (ORP), pH, and temperature are stable (±10% relative standard deviation (RSD)). PRB performance monitoring wells are sampled for nitrate, nitrite, ammonium, and TKN on a quarterly basis (anticipated spring 2023, summer 2023, fall 2023, and winter 2024). Nitrate reduction and PRB performance will be determined by comparing nitrate values found in the upgradient wells (untreated water) and downgradient wells (treated water). In addition, performance monitoring well samples will be analyzed for sulfate, sulfide, alkalinity, dissolved organic carbon (DOC) and dissolved iron during the summer 2023 sampling event. This ancillary data provides insight into PRB function. Since temperature influences microbial activity and production of ancillary by-products, collecting this data in the summer will provide an endmember data point for the maximum concentrations anticipated at the site. Conductivity, TDS, ORP, pH, and temperature are measured with a Myron Ultrameter. Dissolved oxygen (DO) is measured with a YSI DO meter. Turbidity is measured with a Hach field turbidity meter.

Currently we have wells where we can monitor depth to water upgradient, within, and downgradient of the PRB.

Additional water table monitoring wells may be installed on the northern and southern edge of the PRB if unexpected water table elevation trends are observed upgradient, within, and downgradient of the PRB. If everything is functioning as expected we should see water table elevation decrease uniformly as you move closer to the shoreline upgradient-within-downgradient. If we see unexpected water table elevation trends within the PRB, if we don't see the expected trend overall, and if we aren't seeing nitrogen removal those indicators would trigger us to install wells north and south of the PRB to investigate the issue. Additional water table monitoring wells will provide information about groundwater flow direction and velocity. If groundwater is redirected around the PRB due to decreased hydraulic conductivity within the treatment zone, there may be evidence of reduced groundwater flow within the PRB compared to the north and south of the PRB.

B. PRB carbon injection longevity monitoring

Soil borings will be collected once during the contract period. We will collect replicates within the PRB zone of influence and outside the expected zone of influence to quantify the contrast. The boring collection process and analysis is time consuming and expensive so we can't do it multiple times per year due to budget constraints but it would be informative to take multiple cores over time.

Soil borings will be collected near TCINJ 2-5 to determine total organic carbon (TOC) content of soil within the anticipated zone of influence of the injection wells. Soil borings will be collected upgradient of the PRB near the upgradient monitoring wells TCMWC1-4 to determine background TOC content of soil outside of zone of influence. Soil samples will be analyzed for TOC content according to EPA approved methods using an ELAP certified laboratory.

C. Tanbark Creek water quality monitoring

Porewater and surface water samples from approximately 10 stations will be collected bi-annually within Tanbark Creek to establish a timeseries of water quality conditions. Seasonal high (April-May) and seasonal low (Sept-Oct) water table conditions bi-annually are the most important times of the year to sample since those are the endmember conditions. The stations will be the same for every sampling event. Since a similar survey was performed prior to PRB installation, there is already information about the submarine groundwater discharge (SGD) zone and potential station locations. This is accomplished using a patented porewater evaluation instrument called the Trident Probe provided by Coastline Evaluation Inc. (CLEAR). The probe uses a direct-push approach and is deployed from a 20 ft long outboard motorboat. The probe has sensors integrated for temperature and conductivity. The probe also samples porewater and was developed to screen sites for areas where groundwater may be discharging to a surface water body and collect porewater samples from groundwater discharge zones (Chadwick et al., 2003). Specifically, the Trident Probe measures temperature and bulk conductivity contrast between porewater 1 ft below the sediment-water interface and surface water 1 ft above the sediment-water interface. Areas with high temperature contrast and low porewater conductivity values are conditions indicative of groundwater discharge. When the temperature and conductivity signal indicate there is fresh groundwater present, porewater samples are collected for laboratory analysis.

Surface water grab samples are collected from the middle of the water column and porewater samples are collected using a low-flow peristaltic pump. A minimum of 200 mL is purged prior to collection of a porewater sample. Samples are stored on ice and analyzed for nitrogen and other relevant analytes by a NYS ELAP certified laboratory.

Additionally, at each sampling station the surface water column height, measured by hand-held acoustic sounder or by direct reading from a meter stick, and a qualitative description of the sediment bottom type are recorded. Coordinates for each station are recorded using a Wide Area Augmentation System locked GPS, an instrument capable of sub-meter accuracy.

At select stations a patented ultrasonic seepage meter provided by CLEAR measures SGD flow rate (Paulsen et al. 2001, Paulsen et al. 2004). We use the Trident to map out the Submarine Groundwater Discharge (SGD) zone according to porewater conductivity and sediment conditions. The distance of this zone offshore varies according to site conditions. Selected stations for additional analysis would be within the SGD zone. Seepage rate analysis at stations towards the northern and southern area downgradient of the PRB would allow us to get the gradient of groundwater seepage conditions in the SGD zone along the length of the PRB. The ultrasonic seepage meter is checked daily by collecting a “zero” reading with the outflow tube closed. It will be deployed bi-annually at 2 stations for a 1-2 days to quantify SGD flow rate over a tidal cycle. A yearly nitrogen load to the surface water (lbs N/year) is extrapolated using the average volume of discharge per day and the porewater nitrogen concentration.

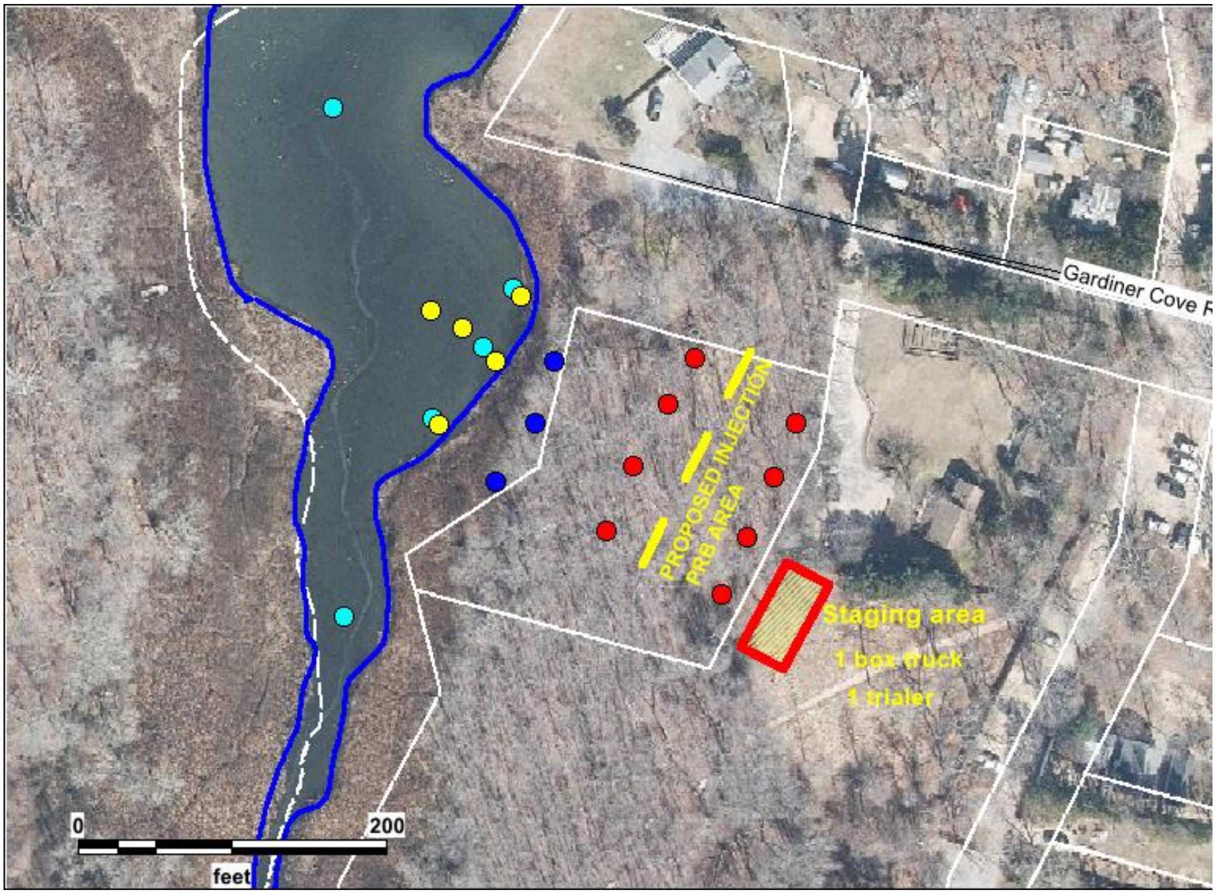

Figure 1: Map of Tanbark Creek proposed PRB injection area and monitoring points. White lines indicate property distinctions. Red, yellow, and light blue dots represent monitoring wells, porewater, and surface water samples respectively, which will be sampled in 2022 after PRB installation. Red dots upgradient and downgradient of the proposed PRB injection area represent monitoring well clusters screened at 10-15 and 20-25 ft below grade. Dark blue dots represent existing cluster wells.

D. Long Term Monitoring, Research, and PRB Maintenance (2024-2028)

Anticipated long term monitoring of PRB performance monitoring wells and offshore water quality conditions will be quarterly, and bi-annually, respectively for several years to understand post-installation performance. The monitoring plan will remain somewhat flexible to allow for additional performance monitoring needs. For example, an additional screen zone for each performance monitoring cluster may provide useful performance data in the future. Additional wells downgradient of the PRB may be valuable to monitor nitrogen transformation and ancillary geochemical reactions. Additional soil sampling at multiple locations within and around the PRB is anticipated to provide preliminary data on the carbon availability and carbon use over time. Soil sample collection frequency should be modified depending on the rate of decline of soil TOC content measured within the PRB. Maintaining flexibility in the monitoring plan to reflect the best strategy as performance monitoring results accumulate will be important moving forward. Each year an updated monitoring plan with justifications will be provided as the monitoring results are analyzed, interpreted, and as the strategy evolves. In the future we would like to test the efficiency of other emulsion percentages in a laboratory setting using native sand in a column experiment. That is not part of this contract but it's part of the long-term plan for injection PRBs in general.

Project Deliverables:

Status updates and outreach to the Peconic Estuary Partnership and Town of East Hampton Water Quality Technical Advisory Committee will be provided in the form of virtual or in-person calls and meetings. We anticipate providing a yearly presentation and report summarizing PRB performance and water quality results.