Springs General Store Ammonium Plume Remediation with a Multi-Phase Permeable Reactive Barrier Pilot Phase 1 Final Report

Summary:

The goal of this project is to fully implement a sequential permeable reactive barrier (PRB) groundwater treatment system to address the ammonium plume identified along the western edge of the Springs General Store which is impacting Accabonac Harbor. Cornell Cooperative Extension of Suffolk County (CCE) and Coastline Evaluation Inc. (CLEAR) recently completed Phase 1 of this project funded by the Accabonac Protection Committee (APC). Thanks to the generous support from the APC, the team investigated the western shoreline of the Springs General Store property and learned more about the strength of the nitrogen plume, as well as the dimensions, and collected information to support the design of an oxygen injection system which is currently being implemented in Phase 2. Data and information generated during this project will help to develop a sound approach for treating ammonium plumes in future PRB applications which is highly relevant to the APC and Town of East Hampton.

Background:

The historic Springs hamlet is home to the Springs General Store, located at the intersection of School Street and Old Stone Highway, within the East Hampton Water Protection District. Despite its current closure due to renovation under new ownership, the Springs General Store has traditionally served as a hub of activity and a gathering place for community members who enjoy congregating outside on the porch and picnic tables and it will continue to serve that purpose as it reopens. Over several years of working at Pussy’s Pond and at the Springs General Store culvert which connects to Accabonac Harbor, many conversations with community members revealed that preserving the natural habitat and maintaining the aesthetic value of the area is of primary importance to the residents.

Accabonac Harbor, which lies within the Peconic Estuary, provides East Hampton residents with numerous aesthetic, recreational, and commercial opportunities, making it an important economic engine for the region. Studies estimate that businesses and industries related to the Peconic Estuary generate roughly $450 million in revenue annually (Peconic

Estuary Program, 2001). However, human and animal activities have had a negative impact on water quality, resulting in eutrophication, hypoxia, increased pathogens, harmful algal blooms, loss of shellfish habitats, and marine fauna mortality (Swanson et al. 2010, Kinney and Valiela 2011).

Excess nitrogen is a primary driver of water quality decline in many coastal embayments across Long Island, with smaller bodies of water, such as salt ponds, creeks, harbors, and embayments, being the most impacted due to limited volume and water exchange (Suffolk County Comprehensive Water Resources Management Plan (SCCWRMP)). To address this issue, Long Island's estuary programs, including the Peconic Estuary Program (PEP), emphasize the need to identify and reduce the primary source of nitrogen pollution into estuaries. East Hampton has also prioritized water quality improvement projects for commercial and residential properties surrounding Accabonac Harbor. While funding sources are available for water quality improvement project implementation, there is less public funding available for preliminary investigations which identify shoreline areas where groundwater remediation is necessary. In the current project the APC filled an important role of providing seed funding to initiate the preliminary investigation and this funding helped identify and characterize a highly concentrated legacy plume.

Measurements of nutrients in Accabonac Harbor using submarine groundwater discharge (SGD) sampling and measurement equipment were first conducted by CCE in 2016 (Trident Probe and Ultrasonic Seepage Meter, Paulsen et al. 2001). These efforts revealed elevated nitrogen concentrations along the western shoreline of the Springs General Store property. In some areas, the SGD contained nitrogen with both nitrate and ammonium while in other locations, specifically near the culvert, nitrogen was primarily in the form of ammonium ranging from 2.4 – 5.9 mg N-$NH4^+$/L (Paulsen and Murray 2017). Samples collected in August 2020 at similar locations confirmed the presence of elevated nitrogen, up to 3.4 mg N/L, along the culvert. Results over several years confirmed that porewater with elevated nitrogen seeping into the surface water is a persistent issue impacting the shallow culvert and greater Accabonac Harbor.

The USGS model generated regional groundwater flow data, which indicates that nitrogen measured in porewater likely originates from further inland and travels to the shoreline via northwest groundwater flow. The three major sources of nitrogen in groundwater are fertilizers (both residential and agricultural), atmospheric deposition due to fossil fuel burning, and septic systems (Kinney and Valiela 2011, Eckhardt and Stackelberg 1995). The predominant land use in the area is residential, suggesting that nitrogen sources are likely related to medium-density residential areas and septic inputs from Springs School.

Septic nitrogen originates as reduced forms of nitrogen, including urea, ammonium, and organic nitrogen which is consistent with the porewater evaluation. Despite recent nearby septic upgrades to Innovative Alternative Onsite Wastewater Treatment Systems (I/AOWTS), the ammonium plume will likely impact the Harbor for over 5 years due to the groundwater travel time. Septic upgrades in the area are highly necessary and will significantly reduce point source nitrogen inputs in the future.

Although septic upgrades can help alleviate the problem, shoreline PRBs are another tool to support water quality improvements in the near term. PRBs have been extensively used in the midwest United States and Canada to treat agricultural and septic-derived nitrate plumes (Robertson, Schipper et al. 2010, Christianson et al. 2020). Recently, PRBs have been installed near impaired waterbodies in Suffolk County and Cape Cod as an approach to mitigate surface water nitrogen pollution (Graffam et al. 2020, Hiller et al. 2016). PRBs are sub-surface barriers that intercept and provide passive remediation of groundwater. They require minimal maintenance and have been shown to remain effective for decades (Robertson et al. 2008).

In addition to their longevity and low-maintenance requirements, PRBs are also cost-effective in the long-term, similar to other passive nitrogen-removing technologies (Schipper et al. 2010, SCSWP pg. 2-117, Fig. 2-54). To install a PRB, a carbon source such as woodchips or vegetable oil carbon emulsion is introduced to facilitate oxygen depletion by aerobic microbes, which subsequently supports nitrate depletion by denitrifying microbes. Woodchip-based PRBs are expected to last well over 5 years. One study found that after 15 years, 80% of carbon remained, meaning less than 1.5% of carbon was used per year. Assuming half of the total carbon was available to microbes, the PRB's lifespan would exceed 30 years without maintenance. Given the sources and transport mechanisms of nitrogen to the shoreline and the effectiveness and longevity of PRBs in treating nitrate plumes, PRBs represent a viable option to reduce nitrogen inputs to Accabonac Harbor.

A recent demonstration of PRB effectiveness in removing nitrate from groundwater was exemplified by the installation of a 100 ft PRB behind a bulkhead adjacent to Shinnecock Bay in Hampton Bays. The Hampton Hills Association received a CPF grant from the Town of Southampton and contracted CCE along with Stony Brook and Tidewater Dock Building Co. to execute the design, installation, and monitoring. Data collected from the PRB system during the September 2022 sampling event showed that the nitrate concentrations in the groundwater entering the barrier ranged from 0.6 to 10 mg N/L. In contrast, the nitrate levels in the treated water were below the reporting level (<0.1 mg N/L) in almost all samples. The PRB system has been monitored regularly across multiple seasons, and it has consistently performed extremely well. For instance, in April 2021, nitrate concentrations in the groundwater entering the barrier ranged from below 1 to 19 mg N/L. The treated water, however, had nitrate concentrations ranging from below detection up to 3 mg N/L. The control areas where no woodchips were present showed little to no nitrate removal during every sampling event, whereas the areas where woodchips were present exhibited high percentage nitrate removal.

One issue that arises at the Springs General Store site is the form of septic-derived nitrogen present, which is primarily ammonium and organic nitrogen, collectively known as TKN. In natural environments, microbes convert these reduced forms of nitrogen to nitrate via a series of reactions called nitrification ($NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$). This process occurs when septic effluent percolates towards the water table in oxygen-rich unsaturated soil or oxygen-rich groundwater. Effective treatment through woodchip based PRBs requires the nitrogen entering the barrier to be in the form of nitrate, which is the dominant form of groundwater nitrogen in most settings. In areas heavily impacted by septic waste, inadequate residence time or insufficient oxygen may impede the conversion of ammonium to nitrate. As a result, ammonium and TKN can be present in groundwater, as was observed at the Springs General Store site.

An ammonium groundwater nitrogen plume requires additional treatment to initiate the conversion of $NH_4^+ \rightarrow NO_3^-$ by supplying sufficient oxygen or other oxidizing agent. Groundwater aeration with oxygen is a well-established technique which has primarily been used in organic contaminant bioremediation (Bass et al. 2000) and to a lesser extent for supporting nitrification (Geise et al. 2003; Luckner and Ebrecht 2000). Air injection involves intermittently pumping oxygen rich air into the saturated zone, causing the dissolved oxygen concentration within the water to increase. Oxygenated water can then passively percolate beyond the immediate area by diffusion as well as by groundwater travel towards the shoreline according to the naturally established hydraulic gradient. Since aerobic microbial processes such as aerobic respiration and nitrification will consume oxygen, re-oxygenation needs to occur relatively frequently via intermittent pumping. Several studies tackled an ammonium plume with bioremediation using PRBs. Both laboratory and field studies successfully achieved ammonium conversion to nitrate or nitrite followed by denitrification using a sequential barrier technique with an oxidizing barrier upgradient of the carbon-rich barrier (Patterson et al. 2004; Van Nooten et al. 2008; Huang et al. 2015). Another benefit of this approach is that air injection is also easily adjustable given that there is generally above-ground access to the aeration device and batteries.

Phase 1 Site Characterization:

As part of the Phase 1 site characterization funded by the APC, CCE installed 6 groundwater wells along the western edge of the Springs General Store property up to 40 feet deep (Fig. 1). The initial round of monitoring revealed ammonium concentrations ranging from < 0.406 in the shallowest depth intervals (5 to 10 ft below grade) up to 21.2 mg N/L. Groundwater nitrogen concentration estimates based on land use suggest that areas of groundwater contribution to the Harbor are expected to have between 6-10 mg N/L (Paulsen and Murray 2017). Thus, concentrations were much higher than anticipated. Along the western edge of the property, ammonia increased with depth and reached a maximum at about 35 ft below grade in all wells (Fig. 1). Highest concentrations were observed in wells at the southwestern edge of the property at greater than 20 ft deep.

In addition to collecting groundwater nitrogen samples, a soil boring was collected to 40 ft below grade (Appendix A). Soil was analyzed for grain size and permeability in 5 ft depth intervals. Grain size data was determined by passing the soil through a series of sieves with decreasing mesh size. The gravel measured at this site fit within a mesh opening of 0.187 to 0.748 inches (4.76 to 19 mm). Very coarse, coarse, medium and fine sand, collectively classified as sand, fits through a mesh opening up to 0.078 inches (2 mm). The smallest particles known as silt and clay are less than 2.9×10^{-3} inches (<0.074 mm).

The top of the soil boring from 5 to 15 ft below grade had a high percentage of gravel (51.95%). From 15 to 25 ft below grade the soil boring was dominated by medium to fine sand. At 25 to 30 ft below grade another layer of coarse soil was present with high percentages of gravel (30.10%), coarse sand (15.30%), and medium sand (24.88%). From 30 to 35 ft below grade the soil boring was mostly medium (37.49%) to fine sand (25.71%). From 35 to 40 ft below grade the soil boring was mostly gravel (36.65%), medium (21.31%), and fine sand (14.20%). In the 35 to 40 ft depth interval we also observed the highest percentage of very fine particles including silt (2.7%) and clay (5.4%) but the proportion of very fine particles was still relatively low compared to the other fraction of larger soil particles.

Groundwater wells were surveyed to a common datum and depth to water level was measured (Appendix B). Distance between wells was measured and groundwater velocity was calculated according to the hydraulic gradient between wells. Groundwater velocity was calculation using Darcy's law (Eqn 1) where K is the hydraulic conductivity of the soil, A is the area, Δh is the difference in water level height between two wells, and Δl is the distance between wells. An average hydraulic conductivity of 280 ft/day was calculated from the grain size analysis using the Shepherd calculation in the HydroGeoSieveXL spreadsheet (a publicly available tool for K calculation found here: HydrogeoSieveXL2-2.xlsm (live.com)) Average groundwater velocity was 3 ft/day which is within the typical range of groundwater velocities commonly found on Long Island but was slightly higher than our initial estimate of 1 ft/day.

Eqn 1: $Q = -KA\frac{\Delta h}{\Delta l}$

Phase 2 Air Injection Installation:

Based on the Phase 1 site characterization, CCE recently installed three gravel columns (30 ft deep x ~1 ft diameter) each equipped with an air injection line. An aeration manifold with valves and pressure gauges delivers oxygen rich air at approximately 12 psi into each air injection line to deliver oxygen into the saturated zone. Three ½ inch diameter by 1 ft long PVC sampling ports were installed within each gravel column at approximately 24-25, 19-20, and 14-15 ft below grade. Preliminary field results from Phase 2 indicate an aeration period of 30 min per day is sufficient to increase the oxygen concentration in groundwater within the gravel column from ~0.7 to over 10 mg/L. After approximately 24 hours, just before the next aeration cycle begins, oxygen levels are reduced but remained above 2 mg/L. Reduced oxygen levels are likely due to both microbially related oxygen consumption from aerobic respiration and nitrification as well as groundwater travel through the column introducing new water which is low in oxygen. Trials are currently ongoing to determine the most effective aeration pattern, but our initial demonstration indicates 30 min of aeration per day is sufficient.

Due to the gravel columns being more permeable than the surrounding soil, water is attracted into the gravel columns from below and as the aeration begins, it creates a slight upward flow of water. This phenomenon was measured both in the laboratory bench tests using a flow meter and in the field trials using a water level logger. We observed higher Total Nitrogen in samples after oxygenation started at the deepest sampling port within the gravel columns. This is likely because the pressure established due to aeration creates an upward flow of water in the gravel column which allows ammonium rich water from deeper in the aquifer to be drawn into the column. This is consistent with our Phase 1 site characterization results where we found highest ammonia concentrations in the 30-35 ft depth interval.

Most importantly, preliminary tests indicate the system is converting ammonium to nitrate. We observed the greatest difference in nitrate concentration before and after aeration in the shallowest depth interval. Thus, the system is shuttling nitrate rich water towards shallower depths. This is ideal because it could reduce the depth of a future PRB installation which creates cost savings in labor and materials. Furthermore, nitrate persists in the downgradient monitoring wells. Downgradient monitoring well samples appear to be a mixture of ambient groundwater and treated water that passed through the gravel columns. Currently the system is being powered by solar panels and triggered by a timer. The system requires very little energy to maintain making this a largely passive approach.

Future Work:

CCE recently applied for additional funding through the Community Preservation Fund to fully implement a sequential PRB groundwater treatment system to address the ammonium plume identified along the western edge of the Springs General Store. The recent application requests funds to support expansion of Phase 2, to install additional gravel columns, as well as execute Phase 3, to install a PRB to provide nitrate removal.

Additionally, CCE is planning to install groundwater monitoring wells at the nearby Springs School which would help us determine groundwater flow and nitrogen plume conditions reaching the Springs General Store study area. Although the Springs School recently updated their septic systems, due to the groundwater travel time, the plume will likely be impacting our study area for over 5 years. The current plan is to install 2 groundwater monitoring well clusters in the area north of northern baseball field; one off 1st and 3rd base along the property line fence. These wells would be downgradient of the school septic system would not interfere with the baseball field use. We would then monitor the water table elevation, field parameters, and groundwater nitrogen concentration every 6 months. This work could involve coordinating with school staff who are interested in providing an educational experience for students.

Figures:

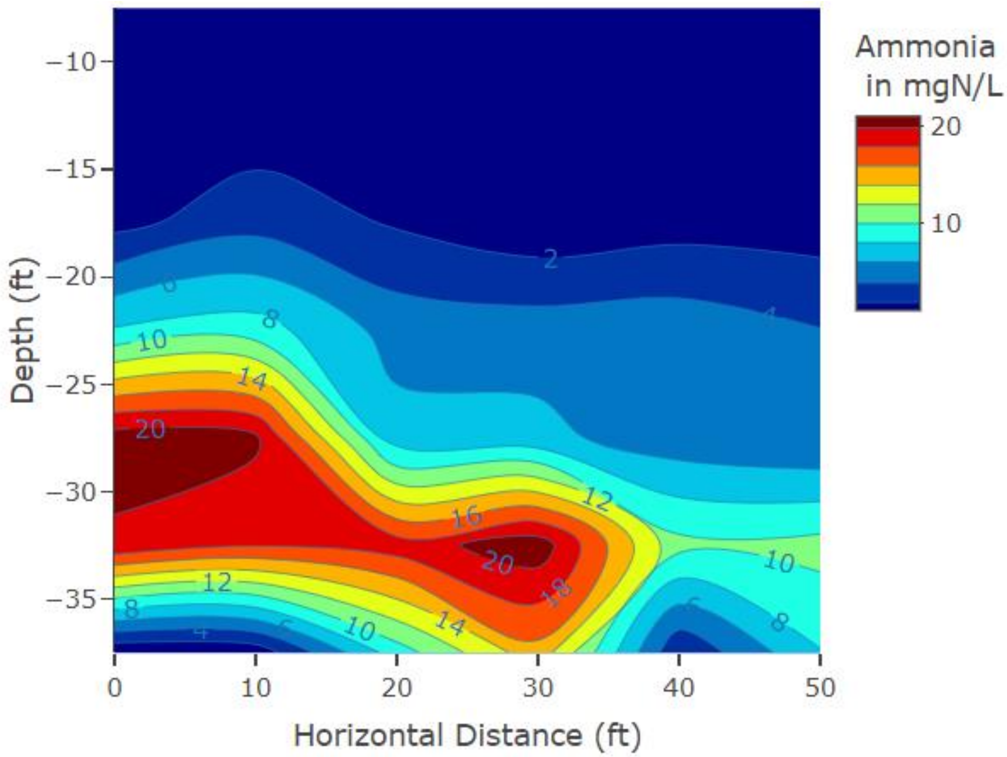

Figure 1: Contour plot of cross-section of ammonium values (mg N/L) measured in 5 ft intervals below grade at 6 groundwater wells along the western edge of the Springs General Store Property as part of the Phase 1 site characterization. Contour lines and colors are at 2 mg N/L intervals. Cool colors represent lower concentrations and warm colors represent elevated ammonium concentrations. For example, green represents concentrations ranging from 10-12 mg N/L and yellow represents 12-14 mg N/L.

Figure 2: Photo of hollow stem auger drilled into the ground to create a ~1ft diameter by 30ft deep column which was then filled with gravel as well as an air injection line and sampling ports.

Figure 3: Photo of the air injection line before it was lowered into the bottom of the gravel column.

Figure 4: Photo of the air injection manifold facilitation air injection to the 3 gravel columns. Manifold includes valves and gauges to allow pressure monitoring and adjustment.

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Appendix A:

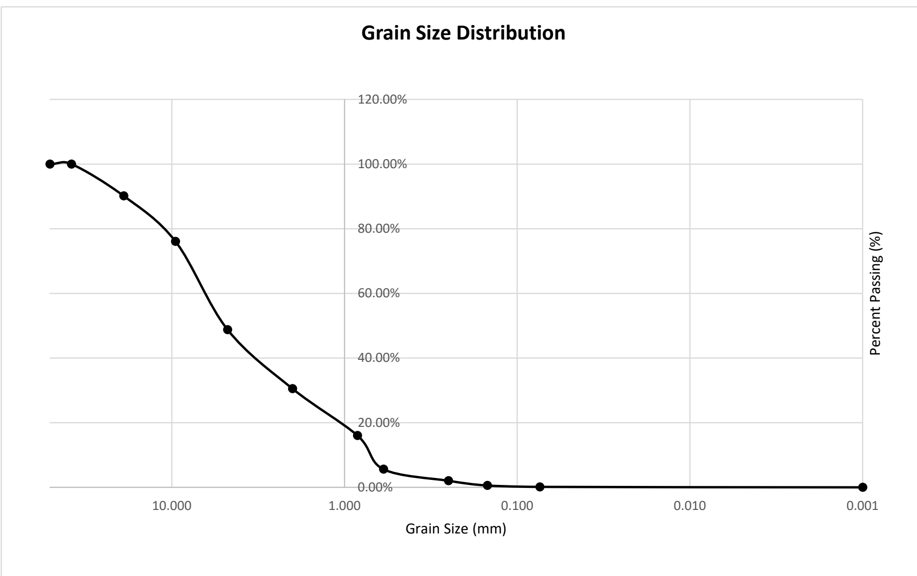
Soil Boring Laboratory Report

Grain Size Analysis Report

Long Island Analytical Laboratories

Client	Cornell Cooperative
Project Location	G4505
Laboratory ID	2052324-01
Sample ID	Springs General Store 0'-5'

Sieve #	Opening (mm)	Weight of Soil Retained (g)	% Soil Retained	Sum of Weights (g)	% Soil Passing	Classification			
4"	101.600	0.00	0.00%	0.00	100.00%				
2"	50.800	0.00	0.00%	0.00	100.00%				
1-1/2"	38.100	0.00	0.00%	0.00	100.00%	51.21%	Gravel		
3/4"	19.000	35.00	9.85%	35.00	90.15%				
3/8"	9.525	50.00	14.07%	85.00	76.08%				
#4	4.760	97.00	27.29%	182.00	48.79%				
#10	2.000	65.00	18.29%	247.00	30.50%	18.29%	Very Coarse		
#20	0.841	51.50	14.49%	298.50	16.01%	14.49%	Coarse		
#40	0.595	37.00	10.41%	335.50	5.60%	10.41%	Medium	48.23%	Sand
#60	0.250	12.70	3.57%	348.20	2.03%	3.57%	Fine		
#100	0.149	5.20	1.46%	353.40	0.56%	1.46%	Very Fine		
#200	0.074	1.50	0.42%	354.90	0.14%	0.42%	Silt		
Pan	0.001	0.50	0.14%	355.40	0.00%	0.14%	Clay		
Total Weight		355.40	100%			100.00%			



Michael D. Veraldi

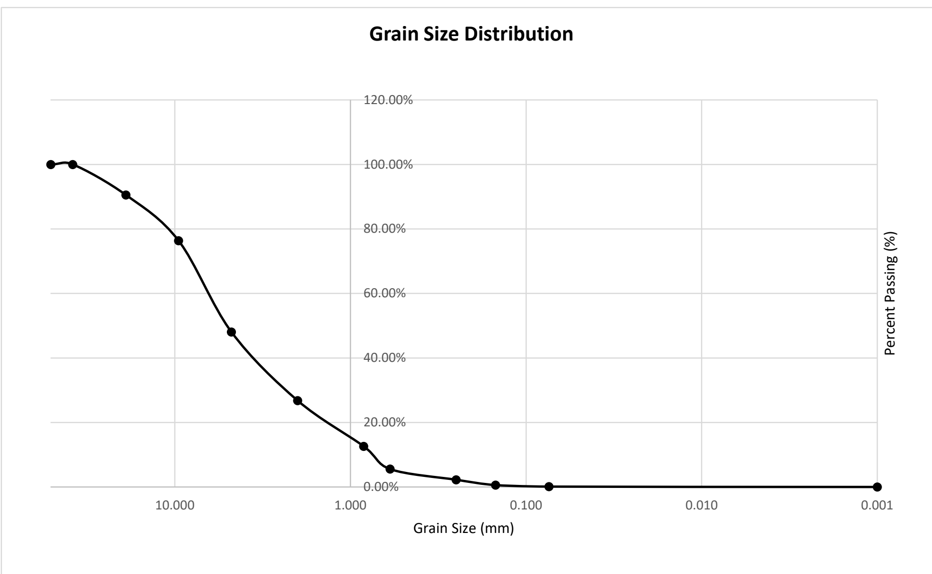
Michael D. Veraldi - Laboratory Technical Director

Grain Size Analysis Report

Long Island Analytical Laboratories

Client	Cornell Cooperative
Project Location	G4505
Laboratory ID	2052324-02
Sample ID	Springs General Store 5'-10'

Sieve #	Opening (mm)	Weight of Soil Retained (g)	% Soil Retained	Sum of Weights (g)	% Soil Passing	Classification			
4"	101.600	0.00	0.00%	0.00	100.00%	51.95%	Gravel		
2"	50.800	0.00	0.00%	0.00	100.00%				
1-1/2"	38.100	0.00	0.00%	0.00	100.00%				
3/4"	19.000	40.00	9.45%	40.00	90.55%				
3/8"	9.525	60.00	14.17%	100.00	76.39%				
#4	4.760	120.00	28.34%	220.00	48.05%				
#10	2.000	90.00	21.25%	310.00	26.80%	21.25%	Very Coarse	47.46%	Sand
#20	0.841	60.00	14.17%	370.00	12.63%	14.17%	Coarse		
#40	0.595	30.00	7.08%	400.00	5.55%	7.08%	Medium		
#60	0.250	14.00	3.31%	414.00	2.24%	3.31%	Fine		
#100	0.149	7.00	1.65%	421.00	0.59%	1.65%	Very Fine		
#200	0.074	2.00	0.47%	423.00	0.12%	0.47%	Silt		
Pan	0.001	0.50	0.12%	423.50	0.00%	0.12%	Clay		
Total Weight		423.50	100%			100.00%			



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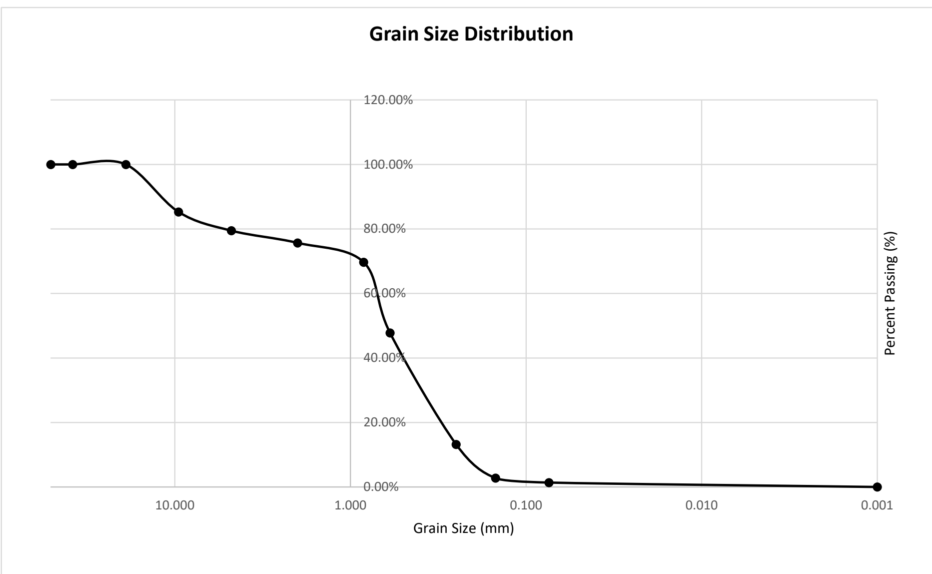
Grain Size Analysis Report

Long Island Analytical Laboratories

Client	Cornell Cooperative
Project Location	G4505
Laboratory ID	2052324-03
Sample ID	Springs General Store 10'-15'

Sieve #	Opening (mm)	Weight of Soil Retained (g)	% Soil Retained	Sum of Weights (g)	% Soil Passing	Classification			
4"	101.600	0.00	0.00%	0.00	100.00%				
2"	50.800	0.00	0.00%	0.00	100.00%				
1-1/2"	38.100	0.00	0.00%	0.00	100.00%	20.55%	Gravel		
3/4"	19.000	0.00	0.00%	0.00	100.00%				
3/8"	9.525	43.00	14.73%	43.00	85.27%				
#4	4.760	17.00	5.82%	60.00	79.45%				
#10	2.000	11.00	3.77%	71.00	75.68%	3.77%	Very Coarse		
#20	0.841	17.50	5.99%	88.50	69.69%	5.99%	Coarse		
#40	0.595	64.00	21.92%	152.50	47.77%	21.92%	Medium	76.71%	Sand
#60	0.250	101.00	34.59%	253.50	13.18%	34.59%	Fine		
#100	0.149	30.50	10.45%	284.00	2.74%	10.45%	Very Fine		
#200	0.074	4.00	1.37%	288.00	1.37%	1.37%	Silt		
Pan	0.001	4.00	1.37%	292.00	0.00%	1.37%	Clay		
Total Weight		292.00	100%			100.00%			



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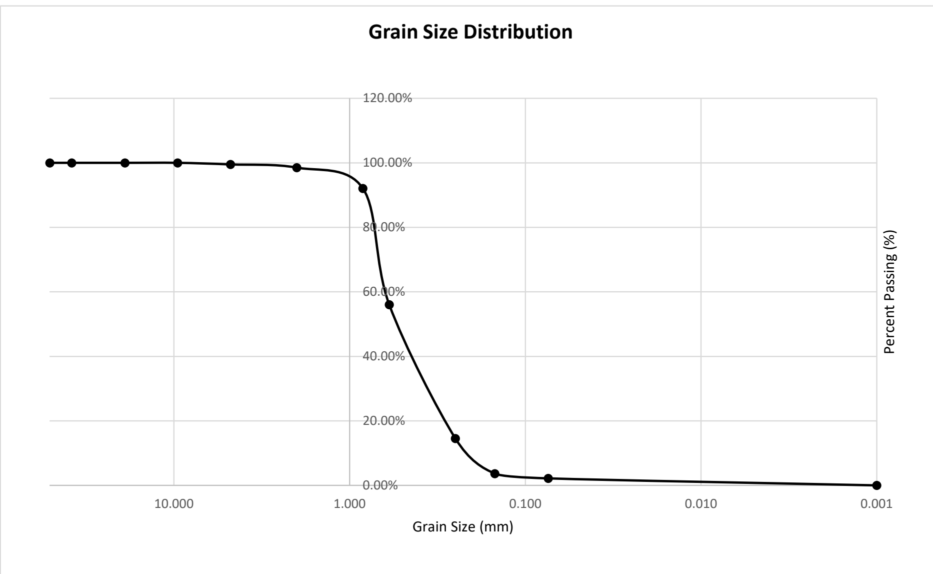
Grain Size Analysis Report

Long Island Analytical Laboratories

Client	Cornell Cooperative
Project Location	G4505
Laboratory ID	2052324-04
Sample ID	Springs General Store 15'-20'

Sieve #	Opening (mm)	Weight of Soil Retained (g)	% Soil Retained	Sum of Weights (g)	% Soil Passing	Classification			
4"	101.600	0.00	0.00%	0.00	100.00%	0.49%	Gravel		
2"	50.800	0.00	0.00%	0.00	100.00%				
1-1/2"	38.100	0.00	0.00%	0.00	100.00%				
3/4"	19.000	0.00	0.00%	0.00	100.00%				
3/8"	9.525	0.00	0.00%	0.00	100.00%				
#4	4.760	1.00	0.49%	1.00	99.51%				
#10	2.000	2.00	0.99%	3.00	98.52%	0.99%	Very Coarse	95.85%	Sand
#20	0.841	13.00	6.42%	16.00	92.09%	6.42%	Coarse		
#40	0.595	73.00	36.07%	89.00	56.03%	36.07%	Medium		
#60	0.250	84.00	41.50%	173.00	14.53%	41.50%	Fine		
#100	0.149	22.00	10.87%	195.00	3.66%	10.87%	Very Fine		
#200	0.074	3.00	1.48%	198.00	2.17%	1.48%	Silt		
Pan	0.001	4.40	2.17%	202.40	0.00%	2.17%	Clay		
Total Weight		202.40	100%			100.00%			



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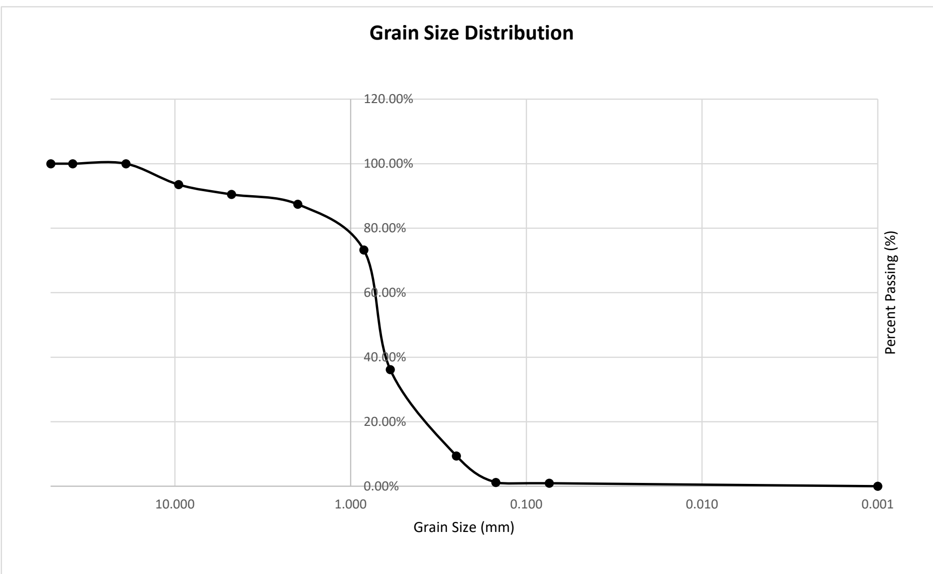
Grain Size Analysis Report

Long Island Analytical Laboratories

Client	Cornell Cooperative
Project Location	G4505
Laboratory ID	2052324-05
Sample ID	Springs General Store 20'-25'

Sieve #	Opening (mm)	Weight of Soil Retained (g)	% Soil Retained	Sum of Weights (g)	% Soil Passing	Classification			
4"	101.600	0.00	0.00%	0.00	100.00%	9.54%	Gravel		
2"	50.800	0.00	0.00%	0.00	100.00%				
1-1/2"	38.100	0.00	0.00%	0.00	100.00%				
3/4"	19.000	0.00	0.00%	0.00	100.00%				
3/8"	9.525	24.50	6.49%	24.50	93.51%				
#4	4.760	11.50	3.05%	36.00	90.46%				
#10	2.000	11.50	3.05%	47.50	87.42%	3.05%	Very Coarse	89.27%	Sand
#20	0.841	53.50	14.17%	101.00	73.25%	14.17%	Coarse		
#40	0.595	140.00	37.09%	241.00	36.16%	37.09%	Medium		
#60	0.250	101.00	26.75%	342.00	9.40%	26.75%	Fine		
#100	0.149	31.00	8.21%	373.00	1.19%	8.21%	Very Fine		
#200	0.074	1.00	0.26%	374.00	0.93%	0.26%	Silt		
Pan	0.001	3.50	0.93%	377.50	0.00%	0.93%	Clay		
Total Weight		377.50	100%			100.00%			



Michael D. Veraldi

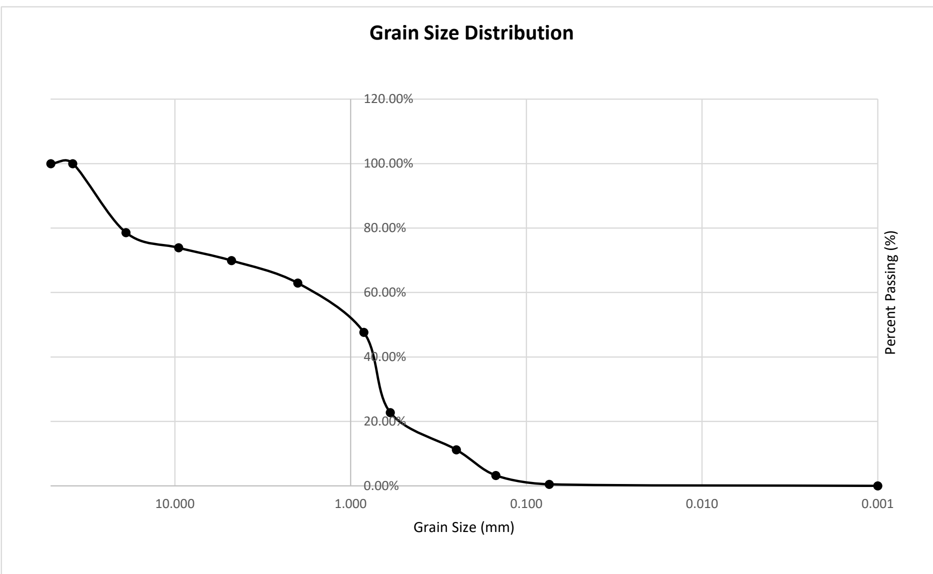
Michael D. Veraldi - Laboratory Technical Director

Grain Size Analysis Report

Long Island Analytical Laboratories

Client	Cornell Cooperative
Project Location	G4505
Laboratory ID	2052324-06
Sample ID	Springs General Store 25'-30'

Sieve #	Opening (mm)	Weight of Soil Retained (g)	% Soil Retained	Sum of Weights (g)	% Soil Passing	Classification			
4"	101.600	0.00	0.00%	0.00	100.00%				
2"	50.800	0.00	0.00%	0.00	100.00%				
1-1/2"	38.100	0.00	0.00%	0.00	100.00%	30.10%	Gravel		
3/4"	19.000	172.00	21.39%	172.00	78.61%				
3/8"	9.525	38.00	4.73%	210.00	73.88%				
#4	4.760	32.00	3.98%	242.00	69.90%				
#10	2.000	56.00	6.97%	298.00	62.94%	6.97%	Very Coarse		
#20	0.841	123.00	15.30%	421.00	47.64%	15.30%	Coarse		
#40	0.595	200.00	24.88%	621.00	22.76%	24.88%	Medium	66.67%	Sand
#60	0.250	93.00	11.57%	714.00	11.19%	11.57%	Fine		
#100	0.149	64.00	7.96%	778.00	3.23%	7.96%	Very Fine		
#200	0.074	22.00	2.74%	800.00	0.50%	2.74%	Silt		
Pan	0.001	4.00	0.50%	804.00	0.00%	0.50%	Clay		
Total Weight		804.00	100%			100.00%			



Michael D. Veraldi

Michael D. Veraldi - Laboratory Technical Director

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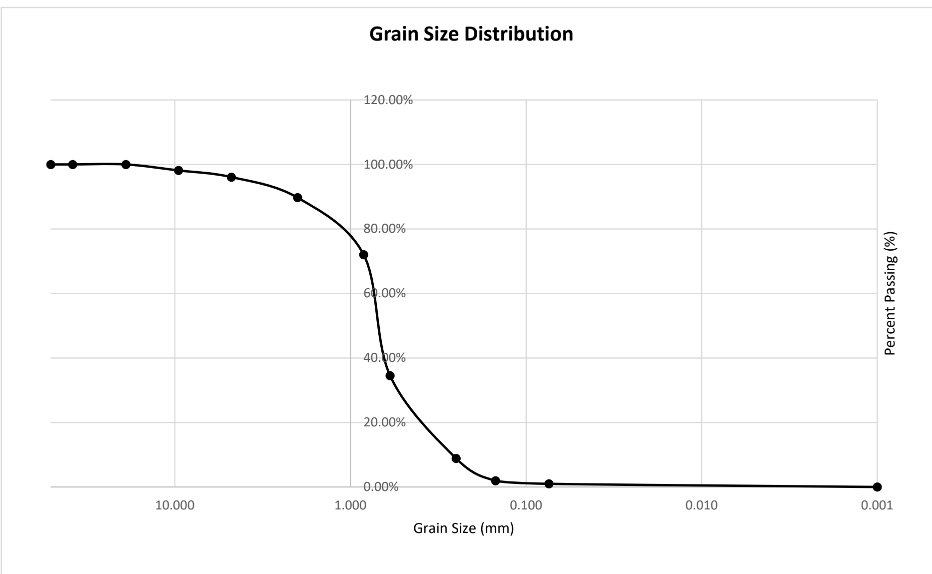
PADEP # 68-294

Grain Size Analysis Report

Long Island Analytical Laboratories

Client	Cornell Cooperative
Project Location	G4505
Laboratory ID	2052324-07
Sample ID	Springs General Store 30'-35'

Sieve #	Opening (mm)	Weight of Soil Retained (g)	% Soil Retained	Sum of Weights (g)	% Soil Passing	Classification			
4"	101.600	0.00	0.00%	0.00	100.00%				
2"	50.800	0.00	0.00%	0.00	100.00%				
1-1/2"	38.100	0.00	0.00%	0.00	100.00%	3.93%	Gravel		
3/4"	19.000	0.00	0.00%	0.00	100.00%				
3/8"	9.525	9.50	1.86%	9.50	98.14%				
#4	4.760	10.50	2.06%	20.00	96.07%				
#10	2.000	32.50	6.38%	52.50	89.70%	6.38%	Very Coarse		
#20	0.841	90.00	17.66%	142.50	72.03%	17.66%	Coarse		
#40	0.595	191.00	37.49%	333.50	34.54%	37.49%	Medium	94.11%	Sand
#60	0.250	131.00	25.71%	464.50	8.83%	25.71%	Fine		
#100	0.149	35.00	6.87%	499.50	1.96%	6.87%	Very Fine		
#200	0.074	5.00	0.98%	504.50	0.98%	0.98%	Silt		
Pan	0.001	5.00	0.98%	509.50	0.00%	0.98%	Clay		
Total Weight		509.50	100%			100.00%			



Michael D. Veraldi

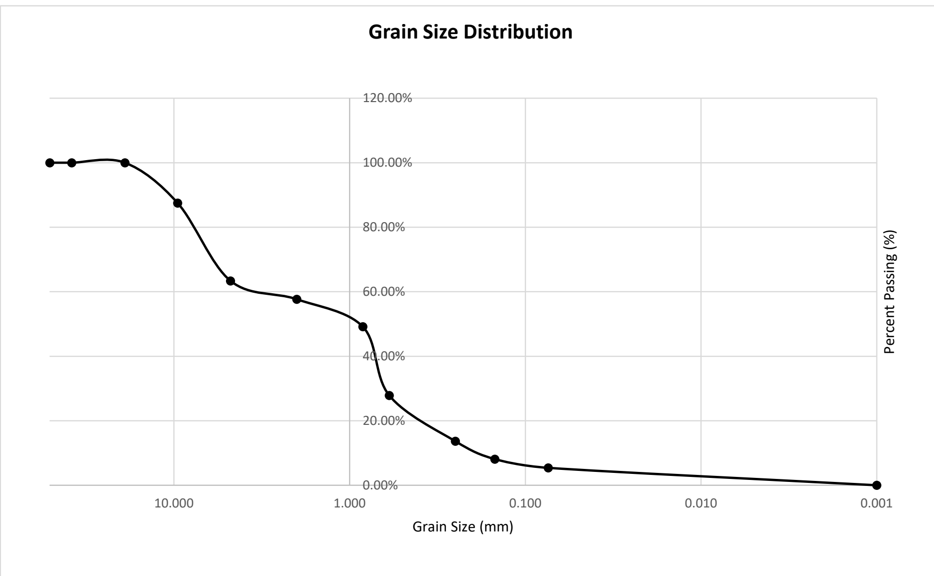
Michael D. Veraldi - Laboratory Technical Director

Grain Size Analysis Report

Long Island Analytical Laboratories

Client	Cornell Cooperative
Project Location	G4505
Laboratory ID	2052324-08
Sample ID	Springs General Store 35'-40'

Sieve #	Opening (mm)	Weight of Soil Retained (g)	% Soil Retained	Sum of Weights (g)	% Soil Passing	Classification			
4"	101.600	0.00	0.00%	0.00	100.00%				
2"	50.800	0.00	0.00%	0.00	100.00%				
1-1/2"	38.100	0.00	0.00%	0.00	100.00%	36.65%	Gravel		
3/4"	19.000	0.00	0.00%	0.00	100.00%				
3/8"	9.525	44.00	12.50%	44.00	87.50%				
#4	4.760	85.00	24.15%	129.00	63.35%				
#10	2.000	20.00	5.68%	149.00	57.67%	5.68%	Very Coarse		
#20	0.841	30.00	8.52%	179.00	49.15%	8.52%	Coarse		
#40	0.595	75.00	21.31%	254.00	27.84%	21.31%	Medium	55.26%	Sand
#60	0.250	50.00	14.20%	304.00	13.64%	14.20%	Fine		
#100	0.149	19.50	5.54%	323.50	8.10%	5.54%	Very Fine		
#200	0.074	9.50	2.70%	333.00	5.40%	2.70%	Silt		
Pan	0.001	19.00	5.40%	352.00	0.00%	5.40%	Clay		
Total Weight		352.00	100%			100.00%			



Michael D. Veraldi

Michael D. Veraldi - Laboratory Technical Director

Cornell Cooperative G4505

All geoprobe cores were pre-soaked with Lab grade DI Water 4 hours prior to permeability analysis.
All permeability rates were calculated by the time it took 1 inch of water to permeate into the soil inside a 1 inch boring collar.

Date of Analysis	6/6/2022							
Laboratory ID	**2052324-01**	**2052324-02**	**2052324-03**	**2052324-04**	**2052324-05**	**2052324-06**	**2052324-07**	**2052324-08**
Sample ID	**Springs General Store 0'-5'**	**Springs General Store 5'-10'**	**Springs General Store 10'-15'**	**Springs General Store 15'-20'**	**Springs General Store 20'-25'**	**Springs General Store 25'-30'**	**Springs General Store 30'-35'**	**Springs General Store 35'-40'**
Time in Seconds	110	97	185	233	202	143	210	136
Inches/Second	0.0091	0.0103	0.0054	0.0043	0.0050	0.0070	0.0048	0.0074
Feet/Day	65.5	74.2	38.9	30.9	35.6	50.3	34.3	52.9

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CHAIN OF CUSTODY / REQUEST FOR ANALYSIS DOCUMENT

CLIENT NAME/ADDRESS: 423 Griffing Ave, Riverhead NY
Cornell Coop. Ext.

CONTACT: Molly Graffam
PHONE: 8604247204
EMAIL: meg372@cornell.edu

PROJECT LOCATION: G4505

SAMPLER (SIGNATURE): Molly G
SAMPLER NAME (PRINT): Molly Graffam

SAMPLE(S) SEALED: YES / NO
CORRECT CONTAINER(S): YES / NO

LABORATORY CHAIN (FOR LAB USE ONLY): 2052324

SAMPLES RECEIVED AT: 2.0 °C

TERMS & CONDITIONS: Accounts are payable in full within thirty days, outstanding balances accrue service charges of 1.5% per month. Tendering of samples to LIAL for analytical testing constitutes agreement by buyer/sampler to LIAL's Standard terms

ANALYSIS REQUIRED

LABORATORY ID # (For Laboratory Use Only)	MATRIX	TYPE	pH	RES. CHLORINE	PRES.	DATE	TIME	SAMPLE # LOCATION	grain size	permeability											# OF CONTAINERS
1.	S					4/6/22	10:00	springs general store 0'-5'	✓	✓											1
2.	S					4/6/22	10:05	springs general store 5'-10'	✓	✓											1
3.	S					4/6/22	10:10	springs general store 10-15'	✓	✓											1
4.	S					4/6/22	10:15	springs general store 15'-20'	✓	✓											1
5.	S					4/6/22	10:20	springs general store 20'-25'	✓	✓											1
6.	S					4/6/22	10:25	springs general store 25'-30'	✓	✓											1
7.	S					4/6/22	10:30	springs general store 30-35'	✓	✓											1
8.	S					4/6/22	10:35	springs general store 35'-40'	✓	✓											1
9.																					
10.																					
11.																					
12.																					
13.																					
14.																					

MATRIX: S=SOIL; SL=SLUDGE; DW=DRINKING WATER; A=AIR; W=WIPE; PC=PAINT CHIPS; BM= BULK MATERIAL, O=OIL, WW=WASTE WATER
TYPE: G=GRAB; C=COMPOSITE; SS=SPLIT SPOON
PRES: (1) ICE; (2) HCL; (3) H_2SO_4; (4) NAOH; (5) $NA_2S_2O_3$; (6) HNO_3; (7) OTHER

TURNAROUND REQUIRED: ☑ NORMAL ☐ STAT
BY / /

COMMENTS / INSTRUCTIONS

RELINQUISHED BY (SIGNATURE)	DATE / TIME	PRINTED NAME	RECEIVED BY (SIGNATURE)	DATE / TIME	PRINTED NAME
Molly G	DATE 5/23/22 TIME 4:20PM	Molly Graffam		DATE TIME	
RELINQUISHED BY (SIGNATURE)	DATE TIME	PRINTED NAME	RECEIVED BY SAMPLE CUSTODIAN: [signature]	DATE 5/23/22 TIME 16:30	Ray Rivera

Appendix B:

Well Elevation Survey

P:\22182.000 TOEH Springs Store Monitoring Well Survey\Survey Dept\Drawings\22182.000 Monitoring wells.dwg 11/30/2022 9:28 AM Tamara Stillman

NOTES

1. MEASUREMENTS ARE IN ACCORDANCE WITH U.S. STANDARDS.
2. HORIZONTAL DATUM IS IN THE NEW YORK STATE PLANE COORDINATE SYSTEM, NAD83, LONG ISLAND ZONE.
3. ELEVATIONS REFERENCE NAVD 1988 (GEOID12A).
4. UNAUTHORIZED ALTERATION OR ADDITION TO A SURVEY MAP BEARING A LICENSED LAND SURVEYOR'S SEAL IS A VIOLATION OF SECTION 7209, SUBDIVISION 2, OF THE NEW YORK STATE EDUCATION LAW.
5. ONLY COPIES FROM THE ORIGINAL OF THIS SURVEY MARKED WITH AN ORIGINAL OF THE LAND SURVEYOR'S "EMBOSSED" OR "INKED" SEAL SHALL BE CONSIDERED TO BE VALID TRUE COPIES.
6. CERTIFICATIONS INDICATED HEREON SIGNIFY THAT THIS SURVEY WAS PREPARED IN ACCORDANCE WITH THE EXISTING CODE OF PRACTICE FOR LAND SURVEYORS ADOPTED BY THE NEW YORK STATE ASSOCIATION OF PROFESSIONAL LAND SURVEYORS. SAID CERTIFICATIONS SHALL RUN ONLY TO THE PERSON FOR WHOM THE SURVEY IS PREPARED AND ON HIS BEHALF TO THE TITLE COMPANY, GOVERNMENTAL AGENCY AND LENDING INSTITUTION LISTED HEREON AND TO THE ASSIGNEES OF THE LENDING INSTITUTION. CERTIFICATIONS ARE NOT TRANSFERABLE TO ADDITIONAL INSTITUTIONS OR SUBSEQUENT OWNERS.
7. WELL APHW ON WEST SIDE OF SCHOOL STREET NOT FOUND IN FIELD.

DESC.	POINT NO.	NORTHING	EASTING	CASING ELEVATION	TOP PIPE ELEVATION	GROUND ELEVATION
	1452	316417.10	1493367.16	4.51' (6" METAL PIPE)	BOLTED SHUT	4.51'
APHW7	1453	316413.92	1493369.37	4.63' (6" METAL PIPE)	BOLTED SHUT	4.63'
	1454	316433.21	1493386.56	4.84' (6" PLASTIC PIPE)	4.78' (1" CAP)	4.74'
APHW12	1458	316426.00	1493432.08	5.56' (6" PLASTIC PIPE)	5.52' (1" CAP)	5.52'
APHW11	1461	316419.63	1493418.83	5.44' (6" PLASTIC PIPE)	5.33' (1" CAP)	5.21'
APHW10	1467	316416.23	1493412.91	5.55' (6" PLASTIC PIPE)	5.50' (2" NO CAP)	5.45'
APHW9	1468	316415.11	1493411.93	5.66' (6" PLASTIC PIPE)	5.60' (1" CAP)	5.54'
APHW13	1471	316269.94	1493411.25	7.88' (6" PLASTIC PIPE)	7.81' (1" CAP)	7.82'
APHW8	1474	316410.59	1493403.24	5.37' (6" PLASTIC PIPE)	5.09' (1" CAP)	5.32'

LEGEND

MON W .... MONITORING WELL
x5.52 .... SPOT ELEVATION
1458 .... WELL POINT NUMBER (LABEL UNKNOWN)

I hereby certify that this map was made from an actual survey completed by me on 11/21/22.

TAMARA L. STILLMAN, P.L.S.
NYSPLS No. 50528

DATE	BY	DESCRIPTION	APPROV. BY

REVISIONS

LKMA

Town of East Hampton
Suffolk County, New York
Springs General Store
Old Stone Highway, Springs, NY

MONITORING WELL SURVEY

L. K. McLEAN ASSOCIATES, P.C.
CONSULTING ENGINEERS & LAND SURVEYORS
437 SO. COUNTRY ROAD, BROOKHAVEN, NEW YORK

Surveyed By: C.M./N.R.	Scale: 1"= 20'	Sheet No. 1	
Drawn By: D.M.	Date: 11/29/2022		1
Approved By: T.L.S.	File No. 22182.000		