Impact of Environmental Muck Dredging at Florida Institute of Technology 2016-2017

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Source to Slime Study in the Indian River Lagoon

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Summary

This project examined groundwater nutrient concentrations in one residential community with onsite sewage treatment and disposal systems (septic tanks), one with sewer service, and one with sewer service that also received reclaimed water for irrigation. Groundwater nitrogen concentrations in the three communities were compared with those in a natural area to refine models developed to identify and allocate nutrient source contributions to the Indian River Lagoon. We were surprised to find that the three communities were equally polluting.

Research acknowledges the contribution of septic tank leachate and reclaimed water to nutrient loadings to receiving waters (Badruzzamen et. al. 2012), but there is little scientific evidence that supports the high groundwater nitrogen concentrations we found in the sewered community. This leads to a need for more research on sewered communities and ultimately presents a management challenge. To effectively address nutrient pollution in our study area, practitioners would need to address all three wastewater treatment types. Before hooking septic tanks up to sewer lines, the sewer lines must be checked for leaks to eliminate that as a possible source of contamination. Furthermore, the wastewater treatment plant that is treating the sewage must be updated to advanced treatment that will reduce the nitrogen concentrations in the irrigation water. If what we found in this pilot study is consistent throughout Brevard County, addressing just septic tank communities would do little to reduce nutrient pollution that can impact the lagoon. Repeating the study design multiple times in different areas can increase the confidence of these findings.

Wastewater contributes to nutrient pollution in receiving ground and surface waters through several different means. In this study, we focus on residential communities with varying wastewater systems including septic tanks, sewered lines, and sewered lines with reclaimed irrigation water. Septic tanks designed to treat bacteria discharge nutrient laden leachate into drainfields. If the drainfields are located too close to the water table, nutrient laden leachate reaches groundwater. Sewer lines that transfer household wastewater to the wastewater treatment plants can become compromised and leak overtime, discharging untreated sewage into groundwater. Reclaimed irrigation water used to reduce Floridian's reliance on potable water for irrigation can be rich in nutrients.

Nutrients such as nitrogen and phosphorus fuel algal blooms that can lead to toxic conditions and contribute to muck formation. During an algal bloom, dissolved nutrients are rapidly taken up and released by billions of algae cells. When the algae die, bacterial decomposition of those cells uses up the oxygen in the water column, resulting in anoxic conditions that lead to fish kills. Those billions of decomposing algae cells along with the fish and other organisms that die from anoxia, fall to the bottom and contribute to muck accumulation.

Stopping the cycle of nutrient enrichment, algal blooms, fish kills, and muck formation requires an understanding of pollutant sources and nutrient dynamics. A better understanding of sources of groundwater contamination is needed to prioritize areas for wastewater upgrades, infrastructure retrofits, and septic to sewer conversions. The goal of this pilot project was to measure groundwater nitrogen concentrations in residential and natural areas to verify regional efforts to allocate sources of nitrogen entering the lagoon with field-collected data.

Models currently being used to estimate pollutant loads to the Indian River Lagoon may be grossly underestimating the contribution of nutrients from groundwater entering the lagoon through baseflow. A better understanding of groundwater nutrient concentrations and processes can help refine loading models and contribute to the creation of a much-needed lagoon nitrogen budget. This project installed permanent groundwater monitoring wells and collected and analyzed 92 monthly groundwater samples in accordance with rigorous data collection protocols including FDEP-SOP-001/01; FS2200 Groundwater Sampling, and EPA standard laboratory methods in a NELAP certified lab.

Study Objectives

The goal of the study was to measure groundwater nitrogen pollution in three different communities to confirm model estimates and compare differences. The following study objectives accomplished this goal.

- Conduct an extensive literature review on groundwater nutrient sources and regional studies. Identify sources of groundwater data within the IRL watershed.
- Create spatial data layers and maps of soils, groundwater, land use, and elevation data, potential sources of nutrients, and hydraulic flows to the IRL.
- Install wells to measure groundwater levels and collect samples.
- Collect 48-72 groundwater samples in sub-watershed basins of Turkey Creek.
- Analyze groundwater samples for ammonia, Total Kjeldahl Nitrogen, nitrate, $\delta^{15}N$ and $\delta^{18}O$ in nitrate, and fecal coliforms.
- Evaluate the extent that residential land uses are contributing nutrients and bacteria to groundwater.

Study Results

There is a perception that septic tank communities are contributing high concentrations of nitrogen to groundwater, because they are designed to treat bacteria and discharge nitrogen normally through the drainfield. In the case of Turkey Creek, there is no single residential community that is more polluting than another. There were interesting differences in nitrogen species among them (Table 1). The highest Total Nitrogen concentration (5.15 ppm) was in the septic tank community, followed by the sewered community (4.55 ppm). The highest organic nitrogen (4.35 ppm) and ammonia (2.45 ppm) concentrations were in the sewered community and the highest nitrate-nitrite concentration (2.5 ppm) was in the reuse community. The three communities had significantly higher groundwater nitrogen concentrations than the natural area, in fact an order of magnitude higher, but they were not significantly different from each other.

Based on the measured data, total nitrogen loading into the Turkey Creek is likely at least 4,623 lbs./year or 14 lbs/year of total Nitrogen per household. Furthermore, we found that nitrogen plumes extended well beyond the 20 to 60 m reported in the literature (Ming *et al.*, 2017), indicating that distance from an OSTDS to the receiving waterway shouldn't be the only indicator used to predict loading potential.

Although in our study all residential communities are equally polluting, this can only be confirmed by repeating the study design multiple times in different areas. We found tremendous variability between and within treatment types and over time that requires statistical analysis that takes this variability into account.

Table 1. Comparison of nitrogen and bacteria median concentrations across communities with septic tanks, sewer lines, and sewer lines with reuse irrigation.

Analyte	**Septic**	**Sewer**	**Reuse**	**Natural**
*NH_3 (mg/L)	1.150^{ab}	$\mathbf{2.450^{a}}$	0.035^{bc}	0.035^{c}
*NO_X-N (mg/L)	0.025^{a}	0.036^{a}	$\mathbf{2.500^{b}}$	0.025^{a}
*TKN (mg/L)	1.550^{a}	$\mathbf{4.350^{b}}$	0.120^{c}	0.220^{c}
*TN (mg/L)	$\mathbf{5.150^{a}}$	4.550^{a}	2.500^{a}	0.225^{b}
Fecal Coliform (CFUs/100mL)	1.000	1.000	1.000	1.000

*Significantly different median at $p < 0.001$ using Kruskal-Wallis. Pairwise comparison (Mann-Whitney tests). Different letters indicate significant differences within rows at $p < 0.05$. Highest value in bold.

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Acknowledgements

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Introduction

Nutrients contribute to Indian River Lagoon (IRL) muck accumulation by fueling organic matter that hastens hyper-eutrophication. The rapid cycling of dissolved nutrients by algae that is released with algal death can cause anoxic conditions and fish kills that ultimately contribute to the organic-rich material decomposing into IRL muck. Addressing sources of nutrients that contribute to this cycle of death, decay and muck accumulation is important to IRL recovery. Research that quantifies nutrient contributions from groundwater and surface water sources can advise, focus and evaluate pollution prevention efforts.

Calculating Pollutant Loads

Nutrient loading to the Indian River Lagoon needs to be allocated to sources in order to meet established Total Maximum Daily Loads (TMDL) through the implementation of Basin Management Action Plans (BMAP). During BMAP implementation, regional partners complete projects to reduce pollutants primarily through stormwater Best Management Practices. As the process continues and additional data are available, partners may update and refine the TMDL to focus efforts and evaluate efficiencies. During refinement of the TMDL for the Banana, North, and Central Indian River Lagoons, modeling estimated about 60-70% of the total volume of water reaching the lagoon was coming from baseflow, which is a groundwater source (Applied Ecology, Inc., 2015; Zarillo and Listopad, 2018). This large contribution of water from base flow can be a substantial source of nutrients entering the lagoon that is not being addressed through the implementation of stormwater projects. To prioritize and address all of the sources of nutrients to the lagoon, it is necessary to understand the contribution of groundwater nutrients entering the lagoon through baseflow.

Baseflow contributions are estimated as the remaining volume of water after taking into account inflows from precipitation minus natural evapotranspiration by plants, and calculated run-off volumes entering the lagoon through the stormwater system. It is basically, the rainwater that soaks into the ground to recharge groundwater. Baseflow enters the lagoon directly through groundwater seepage and indirectly through canals and other tributaries. During the TMDL process, direct runoff was estimated based on rainfall and flow gauge measurements within the watershed (Harper and Baker, 2016). Evapotranspiration is calculated from measured atmospheric moisture derived from MODUS (MOD16) satellite data, a product developed by NASA. Precipitation is based on measured rainfall data. The baseflow contribution is estimated by the following water budget equation:

$$\text{Baseflow} = \text{Precipitation} - \text{Evapotranspiration} - \text{Direct Runoff}$$

The monthly baseflow volume is a function of groundwater input for that specific month in addition to the groundwater storage carried over from the previous month (Harper and Baker, 2016). To better understand source contributions and ground-truth modeling efforts, field-collected groundwater nutrient data are needed. This research collected groundwater data to refine nitrogen load estimates to Turkey Creek, the largest tributary in Brevard County that accumulates and contributes IRL muck.

Nitrogen Cycle

Assessing nitrogen loads from the watershed can be very challenging, because the earth is literally awash in nitrogen. Nitrogen is the most prevalent gas in Earth’s atmosphere and forms the building blocks for prokaryote, plant, and animal cells (amino acids). Living things ingest nitrogen and carbon to grow and release organic nitrogen (ammonia) and carbon (CO_2) as waste during digestion. At death and decay the nitrogen is mineralized to be used by other organic processes, starting the cycle again. During this cycle of life, digestion, death and decay, nitrogen is neither created or destroyed, it simply changes form.

Nitrification occurs when organic nitrogen (ammonia) is oxidized into inorganic forms of nitrogen (nitrate and nitrite). The reaction is driven by bacteria in the aerobic areas of the soil-water interface, the water column, and the root zone of plants. The nitrifier bacteria proliferate in highly porous and aerated soils that are slightly alkaline and have a good balance of ammonium (NH_4) in pore space. If ammonia (NH_3) concentrations are too high in pore space, the conditions actually become toxic and nitrification stops. Unfortunately, laboratory methods do not distinguish between NH_4 and NH_3 and record the total as “ammonia.”

Denitrification occurs when inorganic nitrogen (nitrate and nitrite) is reduced into NO, N_2O, or N_2 gas. This reaction is also bacterially driven but unlike nitrification, it requires anaerobic conditions. Denitrification typically occurs in tightly packed soils with little pore space and high levels of carbon. Wetlands are good places for denitrification to occur. Sand ridges are not!

Plants and other organisms prefer to uptake ammonium (NH_4) instead of nitrate and assimilate it into their tissues. The process of ammonium assimilation immobilizes the nitrogen in the organism, resulting in a temporary nitrogen sink until the organism dies and releases the ammonium back into the soil. The uptake of ammonium by organisms is driven largely by the C:N ratio in the soils and the presence or absence of oxygen. In aerobic conditions, when the C:N ratio is < 25, ammonification occurs, and ammonium (NH_4) and ammonia (NH_3) and carbon dioxide (CO_2) are released into the water column. If the C:N ratio is >25, immobilization occurs, and N is assimilated into microbes where it is measured as part of the total organic nitrogen. This ratio changes to >100 in anaerobic conditions.

Using Isotopes to Understand Nitrogen Dynamics

A better understanding of nitrogen cycles and sources can be accomplished by examining naturally occurring stable N isotopes. Nitrogen occurs in two stable isotopes ^{14}N and the less common ^{15}N isotope. The ratios of these isotopes help clarify N processes as well as fate and transport. Isotopic nitrogen (^{15}N) is a naturally occurring N stable isotope that has one more neutron than the more common form of N, (^{14}N). The ratio of ^{14}N to its isotope ^{15}N is 273:1 in the atmospheric gas N_2, which is used as the standard for comparison (Junk and Svec, 1958). This ratio of ^{15}N:^{14}N differs only slightly in N pools, typically falling within the range of -0.0040 to +0.0060. Isotopic signatures are measured and described as delta values of the isotope ratio (δ X) expressed in parts per thousand ($^0/_{00}$) as calculated with Equation 1, where X is the isotope (^{15}N, ^{18}O, ^{13}C, etc…) and R is the ratio of the isotope to its lighter form ($^{15}N/^{14}N$, $^{18}O/^{16}O$, etc..).

$$\delta X \left({}^{0}/_{00}\right) = \left[(R\ sample / R\ standard) - 1\right] x\ 10^3 \qquad (1)$$

Increasing δX indicates an increase in the heavier isotope (Peterson and Fry, 1987).

Because isotopes have an additional neutron, they react more slowly, require more energy, and are thereby not as reactive as the lighter and more common form. As a result, heavier isotopes accumulate in reaction substrates and solutions, resulting in organics that tend to be enriched in the heavier isotope (high δX). The potential for isotopic enrichment from biogeochemical processes are measured using isotope fractionation values. The following paragraph describes fractionation values for varying N processes that can illuminate N fate and transport through ecosystems.

The process of denitrification has a median isotope fractionation of 1.0185, meaning that when NO_3^- converts to N_2O or N_2 gas, the unreacted NO_3^- in the substrate becomes enriched in δ ^{15}N and the N_2O or N_2 gas produced is depleted by 18.5 $^0/_{00}$ (Bedard-Haughn *et al*., 2003). Ammonia (NH_3) enriched with δ ^{15}N may be the remaining unreacted substrate from either nitrification of NH_3 to NO_3^- (25.0 $^0/_{00}$) or its volatization to NH_3 (24.5 $^0/_{00}$). In contrast, the reactions associated with N_2 fixation to ammonia (1.3 $^0/_{00}$) or ammonification of organics to ammonia (2.5 $^0/_{00}$) are near 0, resulting in little enrichment of the substrate. These naturally occurring bio- and physio-chemical enrichment processes display distinct landscape-scale patterns that vary according to micro-climate, soil moisture, nutrient levels, and soil formation

(Bedard-Haughn *et al*., 2003). In the environment, δ ^{15}N becomes increasingly enriched in organic materials and substrates with active nitrification or volatization processes. This pattern is the opposite of what we would expect if artificially produced fertilizers are applied.

Atmospheric gases and products of atmospheric gases are depleted relative to organic biomass, waste products, and NO_3^- resulting from denitrification. Varying enrichment patterns can be seen in the findings of Showers *et al*. (2007) who found that $\delta^{15}N/ NO_3^-$ varied between natural soil organics (+4 to +7 $^0/_{00}$); commercial fertilizers (near 0 $^0/_{00}$) and septic wastes (+8 to +10 $^0/_{00}$). The challenge of using isotopes to understand nutrient dynamics is to consider the naturally occurring enrichment patterns along with the isotopic patterns expected from different human sources of nitrogen. Examining the patterns of enrichment and depletion in substrates and products over time and space can be used to link nutrient sources and sinks throughout the system.

Nitrogen stable isotope studies have been used successfully to clarify nitrification processes in forest regrowth after disturbance and soil/water N interactions (Compton *et al*., 2007); to identify groundwater and surface water N sources (McClelland *et al*., 1997; Showers *et al*., 2007; Bowen and Valiela, 2008); and to estimate appropriate fertilizer application rates (Quinones *et al*., 2007). Some studies focus at the large scale, examining the naturally occurring variations in landscape δ^{15}N. This requires a thorough understanding of the isotopic signatures of N input and outputs, the effects of N transformative processes, and the compartmentalization of N within the system (Hogberg, 1997).

Study Design

This project tests a modeling and field research method to evaluate the extent that human waste is contributing nitrogen and other contaminants to groundwater. We utilize an existing simplified groundwater nutrient transport model (ArcGIS-Based Nitrate Load Estimation Toolkit or ArcNLET) to predict the potential contribution and collect field groundwater samples to verify the model predictions and anomalies. The goal is to measure the groundwater contribution of nutrient pollutant loads to the Indian River Lagoon from wastewater sources.

We collect monthly groundwater samples to measure nitrogen concentrations and changes over time and to look for other indicators of wastewater such as bacteria and phosphorus. To understand the source (organic nitrogen like ammonia or inorganic nitrate/nitrite) and the likelihood for nitrification or denitrification, we are also examining isotopic signatures of δ^{15}N and δ^{18}O in nitrate. We collected soil samples to assess the potential for nitrogen immobilization versus ammonification. The groundwater nitrogen concentrations were used to verify the predictions of the ArcNLET model that may be integrated into a lagoon-wide loading model. Even though previous baseflow volumes were estimated and calibrated with flow data, very little groundwater concentrations data were available to estimate loading concentrations.

Our study takes place in four sites located along Turkey Creek, a tributary that leads to the IRL. The study sites were selected based on their ecological and land use characteristics to hold constant as many confounding influences as possible. Existing environmental data were collected including surface and groundwater quality, rainfall, groundwater elevations, septic tank locations, and soil data. Based on the analysis, four study sites were selected, three that receive different wastewater treatment systems (septic, sanitary sewer, and reclaimed water) and a natural area. The project installed permanent wells to understand groundwater levels, flows, hydraulic head, and nitrogen and bacteria concentrations to inform nitrogen loading models. This project is a pilot study that does not represent all the possible conditions for wastewater and groundwater interaction that can influence groundwater concentrations. It must be replicated throughout Brevard County in a variety of soil, topography, and groundwater scenarios to better understand polluting potential.

The project was initially budgeted for one year to conduct six sampling events of eight wells (48 samples) but was extended with additional funding and time to install three more wells and conduct four more sampling events (44 samples) for a total of 92 samples and 5 blanks collected over ten monthly sampling events. Additionally, the cost for sampling and analysis of fecal coliforms was added to the scope. The 11 wells installed through this project will continue to be sampled and analyzed for an additional 18 months with funding from other state and local sources. The results will help refine pollutant load models used to prioritize and evaluate projects and to understand differences in groundwater pollution in different residential communities.

Approach

Site Selection

Available spatial data layers for soils, land elevation, land use, and infrastructure were collected, mapped, and analyzed as part of the site selection process (Figure 1a). Thereafter, potential treatment areas were considered based on their proximity to the lagoon and their land use, date of construction, soil type, and wastewater treatment infrastructure (Figure 1b). Each of the residential communities had a different wastewater treatment method. In one community, houses were using on-site sewage treatment and disposal systems (septic tanks) to treat wastewater. The second community had sanitary sewer lines to transfer household wastewater through the sewer system to a wastewater treatment plant (central sewer). The third community had a similar sanitary sewer line and additionally received reclaimed, treated wastewater for irrigation. A matrix of variables was created to compare the potential study sites (Table 2). Development age varied between the reuse community and the other two, a manifestation of improved wastewater treatment and the advancement of reuse lines to new communities. Two study sites were considered for each of the treatments and a natural area was identified to use as a control. One site was selected for each treatment after meeting with the residential managers and conducting site visits to assess access, terrain, density, and participation potential (Figure

1b). It should be noted that both phases of the reclaimed community (Sandy Pines) were selected, representing a single subdivision that is homogenous in age, soil type and density Together, Phases 1 and 2 of Sandy Pines have a similar size to the selected sewered and septic communities. The final neighborhoods listed in Table 2 include Turkey Creek Sanctuary, Sandy Pines Phase 1/2, Port Malabar Unit 43, and Turkey River Estates.

Table 2. Study area comparison matrix. Areas chosen for this study are bolded and italicized. A combination of Phases 1 and 2 for Sandy Pines were selected for the reclaimed community, since these were homogenous in nature and accessible using one central gate.

Treatment Type	**Control**	**Reuse/Sewer**		**Sewer**		**Septic**	
Area Name	***Turkey Creek Sanctuary***	***Sandy Pines Phase 1***	***Sandy Pines Phase 2***	***Pt Malabar Unit 43***	Pt Malabar Unit 4, 15-23	***Turkey River Estates***	Fairhaven
Community Age (range)	N/A	1998 - 2002	1999 - 2003	1969 - 2003	1961 - 2000	1945 - 2007	1959 - 2009
Community Age (mean)	N/A	1999	2001	1975	1971	1978	1980
Total Area (acres)	88.5	24.7	15.4	32.5	71.2	42	26.4
Number Parcels	N/A	98	68	93	135	138	116
Density (#/acre)	N/A	3.97	4.42	2.86	1.90	3.29	4.39
Soil types (description)	Anclote, St. Lucie, Paola, Satellite	Anclote, Pomello, St. Lucie	Anclote, Pomello, St. Lucie, Paola	Pomello, Paola	Anclote, Myakka, Pomello	Myakka, Paola, Pomello	Myakka, Pomello, St. Lucie
Soil type (mean % organic)	1.5	1.9	2.5	0.6	3.2	0.9	1.1
Soil type (hydrologic group)	A/D, A, A, A	A/D, A, A	A/D, A, A, A	A, A	A/D, B/D, A	B/D, A, A	B/D, A, A

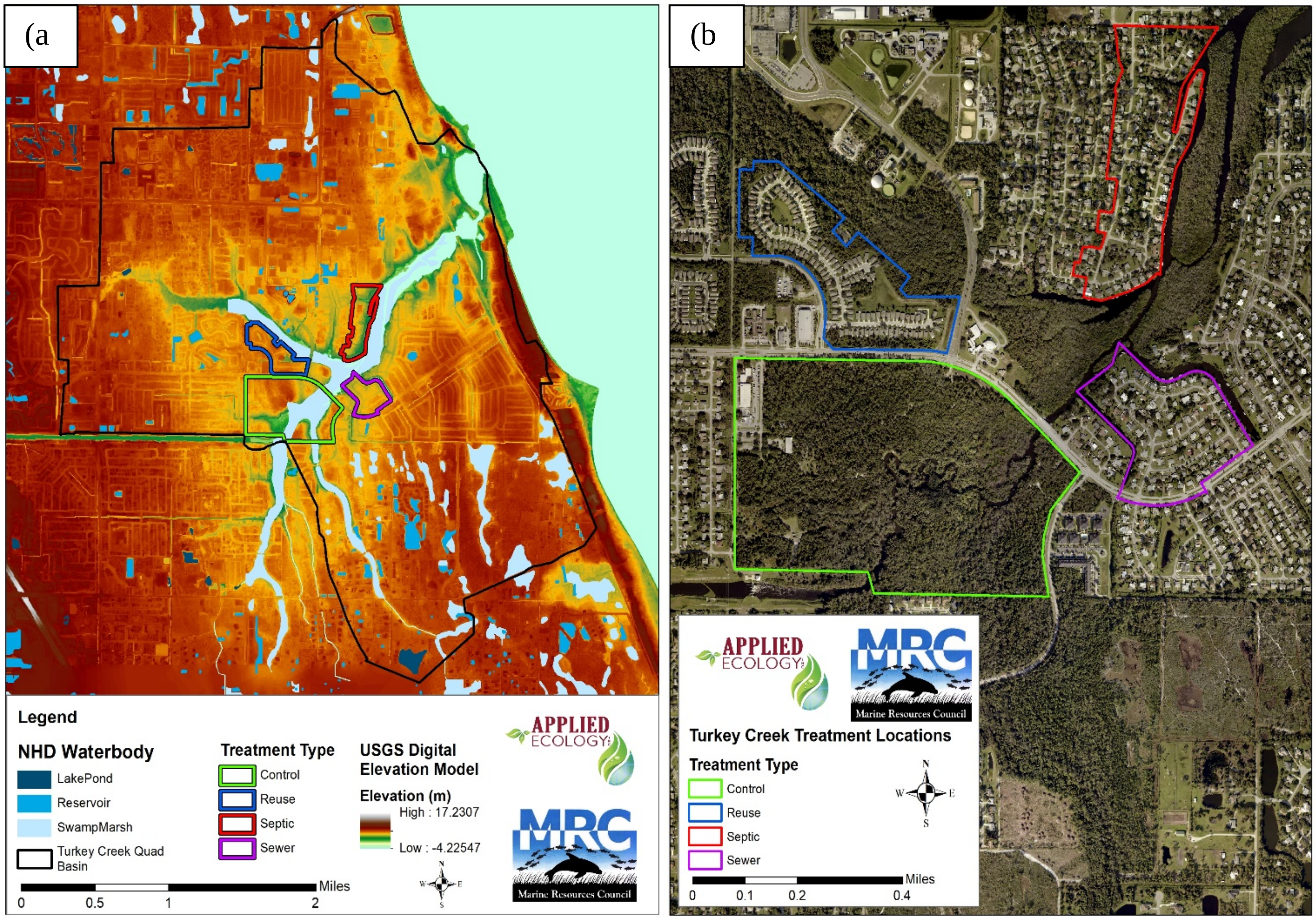


Figure 1: (a) Project area land elevation and (b) Location of the three treatment areas and the control natural area. Polygon colors correspond with treatment colors in Table 2.

Preliminary Groundwater Modeling for Well Siting

Once the communities were identified, data from existing monitoring wells (mostly from the FDEP Petroleum Cleanup Program) were collected and mapped to verify groundwater elevations and inform historical groundwater nutrient concentrations (Figure 2). Historic information, when available, provide guidelines to initiate groundwater modeling for siting well placement.

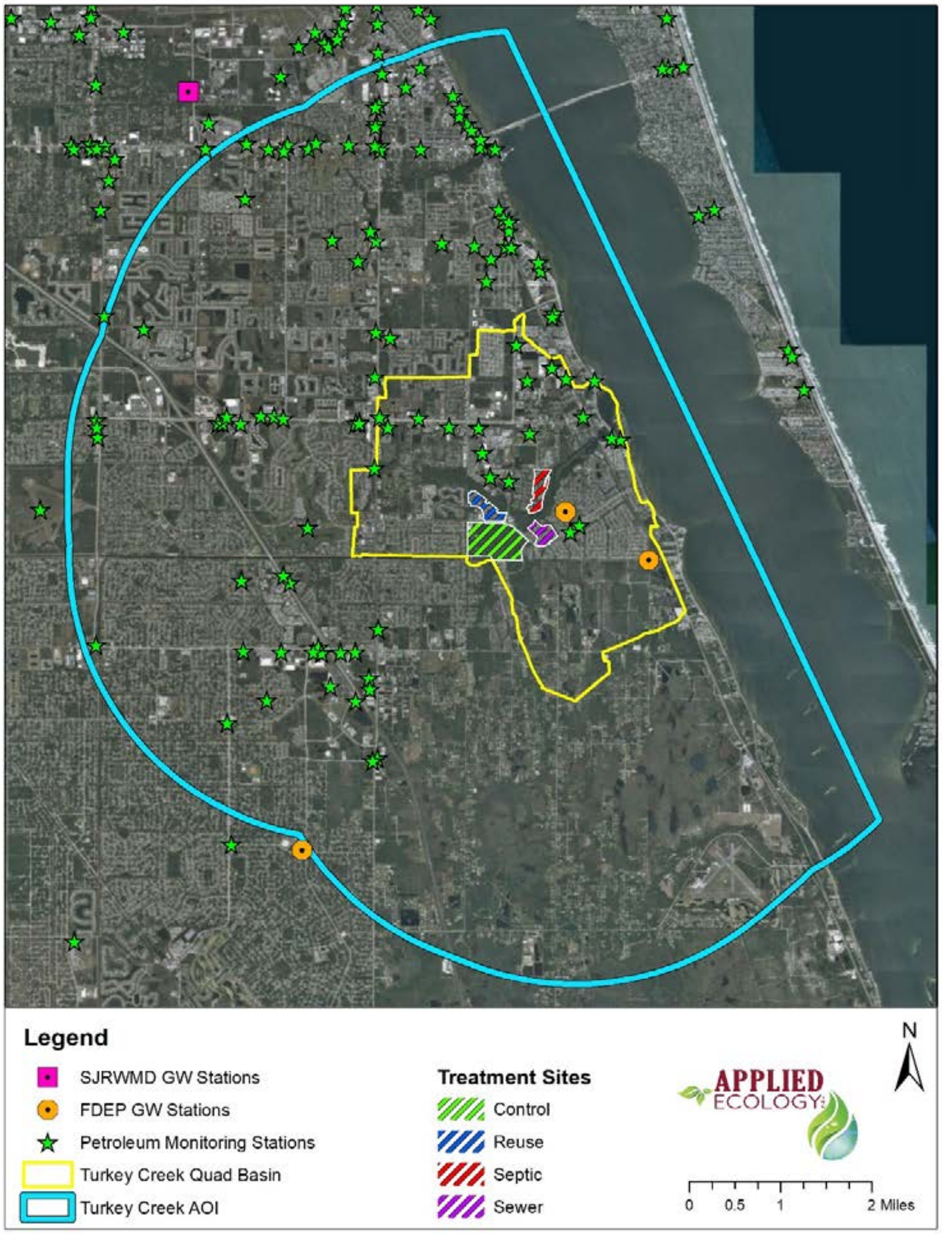


Figure 2: Turkey Creek Model Area of Interest (AOI typically includes 2x the project area for modeling input preparation and calibration purposes), project area (Turkey Creek Quad Basin), and four study areas delineated with existing wells plotted (green stars).

The ArcNLET model was used in this study to estimate nitrate and ammonia plumes in groundwater from the septic tank locations within the study area. ArcNLET (ArcGIS-based Nitrate Load Estimation Toolkit) is a simplified conceptual model of groundwater flow and solute transport developed by Rios, Ye, Wand, and Lee (2011) with joint support from the Florida Department of Environmental Protection (FDEP) and Institute for Energy Systems, Economics and Sustainability (IESES). ArcNLET was originally designed to estimate nitrate loads to surface water bodies from onsite sewage disposal systems, and it was updated to simulate ammonia, critical to better understanding total nitrogen loading to surface water bodies (Zhu *et al*., 2016), particularly in areas such as the Turkey Creek basin with a shallow water table. ArcNLET was selected due to a couple of reasons: 1) it is a relatively simple model that required limited input data but still incorporates key hydrogeological processes of groundwater flow and nutrient transport as well as spatial variability and 2) it is the model currently accepted by the FDEP to receive BMAP credit for removing or retrofitting septic tanks within a watershed with a Total Maximum Daily Load (TMDL). This model does have several limitations including treating the water table as a subdued replica of topography and representing groundwater flow in 2-D and in a steady-state. Other important limitations for the nutrient transport component of this model include the need for an empirical or preferentially a calibrated value for the decay coefficient. Overall, the ArcNLET model requires several model parameters that are largely unknown (see parameters below with an asterisk) and likely site-specific. Model calibration using onsite values for hydraulic head and nitrate and ammonium concentrations are key to providing realistic results.

Typical input datasets for the ArcNLET model include the following (* are largely unknown parameters that require site-specific data for calibration):

- Locations of water bodies
- Locations of septic tanks
- Topography (typically as a Digital Elevation Model or DEM) processed to obtain the water table
- Hydraulic conductivity (processed from the SSURGO soils)
- Porosity (processed from the SSURGO soils) –
- Dispersivity*
- Decay coefficient of denitrification*
- Source load and concentration*

ArcNLET was actually used at different stages during this project: during well siting (preliminary runs) and post data collection (final pre and post-calibration runs). Before any groundwater sampling took place, a series of preliminary runs of the ArcNLET model were conducted, using minimal calibration data from historic data, with the goal of guiding well placement within the selected communities. Initial calibration of the nutrient transport model was challenging due to a lack of existing monitoring wells and nutrient data in the model area.

Groundwater path velocity and direction are easy to interpret by visualizing predicted nutrient plumes provided as output by this model.

For this preliminary modeling effort, the model area of interest (or AOI) was defined as double the size of the project area (excluding the barrier island) to ensure septic tanks outside of the communities of interest would not interfere with placement of wells of other treatment types. Existing monitoring wells within the defined model area were identified, and dozens of documents were downloaded, cataloged, and assessed to compile groundwater elevation and nutrient concentration data. A total of 58 facilities, with 1-20 wells each, were documented, the majority of which had information that could be used to calibrate the hydraulic head estimates in the model. Very few wells had nutrient concentration information in the form of nitrate/nitrite or ammonia. Table 3 includes the summary statistics for the limited wells with nutrient information. Table 4 includes depth to water data for the wells in the model area for the Period of Record (POR). Maps of these two variables based on historic data across the model extent are provided as Figure 3 (Depth to Water or DTW) and Figure 4 (nitrate-nitrate and ammonia concentrations).

Table 3. Summary information for the nutrient information for wells within the Area of Influence (mg/L). Results with no data available are denoted with "ND" and colored with gray text.

Facility ID	POR Range	N	NO3				NH3				TKN			
			Mean	Median	25P	75P	Mean	Median	25P	75P	Mean	Median	25P	75P
8501149	9/6/91 - 6/21/16	2	0.82	0.03	0.03	1.21	ND	ND	ND	ND	ND	ND	ND	ND
8518473	5/13/99 - 11/14/11	11	0.41	0.41	0.38	0.44	ND	ND	ND	ND	ND	ND	ND	ND
8521069	8/16/16 - 8/17/16	8	0.68	0.05	0.04	0.26	ND	ND	ND	ND	ND	ND	ND	ND
9803320	2/19/08 - 9/9/15	58	0.26	0.09	0.04	0.39	ND	ND	ND	ND	ND	ND	ND	ND
8501344	2/25/91 - 11/28/16	14	ND	ND	ND	ND	0.97	0.29	0.17	0.29	ND	ND	ND	ND
8627736	10/27/2015	1	1.06	1.10	0.16	2.00	ND	ND	ND	ND	ND	ND	ND	ND
BR0770	12/11/2014	1	0.00	0.00	0.00	0.00	0.60	0.60	0.60	0.60	ND	ND	ND	ND
BR0774	9/28/2011	1	0.00	0.00	0.00	0.00	0.33	0.33	0.33	0.33	0.46	0.46	0.46	0.46

Table 4: Summary information for the depth to water (DTW) for all the wells within the Area of Influence

Facility ID	POR (Broadcast range)	Max_DTW	Minimum_DTW	Mean_DTW	Median_DTW	25P_DTW	75P_DTW
8500925	9/1/87 - 7/13/11	9.15	1.15		5.15		
8501267	12/10/92 - 9/29/16	9.97	0.50		5.24		
8501269	3/16/16 - 12/12/16	9.64	8.19		8.92		
8501322	3/1/90 - 4/17/13	10.45	2.84		6.65		
8501059	5/16/94 - 12/8/16	15.59	12.72		14.16		
8501110	5/25/93 - 11/8/16	7.84	3.71		5.78		
8501176	4/30/93 - 1/19/95	8.00	2.34		5.17		
8501187	4/15/91 - 9/24/93	6.32	4.40		5.36		
8518311	3/30/93 - 12/26/16	9.00	2.20		5.60		
8518407	7/22/93 - 12/14/16	9.09	1.41		5.25		
8518387	11/4/94 - 7/12/07	9.17	2.85		6.01		
8501344	2/25/91 - 11/28/16	8.06	0.95		4.51		
8501388	5/8/03 - 1/27/10	8.70	2.66		5.68		
8501399	8/11/16 - 11/22/16	2.95	2.01		2.48		
8501149	9/6/91 - 7/19/16	6.95	1.75		4.35		
8501152	8/19/93 - 7/16/13	7.04	1.02		4.03		
8622708	11/16/98 - 5/25/12	5.28	2.00		3.64		
8622712	12/12/91 - 2/1/09	13.74	2.71		8.23		
8626200	3/1/91 - 3/16/11	3.77	2.24		3.01		
8518473	5/22/92 - 4/11/16	8.24	0.08		4.16		
8521069	3/9/94 - 6/30/16	10.45	0.50		5.48		
8735250	4/21/98 - 4/20/16	7.78	3.20		5.49		
8838109	11/8/93 - 2/23/95	7.01	1.65		4.33		
8839126	10/11/94 - 12/5/16	5.37	0.75		3.06		
8840685	3/10/93 - 11/21/16	10.00	3.64		6.82		
8736376	9/30/2003	2.27	2.54		2.41		
9101595	4/30/92 - 6/10/92	6.54	5.90		6.22		
9300243	7/22/04 - 7/26/06	7.96	3.21		5.59		
8841164	6/16/88 - 5/11/91	5.00	2.20		3.60		
8944717	4/4/07 - 1/8/14	4.59	0.11		2.35		
9046729	1/25/96 - 2/8/96	9.21	6.15		7.68		
9804192	2/15/08 - 9/28/16	12.18	2.44		7.31		
9806646	10/2/11 - 4/1/16	9.02	3.03		6.03		
8944592	5/27/93 - 11/26/07	7.68	1.09		4.39		
9502996	3/3/04 - 1/28/10	7.85	2.44		5.15		
9801146	2/17/04 - 2/1/11	8.13	4.58		6.36		
9801561	9/9/2010	6.70	6.70		6.70		
9801645	1/28/09 - 4/7/10	6.88	2.73		4.81		
9803320	10/4/07 - 6/28/16	8.40	1.50		4.95		
8501023	5/28/92 - 2/18/16			12.05	13.35	11.96	14.54
8501141	1/8/92 - 7/8/14			3.77	3.64	2.78	4.74
8518323	7/28/94 - 12/29/05			20.25	20.39	19.80	21.14
8518288	8/21/90 - 2/17/09			5.21	5.30	4.12	6.19
8518413	8/15/2016			22.65	24.31	19.70	25.32
8518492	5/8/91 - 1/13/16			4.56	4.32	3.73	5.16
8519518	5/23/90 - 6/26/90			2.23	2.15	2.08	2.30
8622210	10/26/90 - 11/2/90			2.35	2.38	2.10	2.60
8627736	8/13/99 - 10/25/16			4.61	4.48	3.94	5.09
8943133	8/20/91 - 7/26/16			5.34	5.24	4.85	5.55

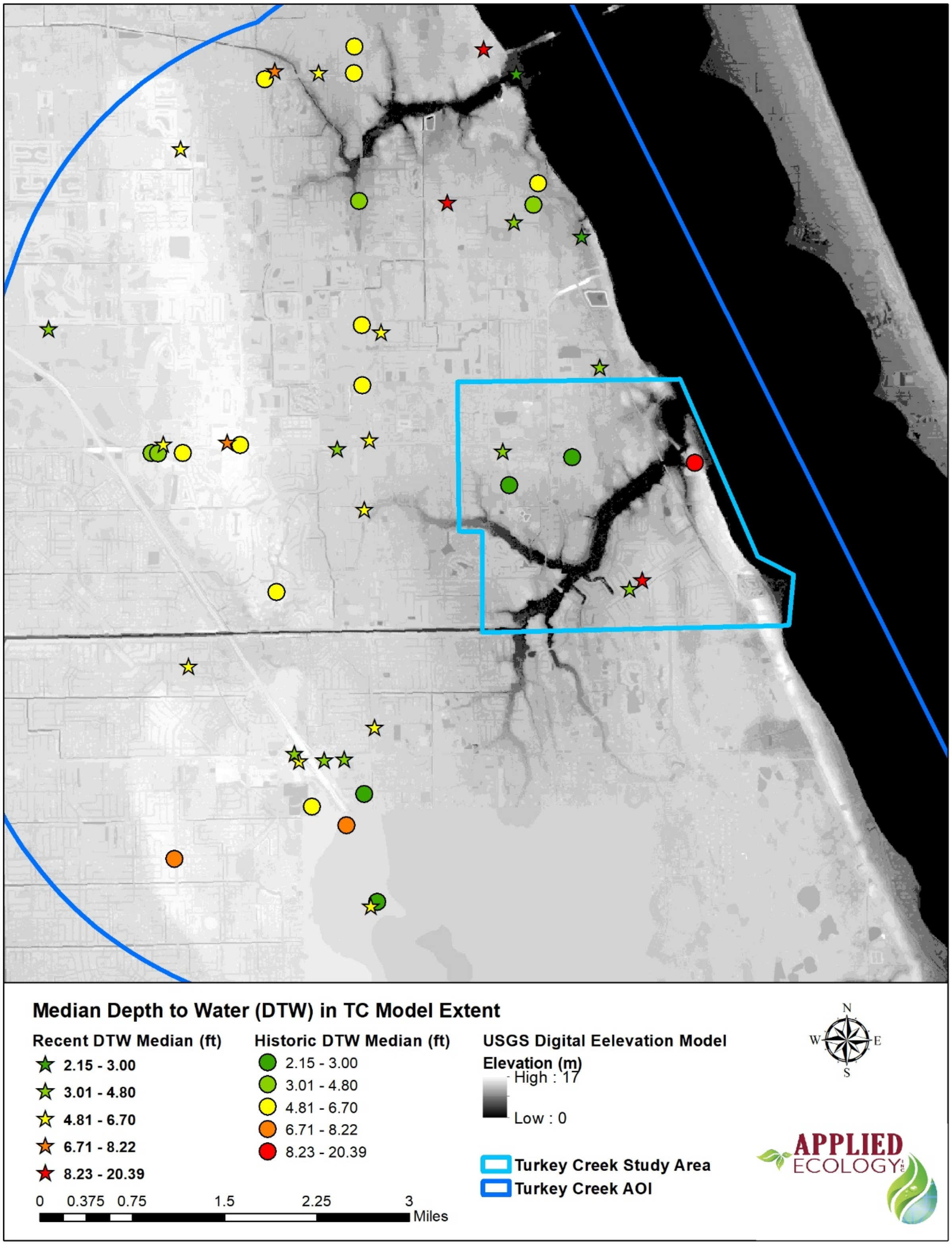


Figure 3: Median depth-to-water based on the period-of-record for existing wells within the model area.

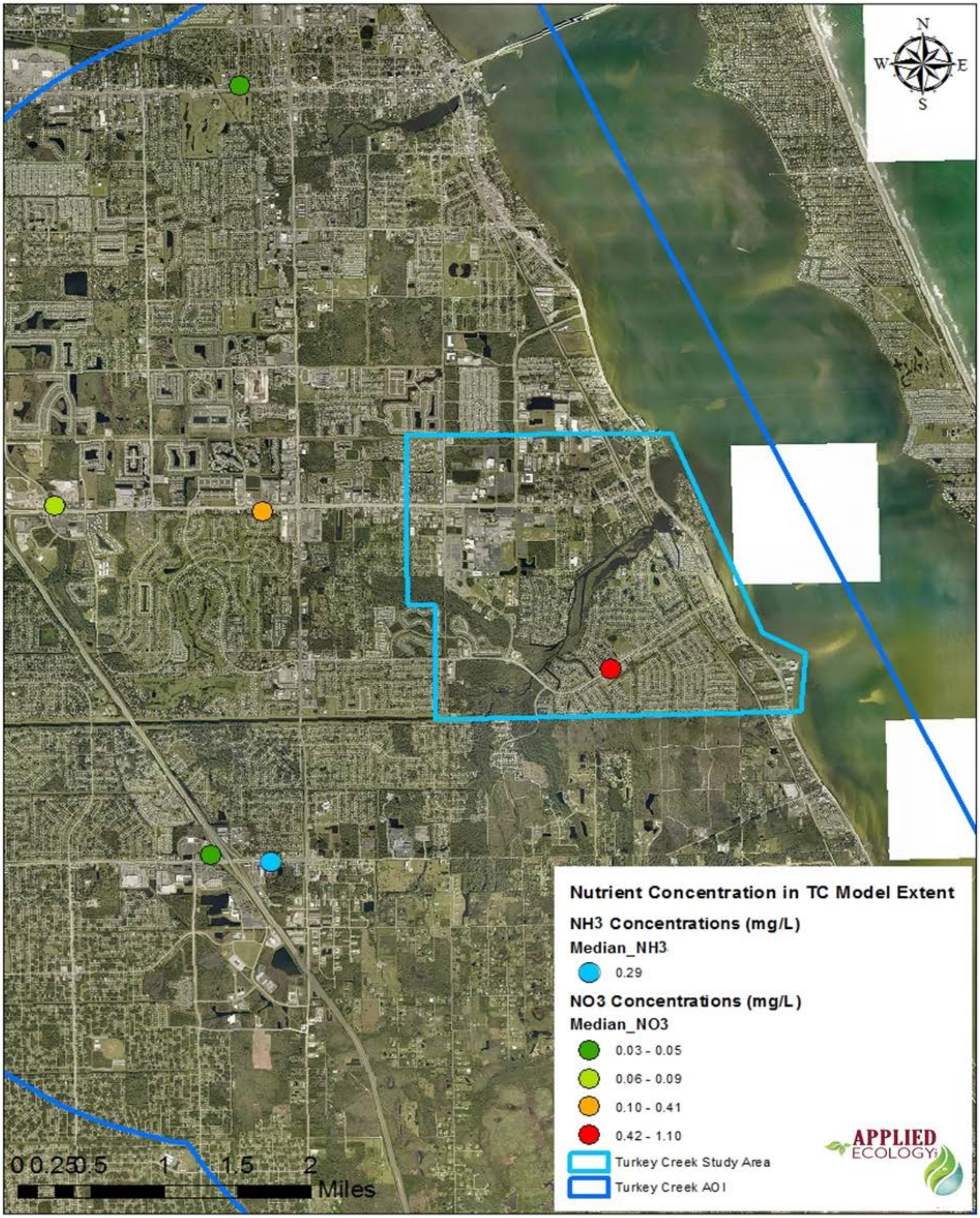


Figure 4: Median nitrate/nitrite and ammonia concentration for existing wells within the model area. White boxes indicate absent imagery.

As part of this initial modeling effort, locations of onsite sewage treatment and disposal system (OSTDS) were received from Brevard County and mapped for the City of Melbourne area within the expanded model study area. With the additional data, the revised expanded model area included 9,697 septic tanks. The ArcNLET model was unable to run the transport model with the high number of septic tanks. After several testing phases, it appeared that the ArcNLET maximum capacity is less than 2,000 septic tanks per run (limitations are based on the 2 GB memory limit of the ArcGIS Desktop software). This limitation was addressed by programming a custom tool to subset the data, integrate model runs in portions of <2,000 tanks/area, and combine the results into a seamless output. Groundwater flow was calibrated for the expanded model area using median and mean DTW values from 47 wells across the expanded model area. Different smoothing factors were tested and data compared to the median, mean, 25% and 75% percentile distribution if available. The smoothing factor of 20 was selected as the best fit for the expanded model area.

Typical model outputs from the ArcNLET model include total nitrate and ammonia loading to each surface water body, as well as a graphical representation of nutrient plumes (Figure 5 and Figure 6) which provide the directionality of the plume and magnitude of predicted ammonia and nitrate concentrations from the source (OSTDS) to the receiving waterbody. The preliminary model run predicted that 90% of the nitrogen loads to Turkey Creek from the septic areas is in the form of ammonia and not nitrate due to the shallow water table and insufficient time for complete nitrification to occur. Subsequent model runs post-calibration with site specific groundwater monitoring datasets drastically changed the ratio and total magnitude of predicted nitrate and ammonia total loading to Turkey Creek.

Areas with greatest potential likelihood of intercepting nutrient plumes downstream from the septic drainfields were selected for well placements. Well placement for this study was in line with the goal of providing representative groundwater datasets of the entire community and not simply highlight the impact of one OSTDS to the local groundwater quality and subsequently Turkey Creek. Well installations were dependent on successful recruitment of private homeowners and practical limitations due to accessibility. The green circles in Figure 6 represent the proposed locations of the groundwater monitoring wells overlaid on the initial prediction of ammonia plumes from OSTDS in the septic community.

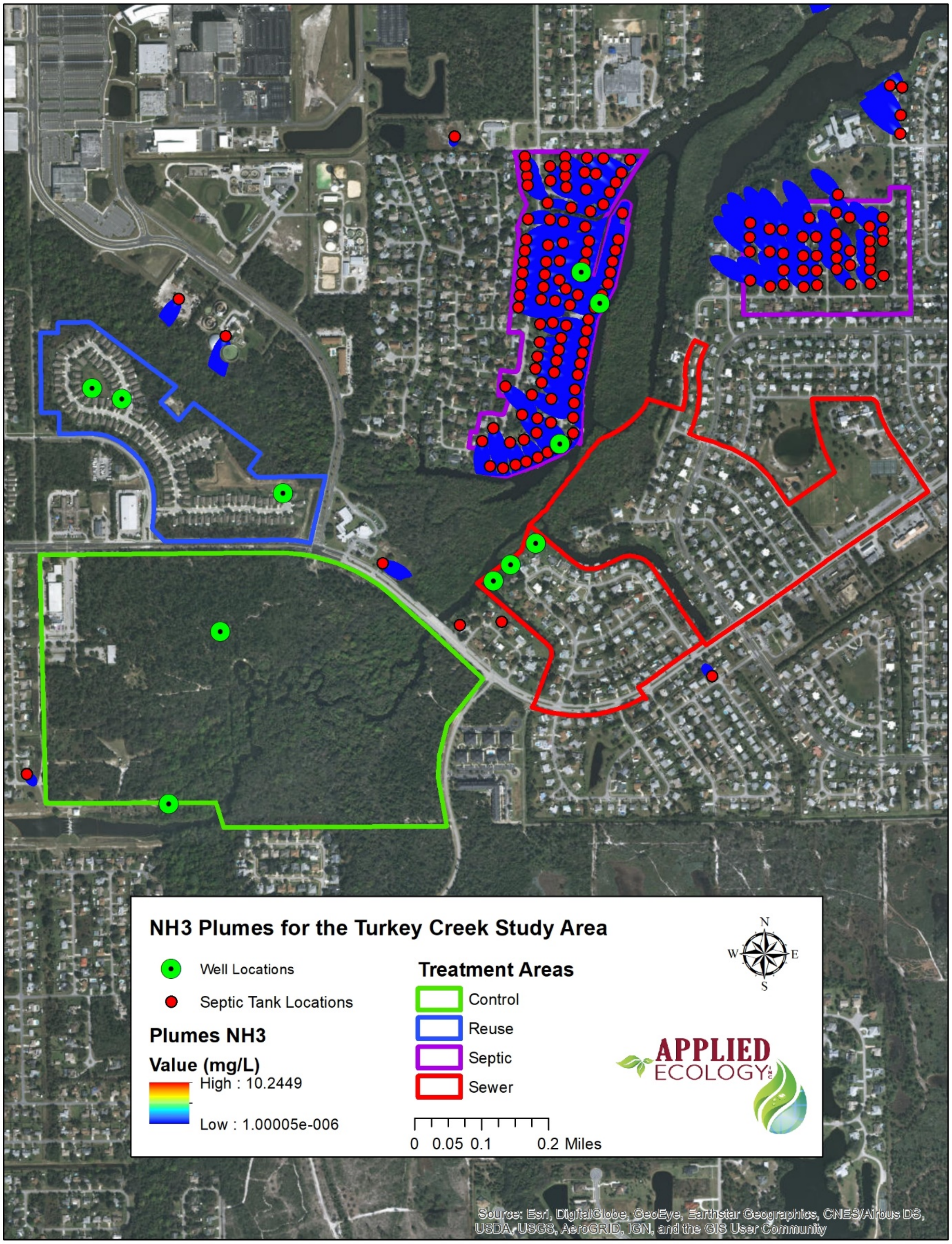
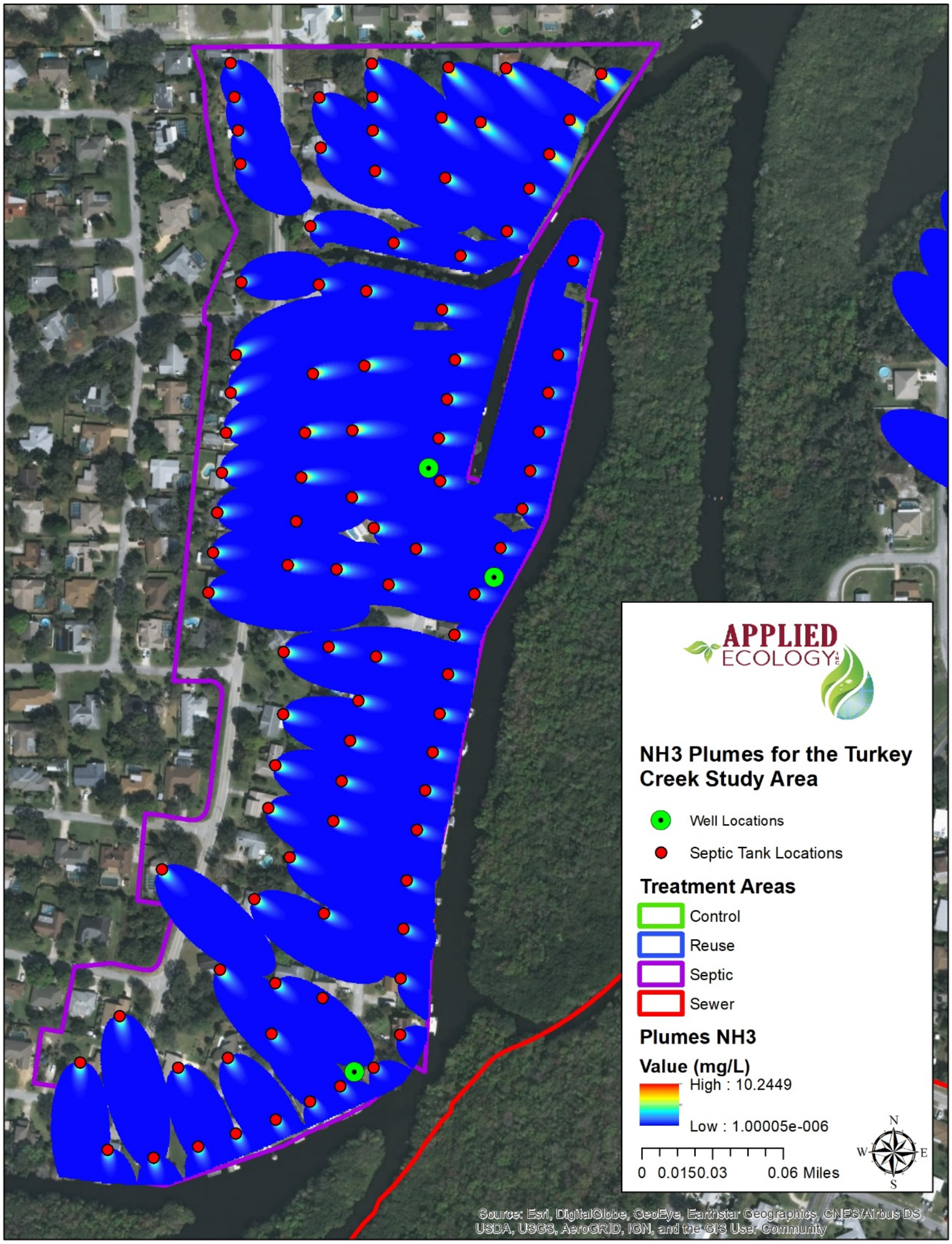


Figure 5: ArcNLET preliminary model output (prior to calibration with site specific project collected groundwater data) of ammonia plumes in the septic tank areas.



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 6: ArcNLET modeled ammonia plumes in the Highland Shores septic tank study area showing plumes extending to Turkey Creek from the septic tank locations in the front yards

Well Installation

Well installation and sampling required access to private property. Property owners were recruited to participate in the research through a variety of methods. Hundreds of letters were mailed to residents living in the select study communities announcing the study objectives and requesting volunteers. Based on previously described modeling efforts, some high priority sites were identified and focused on for recruitment. In these cases, researchers went door-to-door at select houses to recruit them for the study based on their location and suitability. Site visits were conducted to confirm equipment accessibility and well placement. Participants signed an Access Agreement authorizing researchers to use their property for the research, waiving their liability, and clarifying contact information and sampling communications (Appendix A). The rules of human subject research require that the participating property owners remain anonymous and that data collected remain confidential to the greatest extent possible. As such, monitoring sites are referred to by site ID# throughout the project.

Initially, two wells were installed in each of the four study areas over June 12-13, 2017, for a total of eight wells. With a contract amendment and additional resources, three additional wells were installed on December 15, 2017, one in each treatment area: sewer, sewer with reclaimed (reuse), and septic areas for a total of eleven wells. Completion logs for installation of all wells are provided in Appendix B. A hydraulic geoprobe was used for installation (Figure 7a).

Soil cores were collected to characterize soil types and estimate groundwater depths (Figure 7b). A composite sample of soils was collected by grabbing a spoon from each soil type within the core. The soils were than sieved and combusted to better understand carbon content and porosity. Results presented in Table 5 indicate that none of the soils have much organic content. The highest organic content recorded (2.35%) was in the control well (TC2), followed by the sewered community (1.04 % and 2.51%). All remaining soil bores contained < 1% organic matter, suggesting that ammonia mineralization and immobilization into microbes is unlikely to occur and that for the most part, organic decomposition will result in the emission of NH_3 and NH_4 and CO_2. Soil lab results are included in Appendix C.

After the soils were collected, a hollow core was pushed to a depth that would allow at least 10 feet of well screen to intercept the water table. The screen interval represents the depth below surface that the screened portion of the well is located. Each well consisted of a 10-ft long 1.5-inch diameter pre-screened and sand packed well casing, followed by solid well riser to the surface. Sand (30/65 grain-size) was used to back-fill the bore hole around the well, and each well was grouted and flush-finished with a locking well cap and a concrete pad (Figure 7c). All wells were pumped until the water reached consistent temperature, DO, and turbidity levels. Well construction details are summarized in Table 6 and a map of well locations is in Figure 8. Screen interval and depth to water (DTW) are measured in feet which is the standard unit of measurement used in the well installation logs.

Table 5: Well boring soil characterization (%)

Location	**Well ID**	**Carbonate**	**Organics**
Reuse 1	MW RE2456	0.28	0.36
Reuse 2	MW REC	0.43	0.50
Sewer 1	MW SE841	1.57	1.04
Sewer 2	SE 849	1.35	2.51
Septic 1	MW SP1099	0.28	0.46
Septic 2	MW SP1127	0.22	0.83
Natural 1	MW TC-1	0.40	0.90
Natural 2	MW TC2	2.90	2.35

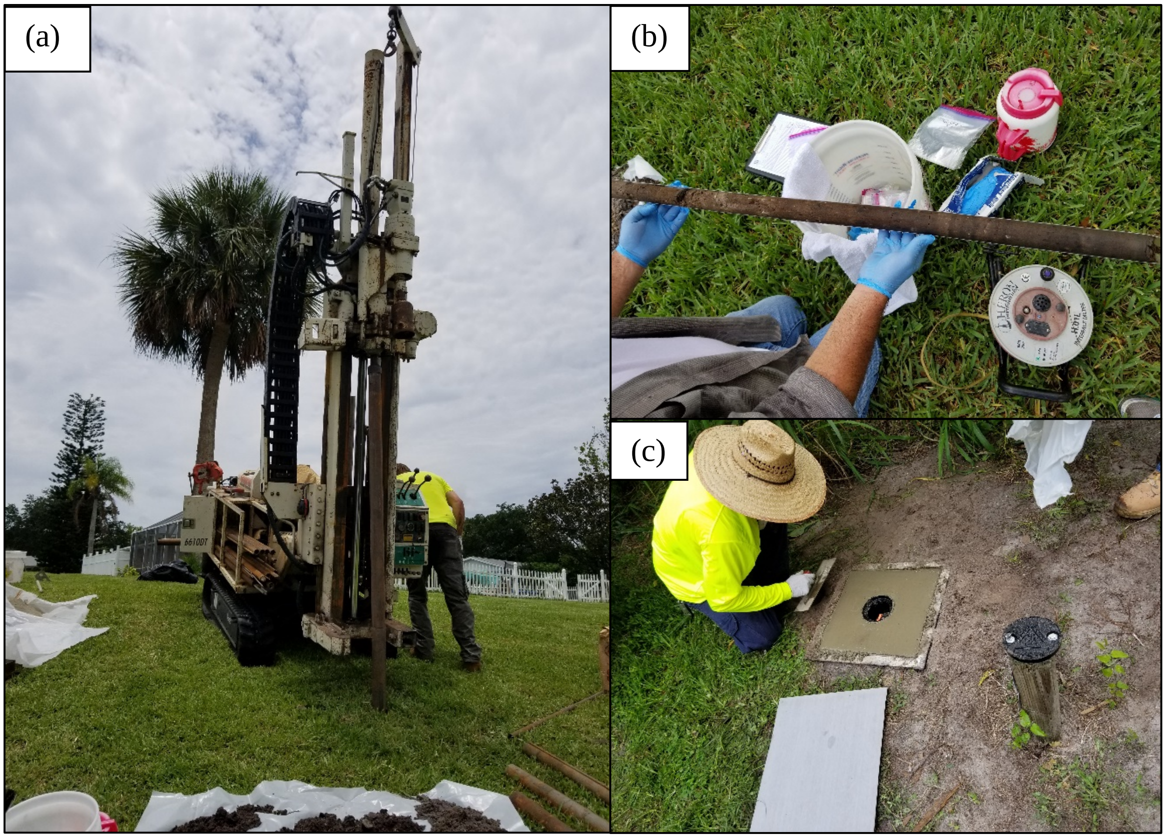


Figure 7: (a) Geoprobe installing well, (b) soil core, and (c) finished well pad.

Table 6: Well installation details.

Well ID	**Screen Interval (ft)**	**Depth to Water (ft)**	**Installation Date**
RE2456	8-18	11.7	6/13/2017
REC	13.6-23.6	17.9	6/13/2017
REC 2	10-20	14.8	12/15/17
SE841	8-18	11.4	6/12/2017
SE 845	12-22	12.8	12/15/17
SE849	8.5-18.5	10.6	6/12/2017
SP981	1-11	7.4	12/15/17
SP1099	2-12	3.25	6/12/2017
SP1127	2-12	3.9	6/12/2017
TC1	14-24	22	6/13/2017
TC2	8-18	12.6	6/13/2017

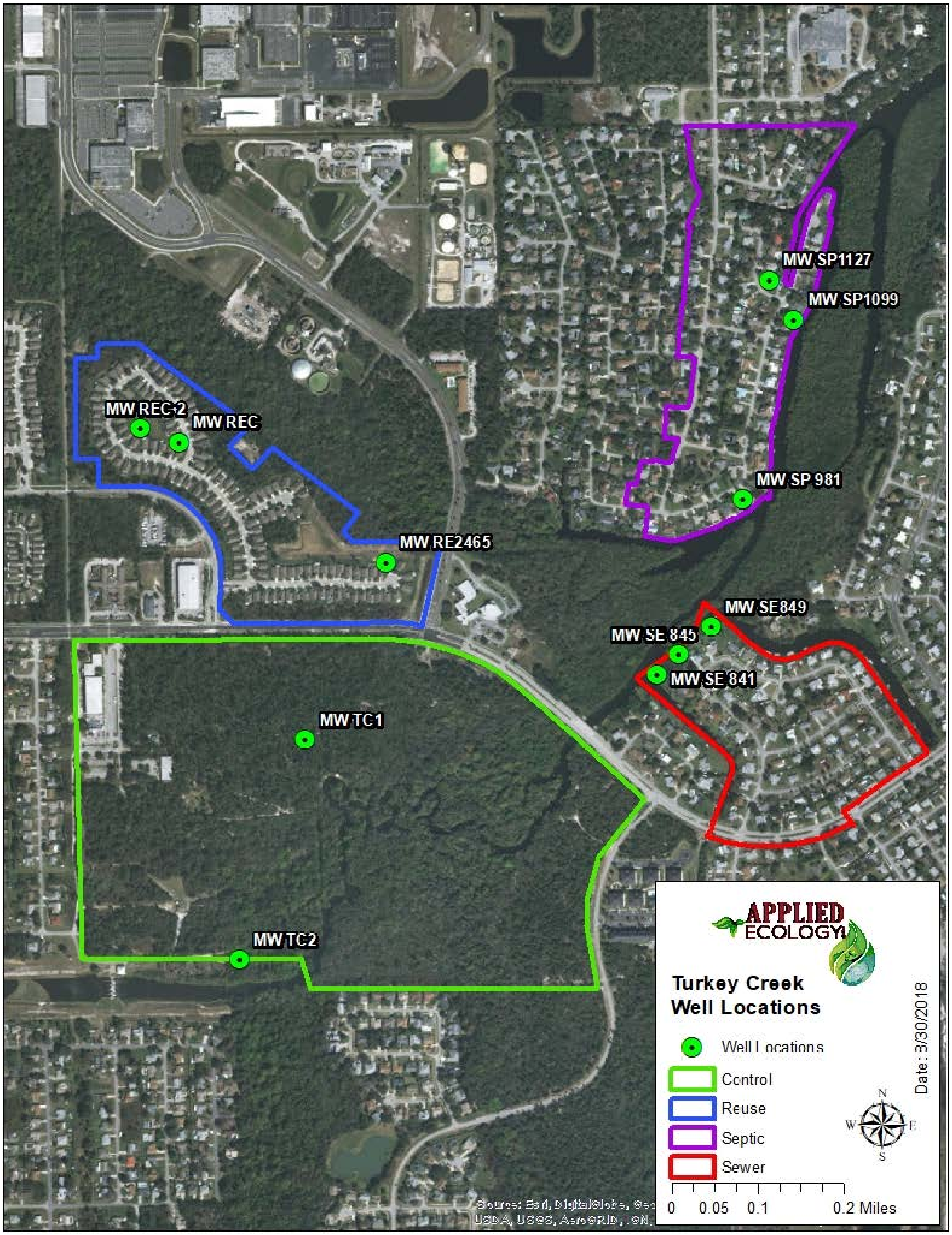


Figure 8: Monitoring well locations.

Sampling Method

A total of 92 samples was collected. Eighty samples were collected over ten monthly sampling events (June 2017 through March 2018) from the eight originally installed wells. Twelve more samples were collected from the three new wells over the last four sampling events (December 2017 through March 2018). All sampling was conducted in accordance with FDEP-SOP-001/01; FS2200 Groundwater Sampling. Samples were collected after well purging was complete as confirmed by three consecutive measurements within the limits stated below:

Temperature:	± 0.2° C
pH:	± 0.2 Standard Units
Specific Conductance:	± 5.0% of reading
Dissolved Oxygen:	≤20% Saturation
Turbidity:	≤20 NTU

Groundwater samples were collected immediately after purging was complete. Using a peristaltic pump, a 250 mL aliquot was collected in a sampling bottle containing sulfuric acid to bring the pH < 2. An additional 100 mL aliquot was collected for coliform analysis. Samples were placed on ice and driven directly to a NELAC certified lab to meet the coliform 6-hour hold time. Samples were analyzed for ammonia-N (NH_3-N, mg/L), Nitrate/ Nitrite-N (NO_X-N, mg/L), Total Kjeldahl Nitrogen (TKN, mg/L) and Fecal Coliforms (CFU/100 mL). Total Nitrogen (TN, mg/L) was calculated. A 30 mL aliquot was field filtered through a 0.2-micron filter and frozen in preparation for $\delta^{15}N$ and $\delta^{18}O$ analyses. Samples with a minimum nitrate concentration of 0.12 mg/L were packed in dry ice and shipped to the University of California-Davis isotope lab to be analyzed using the Sigman bacterial method for the $\delta^{15}N$ and $\delta^{18}O$ isotopic analysis (Sigman *et al*., 2001). Pre-cleaned equipment blank samples were collected at a rate of five percent (5%) of each reported test analyte for the duration of the project per FDEP SOP FQ 1000 - Field Quality Control Requirements. Water quality data that passed all the laboratory and data management QA checks were used for final analysis. Table 7 provides a summary of laboratory methods.

Table 7: Laboratory samples and analytical methods.

Parameter	**Samples**	**Equipment Blanks**	**Analytical Method**	**Hold Time**
Total Kjeldahl Nitrogen	92	5	EPA 351.2	28 days
Ammonia	92	5	EPA 350.1	28 days
Nitrate/nitrite	92	5	EPA 353.2	28 days
Fecal coliforms	92	5	SM 9222 D	6 hours
$\delta^{15}N$ – Nitrate	92	5	Sigman *et al*. 2001	28 days
$\delta^{18}O$ – Nitrate	92	5	Sigman *et al*. 2001	28 days

Results

Data reported in this section include per event raw data by well location, as well as visualization and statistical analyses of all sampled analytes by treatment type (septic, sewer, reuse, and control). Since the data were collected as time series, consideration was provided to the potential lack of independence between data collected throughout the ten events. No significant autocorrelation (0.12-0.43) was found between events based on the data from the ten events, so repeated measured analysis (such as repeated measured ANOVA) were not pursued. Consideration of repeated measured analysis will be taken into account again with an expanded study with a longer timeseries and larger sample size.

As expected, all water quality data presented significant deviations to a normal distribution; as such, either logarithmic transformation of the data or non-parametric statistical alternatives, such as Kruskal-Wallis and Mann-Whitney tests were used for comparison of medians among treatment types. The percentage composition of each analyte that makes up total nitrogen is provided and a spatial distribution of median TN over time is provided as a map. Finally, the δ^{15}N and δ^{18}O results are provided in a tabular and graphical format. Blanks and duplicates meet all required EPA standards, with all blank samples having measured concentrations consistently below laboratory minimum detection limits for all analytes.

As expected, all water quality data presented significant deviations to a normal distribution; as such, non-parametric statistical alternatives, such as Kruskal-Wallis and Mann-Whitney tests were used for comparison of medians among treatment types. The percentage composition of each analyte that makes up total nitrogen is provided and a spatial distribution of median TN over time is provided as a map. Finally, the δ^{15}N and δ^{18}O results are provided in a tabular and graphical format. Blanks and duplicates meet all required EPA standards, with all blank samples having measured concentrations consistently below laboratory minimum detection limits for all analytes.

Sampling Event Data

The results for each of the ten (10) sampling events are provided in Tables 8 – 17 including nitrogen, fecal coliforms, and isotopes. Figure 9 provides total monthly rainfall values for the SJRWMD rainfall gauge 01000410, which is located within Palm Bay’s North Regional Utilities Complex, in close proximity to all the monitored areas. It is important to note that this initial study captured June 2017 through March 2018 monthly data with less than one year representing seasonal variability. The wet season of 2017 included extreme wet weather events (Hurricane Irma), with just under 20” of rainfall recorded for the month of September and close to 12” for the month of October. Results from less than one year of sampling should be used cautiously when predicting long-term annual and seasonal patterns.

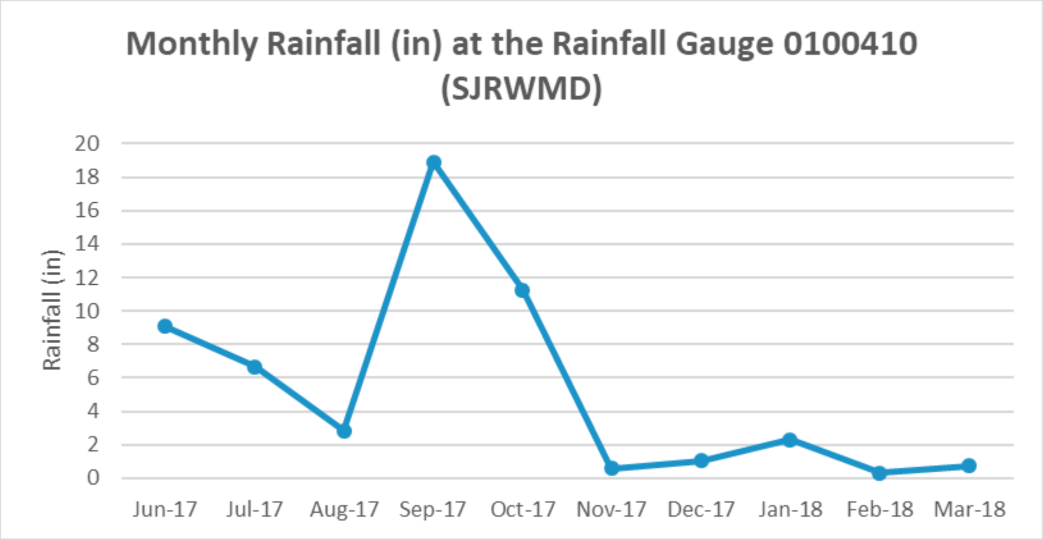


Figure 9. Total monthly rainfall (in) at the rainfall gauge closest to the study sites (SJRWMD gauge 0100410) throughout the duration of the study.

Table 8: Single measurements from the June 15-16, 2017 sampling event per well.

Treatment Area	**Site ID**	Ammonia as N (mg/L)	Nitrate/ Nitrite as N (mg/L)	TKN (mg/L)	TN (mg/L)	Coliform, Fecal (CFU/100 mL)
Control	**MW TC 1**	0.0073 [1]U	0.0340 [2]I	0.0660	0.1000	1.0000 [1]U
	MW TC 2	1.6000	0.0160 [2]I	2.6000	2.6000	50.000
Reuse	**MW RE 2456**	0.0073 [1]U	2.8000	0.4300	3.2000	1.0000 [1]U
	MW RE C	0.0530	12.000	0.4200	12.000	1.0000 [1]U
Septic	**MW SP 1099**	4.3000	2.5000	6.6000	9.1000	80.000
	MW SP 1127	0.0600	4.4000	0.6900	5.1000	3.0000
Sewer	**MW SE 841**	1.4000	0.0950	4.8000	4.9000	100.00
	MW SE 849	4.3000	0.1200	6.3000	6.4000	230.00

[1] "U" qualified values indicate the analytical concentration is below laboratory minimum detection limits (MDLs); vary depending on parameter and sample

[2] "I" qualified values indicates the analytical concentration is greater than or equal to the method detection limit but less than the practical quantitation limit

[3] "B" qualified values are based upon membrane filter colony counts that are outside the method indicated ideal range

[4] "Z" qualified values indicate that too many colonies were present (TNTC); the numeric value represents the estimated colony counts from the highest dilution used in this test; confluent values represent growth of more than the tested coliforms with continuous, indistinguishable colonies

Table 9: Single measurements from the July 13-14, 2017 sampling event per well.

Treatment Area	**Site ID**	Ammonia as N (mg/L)	Nitrate/ Nitrite as N (mg/L)	TKN (mg/L)	TN (mg/L)	Coliform, Fecal (CFU/100 mL)
Control	**MW TC 1**	0.0073 [1]U	0.0290 [2]I	0.0390 [2]I	0.0680	1.0000 [1]U
	MW TC 2	1.2000	0.0160 [1]U	1.8000	1.8000	4.0000 [3]B
Reuse	**MW RE 2456**	0.0073 [1]U	0.1000	0.1900	0.3000	1.0000 [1]U
	MW RE C	0.0210	11.000	0.0370 [1]U	11.000	1.0000 [1]U
Septic	**MW SP 1099**	3.3000	0.0320 [1]U	5.4000	5.4000	2.0000 [3]B
	MW SP 1127	0.0120 [2]I	21.000	1.1000	22.000	1.0000 [1]U
Sewer	**MW SE 841**	1.4000	0.3900	4.3000	4.7000	1.0000 [1]U
	MW SE 849	3.9000	0.2400	5.2000	5.4000	8.0000 [3]B

[1] "U" qualified values indicate the analytical concentration is below laboratory minimum detection limits (MDLs); vary depending on parameter and sample

[2] "I" qualified values indicates the analytical concentration is greater than or equal to the method detection limit but less than the practical quantitation limit

[3] "B" qualified values are based upon membrane filter colony counts that are outside the method indicated ideal range

[4] "Z" qualified values indicate that too many colonies were present (TNTC); the numeric value represents the estimated colony counts from the highest dilution used in this test; confluent values represent growth of more than the tested coliforms with continuous, indistinguishable colonies

Table 10: Single measurements from the August 9 & 14., 2017 sampling event per well.

Treatment Area	**Site ID**	Ammonia as N (mg/L)	Nitrate/ Nitrite as N (mg/L)	TKN (mg/L)	TN (mg/L)	Coliform, Fecal (CFU/100 mL)
Control	**MW TC 1**	0.0073 [1]U	0.0160 [1]U	0.0370 [1]U	0.0330 [1]U	13.000
	MW TC 2	0.6700	0.3900	1.2000	1.6000	1.0000 [1]U
Reuse	**MW RE 2456**	0.0073 [1]U	0.1100	0.0400 [2]*I*	0.1500	1.0000 [1]U
	MW RE C	0.0073 [1]U	15.000	0.0370 [1]U	15.000	1.0000 [1]U
Septic	**MW SP 1099**	4.4000	0.0180 [2]I	5.9000	5.9000	1.0000 [1]U
	MW SP 1127	0.0210	4.9000	0.8900	5.8000	1.0000 [1]U
Sewer	**MW SE 841**	1.7000	0.1800	4.2000	4.3000	1.0000 [1]U
	MW SE 849	4.0000	0.0910	4.8000	4.9000	1.0000 [1]U

[1] "U" qualified values indicate the analytical concentration is below laboratory minimum detection limits (MDLs); vary depending on parameter and sample

[2] "I" qualified values indicates the analytical concentration is greater than or equal to the method detection limit but less than the practical quantitation limit

[3] "B" qualified values are based upon membrane filter colony counts that are outside the method indicated ideal range

[4] "Z" qualified values indicate that too many colonies were present (TNTC); the numeric value represents the estimated colony counts from the highest dilution used in this test; confluent values represent growth of more than the tested coliforms with continuous, indistinguishable colonies

Table 11: Single measurements from the September 20-21, 2017 sampling event per well.

Treatment Area	**Site ID**	Ammonia as N (mg/L)	Nitrate/ Nitrite as N (mg/L)	TKN (mg/L)	TN (mg/L)	Coliform, Fecal (CFU/100 mL)
Control	**MW TC 1**	0.0073 [1]U	3.5000	0.8300	4.4000	4.0000
	MW TC 2	0.0073 [1]U	0.0160 [1]U	0.0400 [2]I	0.0400 [2]I	1.0000 [1]U
Reuse	**MW RE 2456**	0.0073 [1]U	0.0620	0.0630	0.1300	1.0000 [1]U
	MW RE C	0.0073 [1]U	13.000	2.6000	15.000	1.0000 [1]U
Septic	**MW SP 1099**	2.6000	0.0160 [1]U	4.8000	4.8000	2.0000
	MW SP 1127	0.0530	8.1000	1.5000	9.6000	1.0000 [1]U
Sewer	**MW SE 841**	0.6700	2.7000	3.2000	5.9000	3.0000
	MW SE 849	1.8000	0.0680	3.8000	3.8000	5.0000

[1] "U" qualified values indicate the analytical concentration is below laboratory minimum detection limits (MDLs); vary depending on parameter and sample

[2] "I" qualified values indicates the analytical concentration is greater than or equal to the method detection limit but less than the practical quantitation limit

[3] "B" qualified values are based upon membrane filter colony counts that are outside the method indicated ideal range

[4] "Z" qualified values indicate that too many colonies were present (TNTC); the numeric value represents the estimated colony counts from the highest dilution used in this test; confluent values represent growth of more than the tested coliforms with continuous, indistinguishable colonies

Table 12: Single measurements from the October 11-12, 2017 sampling event per well.

Treatment Area	**Site ID**	Ammonia as N (mg/L)	Nitrate/Nitrite as N (mg/L)	TKN (mg/L)	TN (mg/L)	Coliform, Fecal (CFU/100 mL)
Control	**MW TC 1**	0.0073 [1]U	1.6000	0.6000	2.2000	1.0000 [1]U
	MW TC 2	0.0073 [1]U	0.0180 [2]I	0.0930	0.1100	1.0000 [1]U
Reuse	**MW RE 2456**	0.0073 [1]U	0.0580	0.1200	0.1700	1.0000 [1]U
	MW RE C	0.0073 [1]U	7.8000	2.9000	11.000	1.0000 [1]U
Septic	**MW SP 1099**	2.0000	0.0200 [2]I	4.0000	4.1000	13.000
	MW SP 1127	0.0500	0.8200	1.0000	1.9000	400.00
Sewer	**MW SE 841**	0.1500	0.7400	2.5000	3.2000	1.0000 [1]U
	MW SE 849	3.1000	0.1200	4.8000	4.9000	1.0000 [1]U

[1] "U" qualified values indicate the analytical concentration is below laboratory minimum detection limits (MDLs); vary depending on parameter and sample

[2] "I" qualified values indicates the analytical concentration is greater than or equal to the method detection limit but less than the practical quantitation limit

[3] "B" qualified values are based upon membrane filter colony counts that are outside the method indicated ideal range

[4] "Z" qualified values indicate that too many colonies were present (TNTC); the numeric value represents the estimated colony counts from the highest dilution used in this test; confluent values represent growth of more than the tested coliforms with continuous, indistinguishable colonies

Table 13: Single measurements from the November 14-15, 2017 sampling event per well.

Treatment Area	**Site ID**	Ammonia as N (mg/L)	Nitrate/Nitrite as N (mg/L)	TKN (mg/L)	TN (mg/L)	Coliform, Fecal (CFU/100 mL)
Control	**MW TC 1**	0.0073 [1]U	0.3300	0.3800	0.7100	1.0000 [1]U
	MW TC 2	0.0073 [1]U	0.0160 [2]I	0.1200	0.1400	1.0000 [1]U
Reuse	**MW RE 2456**	0.0073 [1]U	0.1400	0.0840	0.2200	1.0000 [1]U
	MW RE C	0.0073 [1]U	20.000	1.3000	22.000	1.0000 [1]U
Septic	**MW SP 1099**	3.6000	0.0160 [1]U	5.2000	5.2000	16.000
	MW SP 1127	0.0870	0.0170 [2]I	1.1000	1.1000	500.00
Sewer	**MW SE 841**	0.6800	0.0470 [2]I	3.3000	3.4000	1.0000 [1]U
	MW SE 849	3.6000	0.0920	4.9000	5.0000	1.0000 [1]U

[1] "U" qualified values indicate the analytical concentration is below laboratory minimum detection limits (MDLs); vary depending on parameter and sample

[2] "I" qualified values indicates the analytical concentration is greater than or equal to the method detection limit but less than the practical quantitation limit

[3] "B" qualified values are based upon membrane filter colony counts that are outside the method indicated ideal range

[4] "Z" qualified values indicate that too many colonies were present (TNTC); the numeric value represents the estimated colony counts from the highest dilution used in this test; confluent values represent growth of more than the tested coliforms with continuous, indistinguishable colonies

Table 14: Single measurements from the December 19-21, 2017 sampling event per well.

Treatment Area	**Site ID**	Ammonia as N (mg/L)	Nitrate/Nitrite as N (mg/L)	TKN (mg/L)	TN (mg/L)	Coliform, Fecal (CFU/100 mL)
Control	**MW TC 1**	0.035 [1]U	0.025 [1]U	0.130 [2]I	0.130 [2]I	1.000 [1]U
	MW TC 2	0.035 [1]U	0.042 [2]I	0.390 [2]I	0.430 [2]I	1.000 [1]U
Reuse	**MW RE 2456**	0.035 [1]U	0.092	0.120 [2]I	0.210 [2]I	Confluent [4]Z
	MW RE C	0.035 [1]U	20.30	0.640	21.00	7.000
	MW RE C2	0.059	1.500	0.460 [2]I	1.900	Confluent [4]Z
Septic	**MW SP 1099**	4.600	0.025 [1]U	5.900	5.900	1.000
	MW SP 1127	0.078	0.025 [1]U	0.840	0.850	4.000
	MW SP 981	1.200	0.025 [1]U	1.800	1.800	31.00
Sewer	**MW SE 841**	1.100	0.025 [1]U	3.000	3.000	6.000
	MW SE 845	8.200	0.025 [1]U	9.100	9.100	TNTC [4]Z
	MW SE 849	3.900	0.025 [1]U	4.400	4.400	1.000 [1]U

[1] "U" qualified values indicate the analytical concentration is below laboratory minimum detection limits (MDLs); vary depending on parameter and sample

[2] "I" qualified values indicates the analytical concentration is greater than or equal to the method detection limit but less than the practical quantitation limit

[3] "B" qualified values are based upon membrane filter colony counts that are outside the method indicated ideal range

[4] "Z" qualified values indicate that too many colonies were present (TNTC); the numeric value represents the estimated colony counts from the highest dilution used in this test; confluent values represent growth of more than the tested coliforms with continuous, indistinguishable colonies

Table 15: Single measurements from the January 16-18, 2018 sampling event per well.

Treatment Area	Site ID	Ammonia as N (mg/L)	Nitrate/ Nitrite as N (mg/L)	TKN (mg/L)	TN (mg/L)	Coliform, Fecal (CFU/100 mL)
Control	**MW TC 1**	0.035 [1]U	0.025 [1]U	0.110 [2]I	0.120 [2]I	1.000 [1]U
	MW TC 2	0.035 [1]U	0.025 [1]U	0.290 [2]I	0.290 [2]I	1.000 [1]U
Reuse	**MW RE 2456**	0.035 [1]U	0.620	0.086 [1]U	0.670	1.000 [1]U
	MW RE C	0.035 [1]U	18.10	0.086 [1]U	18.10	1.000 [1]U
	MW RE C2	0.035 [1]U	1.500	0.280 [2]I	1.800	1.000 [1]U
Septic	**MW SP 1099**	5.800	0.025 [1]U	7.100	7.100	1.000 [1]U
	MW SP 1127	0.084	0.025 [1]U	0.700	0.710	52.00
	MW SP 981	1.100	0.025 [1]U	1.500	1.500	1.000 [1]U
Sewer	**MW SE 841**	1.200	0.025 [1]U	2.900	2.900	1.000 [1]U
	MW SE 845	6.400	0.025 [1]U	7.400	7.500	Confluent [4]Z
	MW SE 849	3.700	0.025 [1]U	4.400	4.400	1.000 [1]U

[1] "U" qualified values indicate the analytical concentration is below laboratory minimum detection limits (MDLs); vary depending on parameter and sample

[2] "I" qualified values indicates the analytical concentration is greater than or equal to the method detection limit but less than the practical quantitation limit

[3] "B" qualified values are based upon membrane filter colony counts that are outside the method indicated ideal range

[4] "Z" qualified values indicate that too many colonies were present (TNTC); the numeric value represents the estimated colony counts from the highest dilution used in this test; confluent values represent growth of more than the tested coliforms with continuous, indistinguishable colonies

Table 16: Single measurements from the February 13-15, 2018 sampling event per well.

Treatment Area	Site ID	Ammonia as N (mg/L)	Nitrate/ Nitrite as N (mg/L)	TKN (mg/L)	TN (mg/L)	Coliform, Fecal (CFU/100 mL)
Control	**MW TC 1**	0.035 [1]U	0.025	0.086 [1]U	0.088 [2]I	1.000 [1]U
	MW TC 2	0.036 [2]I	0.025	0.340 [2]I	0.340 [2]I	1.000 [1]U
Reuse	**MW RE 2456**	0.035 [1]U	2.500	0.086 [1]U	2.500	1.000 [1]U
	MW RE C	0.035 [1]U	19.60	0.086 [1]U	19.60	1.000 [1]U
	MW RE C2	0.035 [1]U	1.500	0.22 [2]I	1.700	1.000 [1]U
Septic	**MW SP 1099**	4.900	0.025	6.000	6.000	1.000 [1]U
	MW SP 1127	0.035 [1]U	4.400	0.990	5.400	1.000 [1]U
	MW SP 981	0.960	0.025	1.300	1.300	1.000 [1]U
Sewer	**MW SE 841**	1.200	0.025	3.100	3.100	1.000 [1]U
	MW SE 845	3.600	0.025	6.800	6.800	1.000 [1]U
	MW SE 849	0.950	0.025	4.200	4.200	1.000 [1]U

[1] "U" qualified values indicate the analytical concentration is below laboratory minimum detection limits (MDLs); vary depending on parameter and sample

[2] "I" qualified values indicates the analytical concentration is greater than or equal to the method detection limit but less than the practical quantitation limit

[3] "B" qualified values are based upon membrane filter colony counts that are outside the method indicated ideal range

[4] "Z" qualified values indicate that too many colonies were present (TNTC); the numeric value represents the estimated colony counts from the highest dilution used in this test; confluent values represent growth of more than the tested coliforms with continuous, indistinguishable colonies

Table 17: Single measurements from the March 14-16, 2018 sampling event per well.

Treatment Area	**Site ID**	Ammonia as N (mg/L)	Nitrate/ Nitrite as N (mg/L)	TKN (mg/L)	TN (mg/L)	Coliform, Fecal (CFU/100 mL)
Control	**MW TC 1**	0.035	0.025 [1]U	0.150 [2]I	0.160 [2]I	1.000 [1]U
	MW TC 2	0.110	0.025 [1]U	0.380 [2]I	0.380 [2]I	1.000 [1]U
Reuse	**MW RE 2456**	0.035 [1]U	6.00	0.086 [1]U	6.000	1.000 [1]U
	MW RE C	0.035 [1]U	24.40	0.086 [1]U	24.40	1.000 [1]U
	MW RE C2-A *	0.035 [1]U	1.700	0.330 [2]I	2.000	1.000 [1]U
	MW RE C2-B *	0.035 [1]U	1.600	0.290 [2]I	1.900	1.000 [1]U
Septic	**MW SP 1099**	7.600	0.025 [1]U	8.300	8.300	1.000 [1]U
	MW SP 1127	0.038 [2]I	2.100	0.530	2.700	1.000 [1]U
	MW SP 981	1.300	0.025 [1]U	1.600	1.600	1.000 [1]U
Sewer	**MW SE 841**	1.200	0.025 [1]U	2.600	2.700	1.000 [1]U
	MW SE 845	5.800	0.025 [1]U	6.200	6.200	6.000
	MW SE 849	3.800	0.025 [1]U	4.200	4.200	1.000 [1]U

[1] "U" qualified values indicate the analytical concentration is below laboratory minimum detection limits (MDLs); vary depending on parameter and sample

[2] "I" qualified values indicates the analytical concentration is greater than or equal to the method detection limit but less than the practical quantitation limit

[3] "B" qualified values are based upon membrane filter colony counts that are outside the method indicated ideal range

[4] "Z" qualified values indicate that too many colonies were present (TNTC); the numeric value represents the estimated colony counts from the highest dilution used in this test; confluent values represent growth of more than the tested coliforms with continuous, indistinguishable colonies

* Well became dry during the sampling process, thus sample was split and taken before and after recharge

Ammonia

Ammonia summary statistics for the ten sampling events are provided in Table 18 and a graph of mean concentrations by treatment area is in Figure 10. Average ammonia concentrations varied among the four study sites, with highest concentrations in the sewer area, followed by the septic area, the natural area, and lowest at the reuse area (Figure 10). It is surprising that the septic and sewer communities are so similar, suggesting that the sewer lines or laterals may be leaking. In the septic and sewer community wells, ammonia concentrations were higher in the early summer months, declined in August and September, and then increased through October and December, and started to decrease again from December to February. This appears to represent a lag effect from the measured local rainfall (Figure 9) which causes a cumulative elevation of the groundwater table. As groundwater levels rise, there is less pore space available for denitrification to transform ammonia to nitrate/nitrite. Measured concentrations were highest when peak table values were reached, typically a month after the high rainfall period ended (late October, with 2-month total preceding rainfall > 30”). Measured ammonia concentrations were also relatively high during late spring and early summer (May and June), when measured local rainfall was atypically high.

Table 18: Ammonia (mg/L) summary statistics for ten events. Highest mean and median values bolded, lowest mean and median values italicized.

Treatment Area	Site ID	Mean	Median	Std Dev	Min	Max
Natural	**MW TC 1**	*0.0184*	*0.0073*	0.0143	0.0073	0.0350
	MW TC 2	0.3708	0.0355	0.5860	0.0073	1.6000
Reuse	**MW RE 2456**	*0.0184*	*0.0073*	0.0143	0.0073	0.0350
	MW RE C	0.0243	0.0280	0.0165	0.0073	0.0530
	MW RE C2	0.0398	0.0350	0.0107	0.0350	0.0590
Septic	**MW SP 1099**	4.3100	4.3500	1.6079	2.0000	7.6000
	MW SP 1127	0.0518	0.0515	0.0259	0.0120	0.0870
	MW SP 981	1.1400	1.1500	0.1451	0.9600	1.3000
Sewer	**MW SE 841**	1.0700	1.2000	0.4503	0.1500	1.7000
	MW SE 845	**6.0000**	**6.1000**	1.8974	3.6000	8.2000
	MW SE 849	3.3050	3.7500	1.0813	0.9500	4.3000

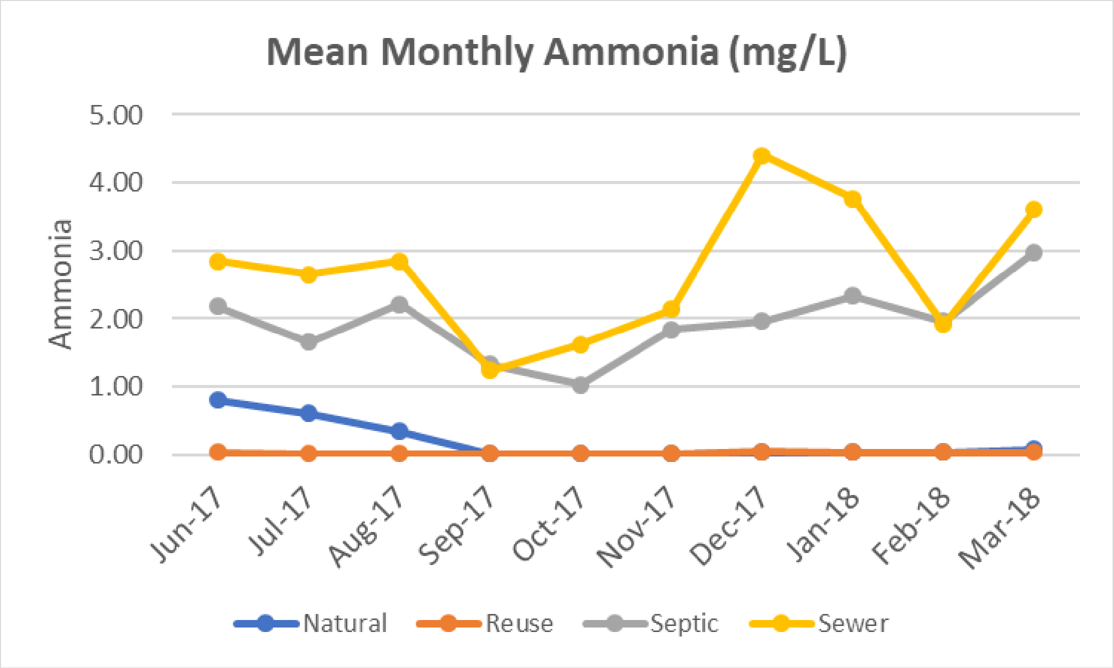


Figure 10: Mean monthly ammonia concentrations by treatment area.

Nitrite/Nitrate

Nitrate/nitrite summary statistics for the ten sampling events are provided in Table 19 and a graph of mean concentrations by treatment area is in Figure 11. The reuse common area well (MW REC) consistently had nitrate/nitrite concentrations above 10 mg/L, but the other reuse wells (MW RE 2456 and MW RE C2) have had low to intermediate levels of nitrate/nitrite, bringing the average concentration for the reuse community down between 4-11 mg/L. Nevertheless, mean nitrate/nitrite levels were consistently and significantly higher for the reuse community in comparison to all other treatment types. Mean values for this community appear to show an increasing trend since November 2017 through March 2018, but seasonal trends are only based on one year of date and no conclusions can be made. The Palm Bay reuse facility is permitted to discharge 29.4 mg/L of TN. An irrigation well sample confirmed that they are discharging at their permitted concentration (28.9 mg/L TN with 28.4 mg/L nitrate/nitrite). This community also has a lawn service that was frequently noticed on site.

Nitrate/nitrite concentrations increased dramatically in septic tank well MW SP 1127 in the month of July, but quickly decreased thereafter. The lowest nitrate/nitrite concentrations were consistently found in the natural and sewer areas (Figure 11).

Table 19: Nitrate/Nitrite (mg/L) summary statistics for ten events. Highest mean and median values bolded, lowest mean and median values italicized.

Treatment Area	**Site ID**	Mean	Median	Std Dev	Min	Max
Natural	**MW TC 1**	*0.023*	*0.025*	0.006	0.016	0.034
	MW TC 2	0.597	0.034	1.131	0.016	3.500
Reuse	**MW RE 2456**	1.248	0.125	1.971	0.058	6.000
	MW RE C	**16.12**	**16.55**	5.170	7.800	24.40
	MW RE C2	1.560	1.500	0.089	1.500	1.700
Septic	**MW SP 1099**	0.270	*0.025*	0.783	0.016	2.500
	MW SP 1127	4.579	3.250	6.366	0.017	21.00
	MW SP 981	0.025	*0.025*	0.000	0.025	0.025
Sewer	**MW SE 841**	0.425	0.071	0.832	0.025	2.700
	MW SE 845	0.025	*0.025*	0.000	0.025	0.025
	MW SE 849	0.083	0.080	0.068	0.025	0.240

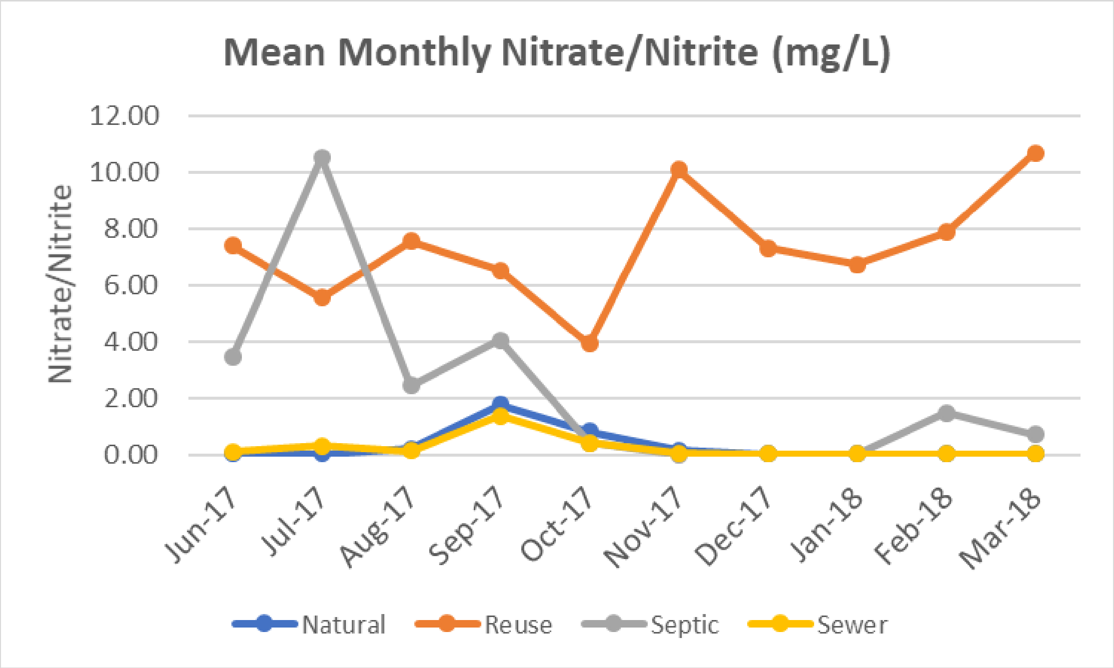


Figure 11: Mean monthly nitrate/nitrite concentrations by treatment type.

Total Kjeldahl Nitrogen (TKN)

Total Kjeldahl Nitrogen (TKN) is a measure of the concentration of organic nitrogen plus ammonia. Summary statistics for the ten sampling events are provided in Table 20 and a graph of mean concentrations by treatment area is in Figure 12. The TKN concentrations in the sewer community wells were consistently higher than other treatment types, and the reuse concentrations were consistently lower, and mostly similar to those measured for our control wells (Figure 12). A large percentage of the measured TKN in the sewer community was composed of ammonia, and the same interpretation can be applied to these results. The lowest concentrations of TKN were measured for the natural and reuse wells. More discussion on the type of nitrogen species by well type and community is included below (Total Nitrogen section, Table 22).

Table 20: TKN (mg/L) summary statistics for ten events. Highest mean and median values bolded, lowest mean and median values italicized.

Treatment Area	**Site ID**	Mean	Median	Std Dev	Min	Max
Natural	**MW TC 1**	*0.087*	0.090	0.041	0.037	0.150
	MW TC 2	0.881	0.495	0.772	0.290	2.600
Reuse	**MW RE 2456**	0.131	*0.086*	0.113	0.040	0.430
	MW RE C	0.819	0.253	1.093	0.037	2.900
	MW RE C2	0.316	0.290	0.090	0.220	0.460
Septic	**MW SP 1099**	5.920	5.900	1.214	4.000	8.300
	MW SP 1127	0.934	0.940	0.273	0.530	1.500
	MW SP 981	1.550	1.550	0.208	1.300	1.800
Sewer	**MW SE 841**	3.390	3.150	0.775	2.500	4.800
	MW SE 845	**7.375**	**7.100**	1.250	6.200	9.100
	MW SE 849	4.700	4.600	0.696	3.800	6.300

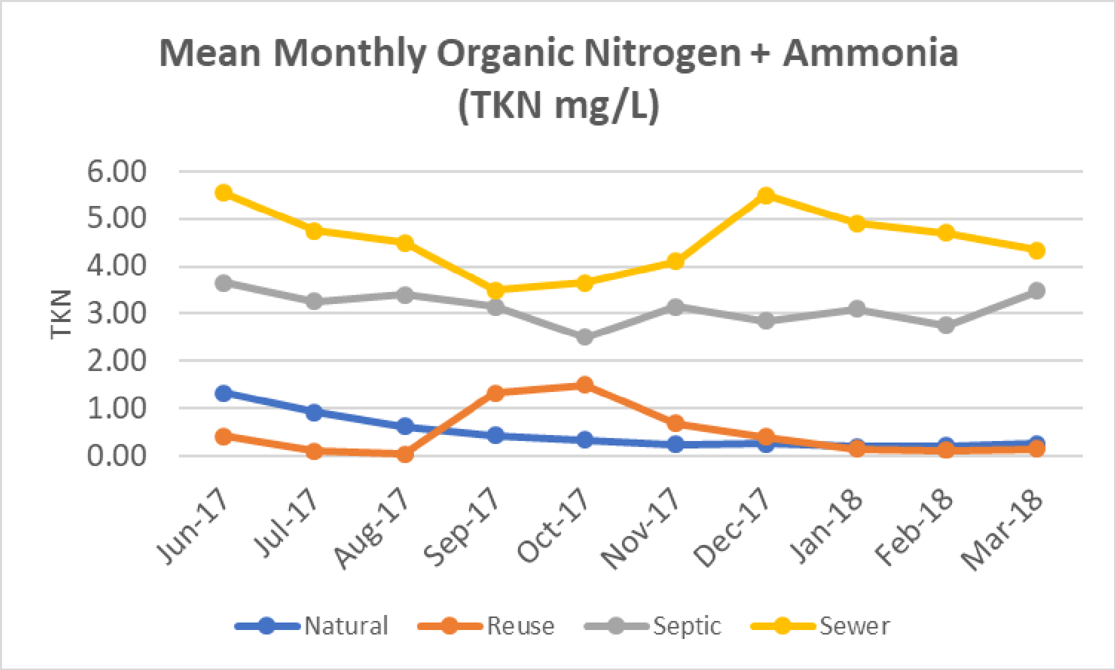


Figure 12: Mean monthly TKN concentrations by treatment type.

Total Nitrogen

Total nitrogen is a calculation of TKN + nitrate/nitrite and is a general measure of the amount of nitrogen that will potentially contribute to nitrogen loads to the lagoon tributaries from groundwater. Figure 13 displays the time series plots for measured TN at each well by treatment type throughout the monitoring period. Summary statistics for the ten sampling events are provided in Table 21 and a graph of mean concentrations by treatment area is in Figure 14.

Fluctuations in the measured concentrations are highest for the reuse and septic communities, while concentration values are relatively stable for the sewer and natural communities. An increase in TN concentrations is evident in the septic community in July, after heavy rainfall occurred in June (Figure 9). Increases in TN concentrations also occurred in the reuse community from November 2017-March 2018, during a very dry period, where reclaimed irrigation would likely be used more frequently (Figure 13 and Figure 14). This community appeared to use year-round landscaping maintenance services. Total mean nitrogen concentrations are overall higher for the reuse community for most of the sampling period, driven by the high nitrate concentrations, closely followed by those for both the sewer and septic community areas. TN mean concentrations for our control area are consistently below any of the other treatments.

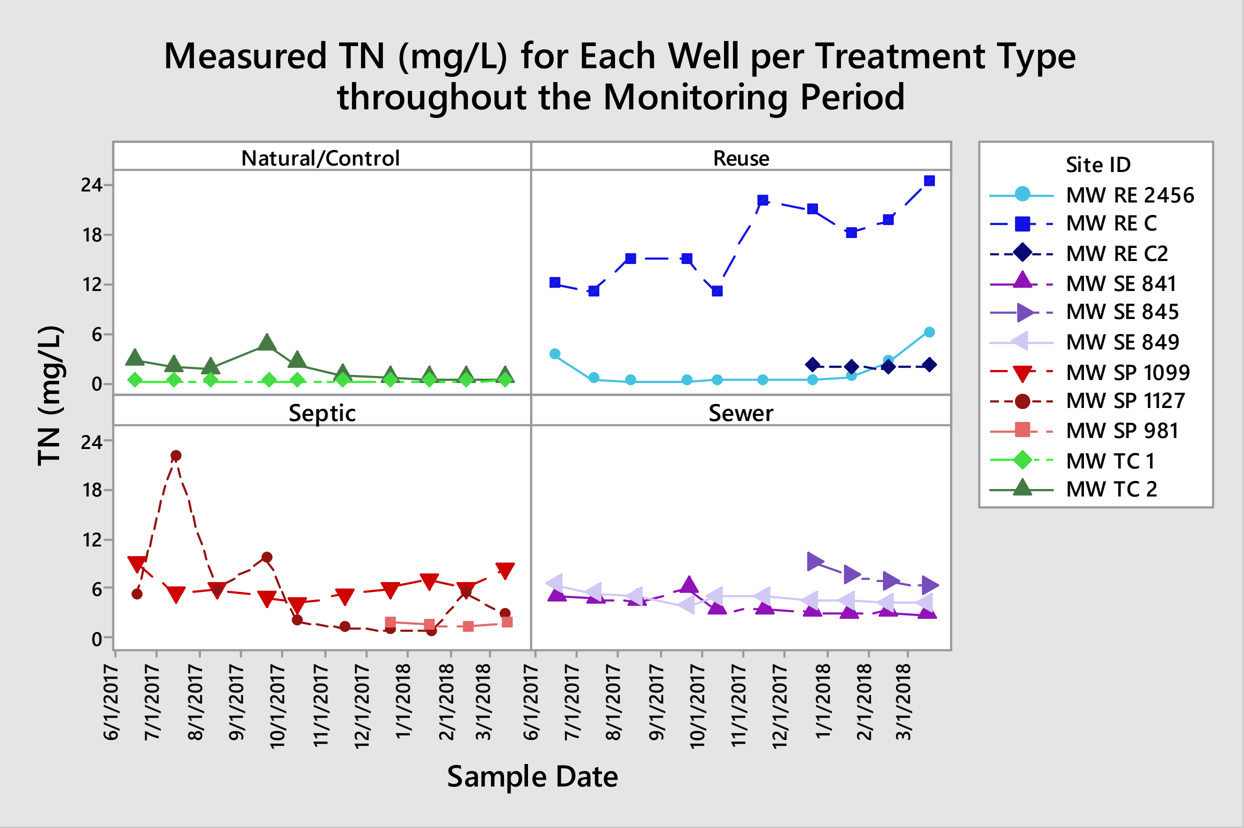


Figure 13. Time series plots of measured TN (mg/L) at each well within the Turkey Creek study region.

Table 21: TN (mg/L) summary statistics for ten events. Highest mean and median values bolded, lowest mean and median values italicized.

Treatment Area	**Site ID**	Mean	Median	Std Dev	Min	Max
Natural	**MW TC 1**	*0.099*	*0.105*	0.042	0.033	0.160
	MW TC 2	1.475	1.155	1.335	0.290	4.400
Reuse	**MW RE 2456**	1.355	0.260	1.967	0.130	6.000
	MW RE C	**16.910**	**16.550**	4.815	11.000	24.400
	MW RE C2	1.860	1.900	0.114	1.700	2.000
Septic	**MW SP 1099**	6.180	5.900	1.558	4.100	9.100
	MW SP 1127	5.516	3.900	6.447	0.710	22.000
	MW SP 981	1.550	1.550	0.208	1.300	1.800
Sewer	**MW SE 841**	3.810	3.300	1.072	2.700	5.900
	MW SE 845	7.400	7.150	1.252	6.200	9.100
	MW SE 849	4.760	4.650	0.746	3.800	6.400

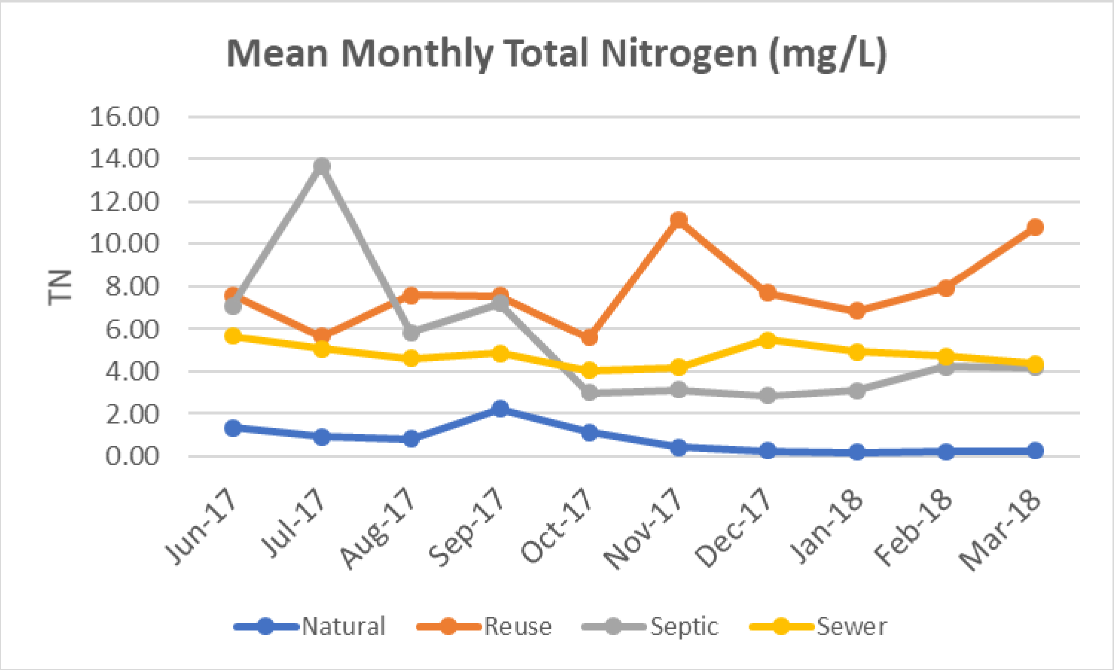


Figure 14: Mean monthly TN concentrations by treatment type.

Spatial variability of measured concentration data is very high, with wells within the same community and located relatively close to each other providing different results. This is particularly true for the reclaimed community. Median TN values were highest for one of the three reuse wells, while the other two wells produced relatively low-medium TN values (Figure 13). Relocating one of the wells in a poor recharge area has provided more consistent higher concentration data. The sewer and septic communities had wells with similar ranges of TN concentrations (averages within 2 mg/L in most cases), with greater spatial variability observed for the septic community (Figure 15).

Spatial variability of measured TN concentration data is likely driven by elevation, soil type, depth to water table, and adjacent land use. In some cases, wells installed at the edge of the community closer to a semi-natural landscape might be less representative of the community groundwater quality. Within the septic communities, the age of the OSTDS, the distance of the installed monitoring well to the drainfield, and intensity of use of the system (1 person versus 4 in the household), can also add to the measured variability. For the sewered communities, any potential lateral or connection leakages would impact the water quality locally and could add to the measured variability. Overall, understanding spatial variability and how to best represent a community would require greater replication of effort within each community. We are addressing some of these questions in a subsequent larger-scale study, using direct push point technology to increase sampling size in a few communities.

Since TN is a calculation of all forms of nitrogen measured, it is useful to determine the extent that TN is dominated by a specific nitrogen constituent. Even though no statistically significant difference between total nitrogen concentrations was found between the reuse and the sewered or septic communities, these are dominated by different types of nitrogen species: the reuse TN is typically dominated by high nitrate/nitrite, while the septic community's total nitrogen is composed of high percentages of ammonia (Table 22, shaded cells present the most important TN constituent by site). Contrasting with the two other septic wells, SP 1127 measured TN concentrations are composed of nitrate (56%) and organic nitrogen, with minimal ammonia (> 4%). While initially surprising due to the shallow water table onsite, the placement of the well is not directly downstream from the drainfield (a mounded system leaving little room downstream) and the nutrient plumes captured might correspond to those from upstream systems. This would have allowed enough transport time for nitrification to have occurred prior to sampling. In addition, confounding variables such as potential use of fertilizer onsite, suspected with sudden nitrate spikes during specific months, might have also skewed the overall percentage composition.

Table 22: Percentage of components making up the Mean total nitrogen (TN) calculation. Shaded areas represent the nitrogen predominant constituent at each site.

Treatment Area	**Site ID**	Mean TN (mg/L)	Ammonia %	Nitrate / Nitrite %	TKN %
Natural	MW TC 1	0.099	19	28	89
	MW TC 2	1.475	23	26	77
Reuse	MW RE 2456	1.355	4.5	68	33
	MW RE C	16.91	0.1	95	5.8
	MW RE C2	1.860	2.1	84	17
Septic	MW SP 1099	6.180	69	3.1	97
	MW SP 1127	5.516	3.6	56	44
	MW SP 981	1.550	74	1.6	99
Sewer	MW SE 841	3.810	30	8.8	91
	MW SE 845	7.400	80	0.3	99
	MW SE 849	4.760	69	1.7	99

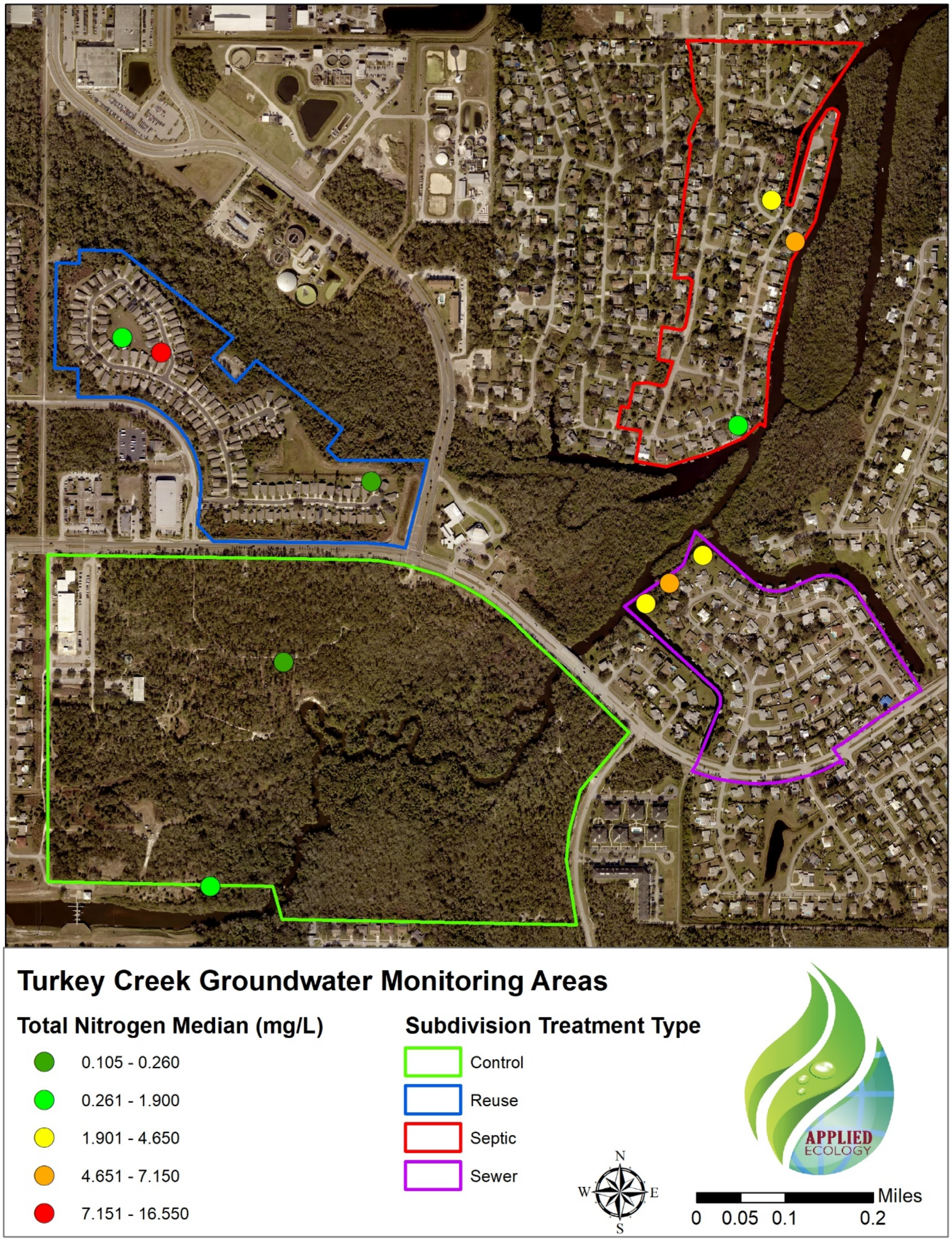


Figure 15: Median Total Nitrogen measured in mg/L at the 11 groundwater sampling sites in Turkey Creek, Florida (based on ten sampling events for the eight original wells and four events for the new wells).

Site Comparisons

A comparison of the three treatment communities and the natural area was conducted to determine which community type was potentially polluting groundwater the most. Due to the variability of the results (both spatial and temporal), it is important to have statistical significance associated with these initial results prior to any prioritization effort to reduce pollution to the Lagoon. It is important to note that statistical power is relatively low with only 10 sampling events and three replicates (wells) per treatment type, and any conclusions derived below should be expanded and confirmed with additional datasets currently being collected throughout the County. The lack of statistical power likely resulted in several marginally non-significant results discussed below. The non-parametric, Kruskal-Wallis and Mann-Whitney test was conducted between sites to assess differences in ammonia, nitrate/nitrite, TKN, and TN concentrations. Median values were used as central tendency due to the heavily skewed, non-normal data distribution. Table 23 below summarizes the differences.

Table 23: Statistically significant differences in concentrations (medians reported)

Analyte	Septic	Sewer	Reuse	Natural
*NH_3 (mg/L)	1.150^{ab}	**2.450^{a}**	0.035^{bc}	0.035^{c}
*NO_X-N (mg/L)	0.025^{a}	0.036^{a}	**2.500^{b}**	0.025^{a}
*TKN (mg/L)	1.550^{a}	**4.350^{b}**	0.120^{c}	0.220^{c}
*TN (mg/L)	**5.150^{a}**	4.550^{a}	2.500^{a}	0.225^{b}
Fecal Coliform (CFUs/100 mL)	1.000	1.000	1.000	1.000

*Significantly different median at $p<0.001$ using Kruskal-Wallis. Pairwise comparison (Mann-Whitney tests). Different letters across rows indicate significant differences in treatment types at $p<0.05$. Highest value in bold.

Ammonia concentrations in the septic community were significantly higher than those in the natural area and ammonia concentrations in the sewer area were significantly higher than the reuse and natural areas ($p<0.00001$). Although the ammonia median concentration was higher in the sewer area than the septic area, the difference was marginally non-significant ($p=0.08$). Ammonia concentrations in the reuse area did not significantly differ from the natural area.

The reuse area had significantly higher nitrate/nitrite concentrations than septic ($p<0.001$), sewer ($p<0.00001$), and natural areas ($p<0.00001$). Septic, sewer and natural area nitrate/nitrite concentrations did not significantly differ, although the difference between sewer and natural nitrate/nitrite concentrations was approaching statistical significance ($p=0.08$).

The sewer area had significantly higher TKN concentrations than the other three areas ($p<0.00001$), which is not surprising considering the high ammonia concentrations. The septic area had significantly higher TKN concentrations than the reuse and natural areas. Reuse and natural areas TKN concentrations did not significantly differ.

TN concentrations were highest in the septic area, followed by the sewer area, and the reuse area although the differences between the three were not found to be significant. The sewer ($p<0.00001$), septic ($p<0.00001$), and reuse ($p<0.001$) areas had statistically higher TN concentrations than the natural area.

Median fecal coliform counts among treatment types are marginally non-significant ($p=0.06$) with high variability measured for both the septic and sewer communities. A larger sample size might have allowed greater power to detect significant differences.

Fecal Coliforms

Fecal coliform summary statistics for the ten sampling events are provided in Table 24 and a graph of mean concentrations by treatment area is in Figure 16. The results for the seventh sampling event were too numerous to count for MW SE 845 and confluent for MW RE 2456 and MW RE C2. The results for the eighth sampling event were confluent for MW SE 845. These values were assumed to be 500 CFU for Figure 16. The value “too numerous to count” (TNTC) indicates that there were too many fecal CFUs to allow an individual colony count, and the analyst must report TNTC. The values that are confluent indicate that other bacterial growth obscured the ability of fecal coliform colonies to be visualized and counted. The lab performed multiple dilutions, if necessary, to better quantify the higher number of CFUs in these TNTC cases.

The septic well MW SP 1099 has the highest maximum concentration of fecal bacteria (500 CFU/mL) followed by one of the sewered wells (230 CFU/mL). The graph of treatment area mean concentrations over time shows a large increase in fecal coliforms in septic well MW SP 1099 in October and November and a large increase for reuse in December (Figure 16). It is important to note that these spikes of contamination are sporadic and not consistent throughout the monitoring effort. This suggests that bacterial contamination “break-through” is happening when conditions are not suitable for adequate treatment, such as when groundwater levels increase or the septic system is over-used. It also is an indication that the typical one-time sampling to confirm or dismiss bacterial contamination might be inadequate to detect contamination of less than catastrophic nature and continuous monitoring might be necessary.

Table 24: Fecal Coliform (CFU/100mL) summary statistics for all events. (statistics calculated with values that were confluent and TNTC, values were estimated at 500 CFU/mL)*

Treatment Area	**Site ID**	Average	Median	Std Dev	Min	Max
Control	**MW TC 1**	1.000	1.000	0.000	1.000	1.000
	MW TC 2	7.700	1.000	15.30	1.000	50.00
Reuse	**MW RE 2456***	50.90	1.000	157.8	1.000	500.0
	MW RE C	1.600	1.000	1.900	1.000	7.000
	MW RE C2*	100.8	1.000	223.2	1.000	500.0
Septic	**MW SP 1099**	11.80	1.200	24.60	1.000	80.00
	MW SP 1127	96.40	2.000	188.5	1.000	500.0
	MW SP 981	8.500	1.000	15.00	1.000	31.00
Sewer	**MW SE 841**	11.60	1.000	31.10	1.000	100.0
	MW SE 845*	251.8	253.0	286.7	1.000	500.0
	MW SE 849	25.00	1.000	72.10	1.000	230.0

Referencing a regulatory target provides a framework for discussion. Fecal coliforms are regulated by EPA through three different target criteria (Chapter 62-302: Surface Water Quality Standards, USEPA, 2015). One of the three sets a limit to the number of samples collected that exceed 31 CFU/100mL. This surface water quality standard is commonly referred to as the ten percent threshold value target and doesn’t allow more than 10% of samples to exceed 31 CFU/100mL. In this study, only two wells (one septic and one sewer) exceeded the 10% threshold for the 10 sampling events (Table 25). Seven of the other nine wells had one sampling event out of 10 (10%) exceeding the recommended 31 CFU/100mL.

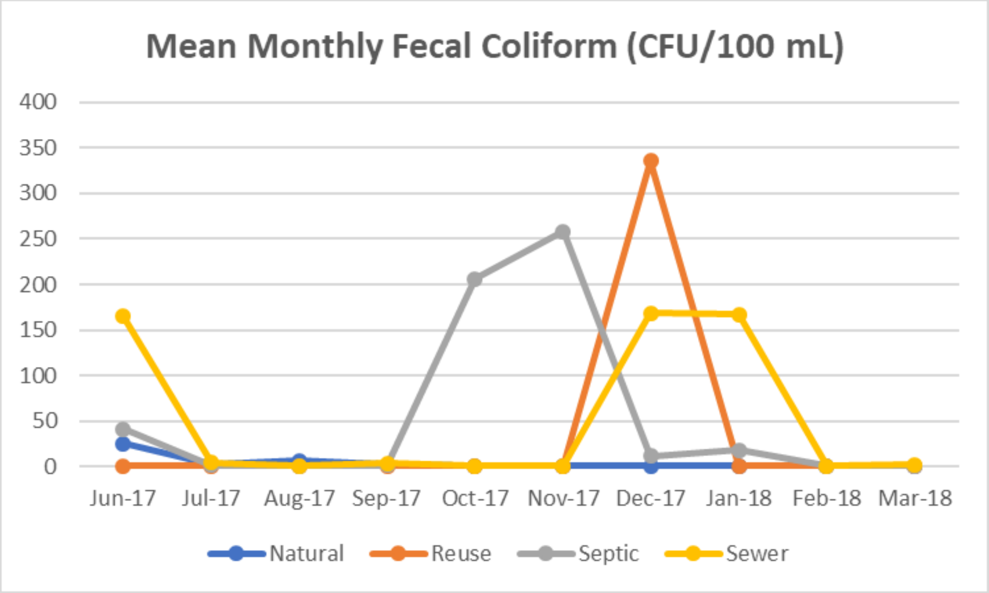


Figure 16: Mean monthly fecal coliform concentrations by treatment type.

Table 25: Percentage of samples that exceed EPA standard of 31 CFU/mL for fecal coliform.

Treatment Area	Site ID	Percent Exceedance
Control	MW TC 1	0
	MW TC 2	10
Reuse	MW RE 2456*	10
	MW RE C	0
	MW RE C2*	10
Septic	MW SP 1099	10
	MW SP 1127	**30**
	MW SP 981	10
Sewer	MW SE 841	10
	MW SE 845*	**20**
	MW SE 849	10

Isotope Results

Thirty-five (35) samples had nitrate concentrations of 0.12 mg/L that could be analyzed by the Sigman bacterial method for the $\delta^{15}N$ and $\delta^{18}O$ isotopic analysis (Sigman *et al*., 2001). The accuracy and precision of the measurements were verified through the use of known standards in the lab.

Isotopic signatures varied dramatically with $\delta^{15}N$ signatures ranging from 3.27 to 71.69 and $\delta^{18}O$ signatures ranging from -1.7 to +24.33 (Table 26 and Figure 17). About half (48%) of the samples demonstrated enriched $\delta^{15}N$ (+8 to +10) signatures that one would expect to see in septic wastes with the others falling into the natural soil isotope range (Showers *et al*., 2007).

A study by Roadcap *et al*. (2001) investigated the effectiveness and applicability of using the nitrate-oxygen isotope ratio to identify sources of nitrate (NO_3^-). They characterized the isotopic shift that occurred during microbial denitrification that preferentially selects the lighter $^{14}N\text{-}NO_3^-$, leaving behind enriched $^{15}N\text{-}NO_3^-$. Their research and that of others (Bottcher *et al*., 1990; Aravena and Roberston, 1998); determined that as denitrification of NO_3 occurs, the enrichment ratio of $\delta^{18}O$:$\delta\ ^{15}N$ is 1:2. With this understanding, source contributions can be clarified using a matrix with enrichment signatures expected of synthetic fertilizers and manure or septic wastes (Figure 17).

Table 26: $\delta^{15}N$ and $\delta^{18}O$ results (minimum nitrate concentration of 0.12 mg/L nitrate/nitrite).

Sample	Event	Well ID	Treatment	Sample Date	$\delta\ ^{15}N_{Air}$ (‰)	$\delta\ ^{18}O_{VSMOW}$ (‰)	Nitrate/Nitrite as N (mg/L)
1	1	MW TC 1	Natural	6/15/2017	3.27	8.41	0.34
2	1	MW RE 2456	Reuse	6/15/2017	6.54	1.97	2.80
3	1	MW REC	Reuse	6/15/2017	7.24	1.92	120
4	1	MW SP 1099	Septic	6/16/2017	13.1	9.69	2.50
5	1	MW SP 1127	Septic	6/16/2017	9.58	6.11	4.40
6	2	MW REC	Reuse	7/13/2017	7.04	1.27	11.0
7	2	MW SP 1127	Septic	7/14/2017	10.5	7.36	21.0
8	3	MW TC 2	Natural	8/9/2017	6.23	5.35	0.39
9	3	MW REC	Reuse	8/9/2017	7.02	1.22	15.0
10	3	MW SP 1127	Septic	8/14/2017	17.6	14.1	4.90
11	4	MW TC 2	Natural	9/20/2017	3.63	1.09	3.50
12	4	MW REC	Reuse	9/20/2017	7.39	1.20	13.0
13	4	MW SP 1127	Septic	9/20/2017	15.9	10.1	8.10
14	4	MW SE 841	Sewer	9/21/2017	37.8	18.6	2.70
15	5	MW TC 2	Natural	10/11/2017	7.53	2.90	1.60
16	5	MW REC	Reuse	10/11/2017	7.55	0.50	7.80
17	5	MW SP 1127	Septic	10/12/2017	31.4	17.1	0.82
18	5	MW SE 841	Sewer	10/12/2017	71.7	24.3	0.74
19	5	MW SE 849	Sewer	10/12/2017	13.3	19.9	0.12
20	6	MW TC 2	Natural	11/14/2017	31.5	16.6	0.33
21	6	MW RE 2456	Reuse	11/14/2017	4.14	-0.26	0.14
22	6	MW REC	Reuse	11/14/2017	8.78	1.82	20.0
23	7	MW REC	Reuse	12/21/2017	8.77	2.22	20.3
24	7	MW REC 2	Reuse	12/21/2017	7.28	3.13	1.50
25	8	MW RE 2456	Reuse	1/18/2018	5.87	-0.74	0.62
26	8	MW REC	Reuse	1/18/2018	8.54	1.91	18.1
27	8	MW REC 2	Reuse	1/18/2018	5.95	3.11	1.50
28	9	MW RE 2456	Reuse	2/15/2018	5.24	-1.70	2.50
29	9	MW REC	Reuse	2/15/2018	8.87	2.17	19.6
30	9	MW REC2	Reuse	2/15/2018	5.88	3.02	1.50
31	9	MW SP 1127	Septic	2/13/2018	15.6	7.88	4.40
32	10	MW RE 2456	Reuse	3/16/2018	5.28	-0.56	6.00
33	10	MW REC	Reuse	3/16/2018	8.58	2.14	24.4
34	10	MW REC 2-B	Reuse	3/16/2018	6.18	3.41	1.60
35	10	MW SP 1127	Septic	3/14/2018	11.9	5.68	2.10

We created a source allocation matrix similar to Roadcap *et al*. (2001) to better understand source and denitrification processes in the soil in the natural areas and treatment communities (Figure 17). Some interesting patterns emerge when plotted this way. The reuse community isotopic signatures are the most consistent, clustering tightly together in the range of (+4 - +8) that could be indication of little denitrification or of mixing of wastewater with mineral fertilizer nitrogen sources. The septic community isotopes are indicative of enrichment that occurs during denitrification activities. The δ^{15}N signatures were all within the range for wastewater (+8 - +10). In the sewer community, there were few samples with high enough nitrate concentration to analyze because most of the nitrogen in the sewer community was in the form of ammonia. The three sewer samples that were analyzed for δ^{18}O and δ^{15}N had highly enriched signatures, indicative of extreme denitrification that could be associated with bacterial decomposition of wastes. Although the δ^{15}N signatures varied from +10 ppt to 71 ppt, the δ^{18}O signatures varied little in the sewered area. It will be interesting to see if this tendency continues as we explore more sewered communities. The natural area well that had nitrate concentrations high enough to analyze was located downstream from a house that has a septic tank. The δ^{15}N signatures in this well are consistent with that of wastewater.

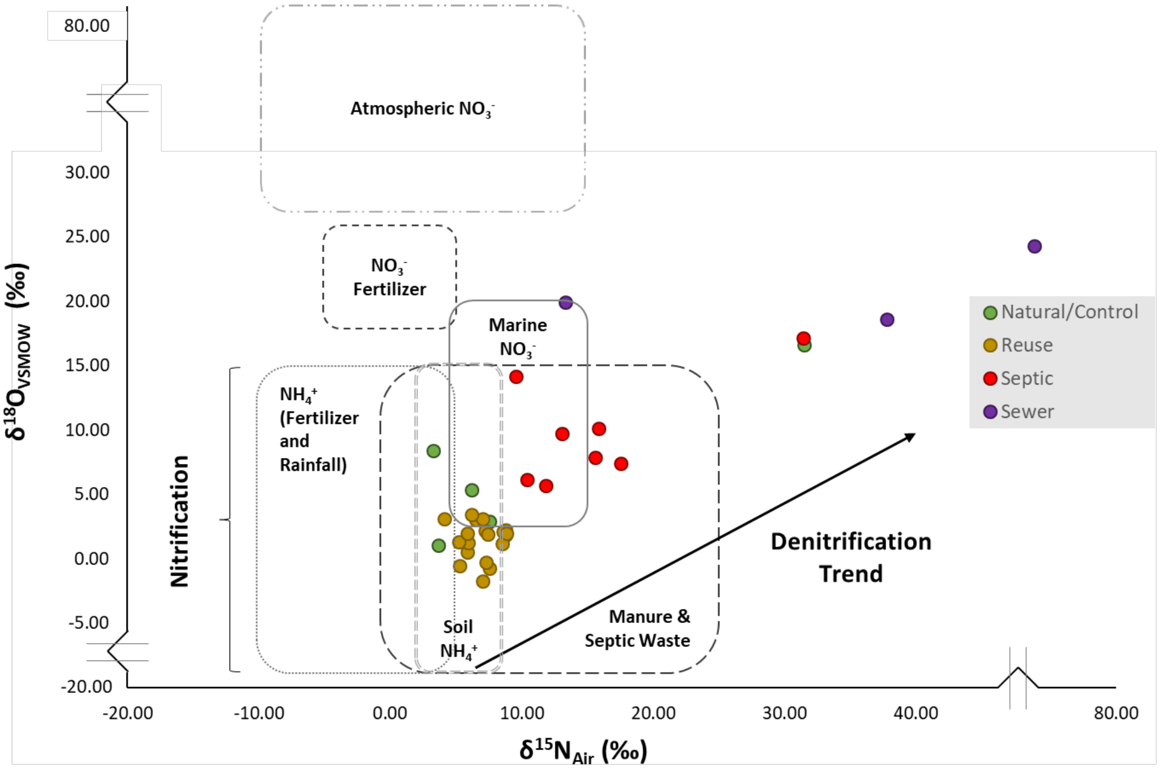


Figure 18: Plot of δ^{15}N and δ^{18}O results adapted from Kendall et al. (2007).

Table 27: Summary of $\delta^{15}N$ and $\delta^{18}O$ results by treatment type.

Natural (n=5)	**Average**	**Std Dev**	**Min**	**Max**
$\delta\,^{15}N_{Air}$ (‰)n	10.43	11.91	3.27	31.51
$\delta\,^{18}O_{VSMOW}$ (‰)n	6.87	6.09	1.09	16.60
Reuse (n=19)				
$\delta\,^{15}N_{Air}$ (‰)n	6.96	1.37	4.14	8.87
$\delta\,^{18}O_{VSMOW}$ (‰)n	1.46	1.43	-1.70	3.41
Septic (n=8)				
$\delta\,^{15}N_{Air}$ (‰)n	15.68	6.94	9.58	31.41
$\delta\,^{18}O_{VSMOW}$ (‰)n	9.76	4.01	5.68	17.12
Sewer (n=3)				
$\delta\,^{15}N_{Air}$ (‰)n	40.94	29.30	13.34	71.69
$\delta\,^{18}O_{VSMOW}$ (‰)n	20.96	2.99	18.61	24.33

Post-sampling Model Calibration and Results

The original uncalibrated model run used for well siting was refined, reduced, and calibrated using the data obtained from the ten sampling events. The model boundary was reduced to the Turkey Creek quad-basin for this post-sampling model run, allowing calibration to take place only in the area of interest. As previously described, the required input variables were generated including the digital elevation model (DEM) data, both hydraulic conductivity and porosity soil data from the USDA Soil Survey Geographic (SSURGO) database, and septic tank and drainfield location data (Rios *et al.*, 2011). The drainfield location was slightly modified from the initial model run for the areas where we had accurately determined the location of the drainfield. In other areas, parcel centroids were still used as input drainfield locations. Once site-specific data for ten sampling events were collected, the ArcNLET flow and transport modules were calibrated individually, and the load estimation module was performed estimate loading into Turkey Creek. Data from the calibration efforts and final model loading outputs are provided in the subsections below. There were 330 septic tanks used in the calibrated model (Figure 18). These septic tanks are representative of the majority of septic tanks in the Turkey Creek Quad Basin connected to Turkey Creek.

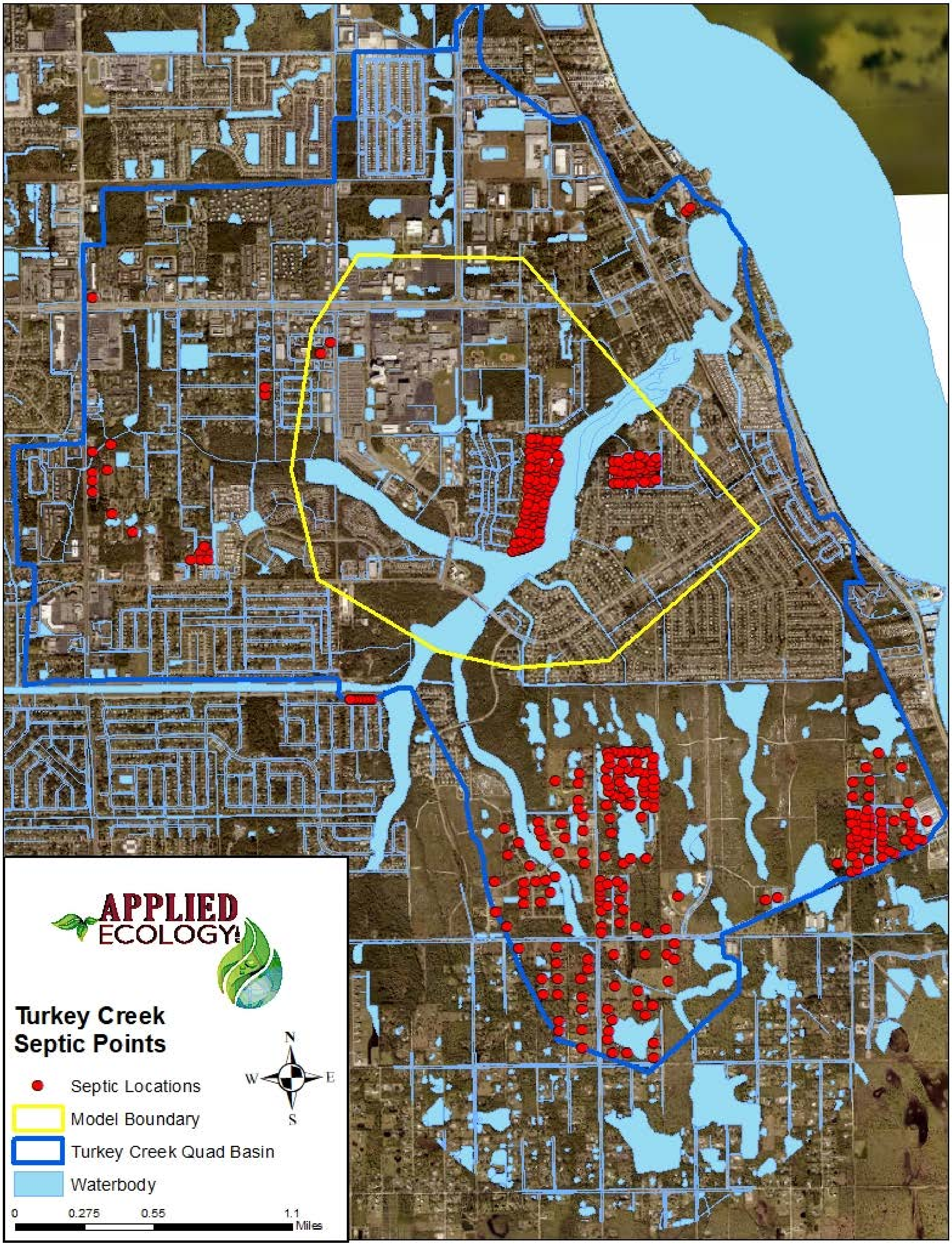


Figure 19: Septic tanks within the Turkey Creek quad-basin that were used in the calibrated run of ArcNLET.

The first step in the ArcNLET model calibration is to perform the Groundwater Flow module (Rios *et al.*, 2011). This step of the model utilizes a DEM and a smoothing factor and generates four outputs: velocity (magnitude & direction), hydraulic gradient, and the smoothed DEM (sdem) which is a subdued replica of the water table. All these products predict the groundwater flow (direction and velocity) based on hydraulic head exclusively. The sdem raster values are used to calibrate the groundwater flow in the model by comparing them to the actual depth to water of the monitoring wells. The groundwater flow is calibrated by attempting to maximize the correlation coefficient while maintaining a linear 1:1 relationship between the measured groundwater water level (at our five well locations) and the smoothed DEM. Often the flow module is run iteratively using several smoothing factors to establish the best possible agreement between the smoother DEM and the mean observed hydraulic head. A smoothing factor of 5 was chosen to use for the final calibration of the groundwater flow model as its slope was the closest to a one-to-one relationship (Figure 19). A one-to-one relationship of slope is preferred as it is indicative of an equal rate of change between the median hydraulic head values and modelled smoothed DEM, which is consistent with the model's assumption that the water table is a replica of the DEM.

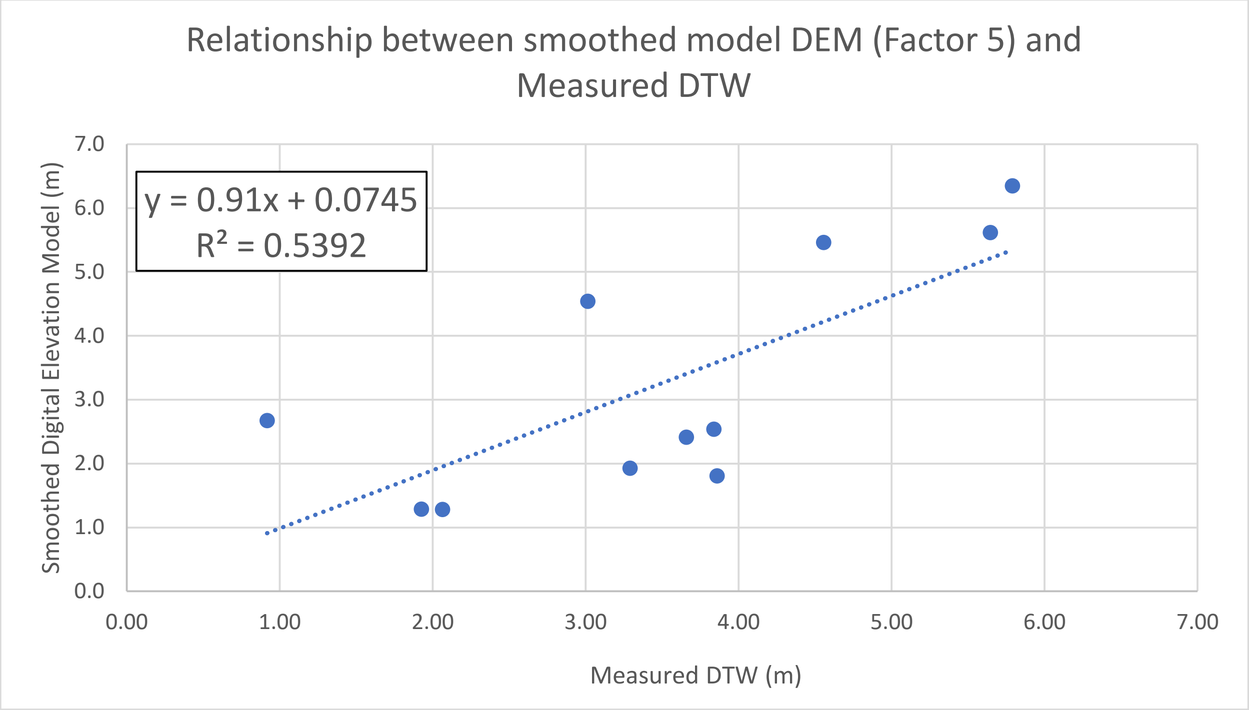


Figure 20: Relationship between smoothed Digital Elevation Model (DEM) and measured median depth to water for a smoothing factor of 5.

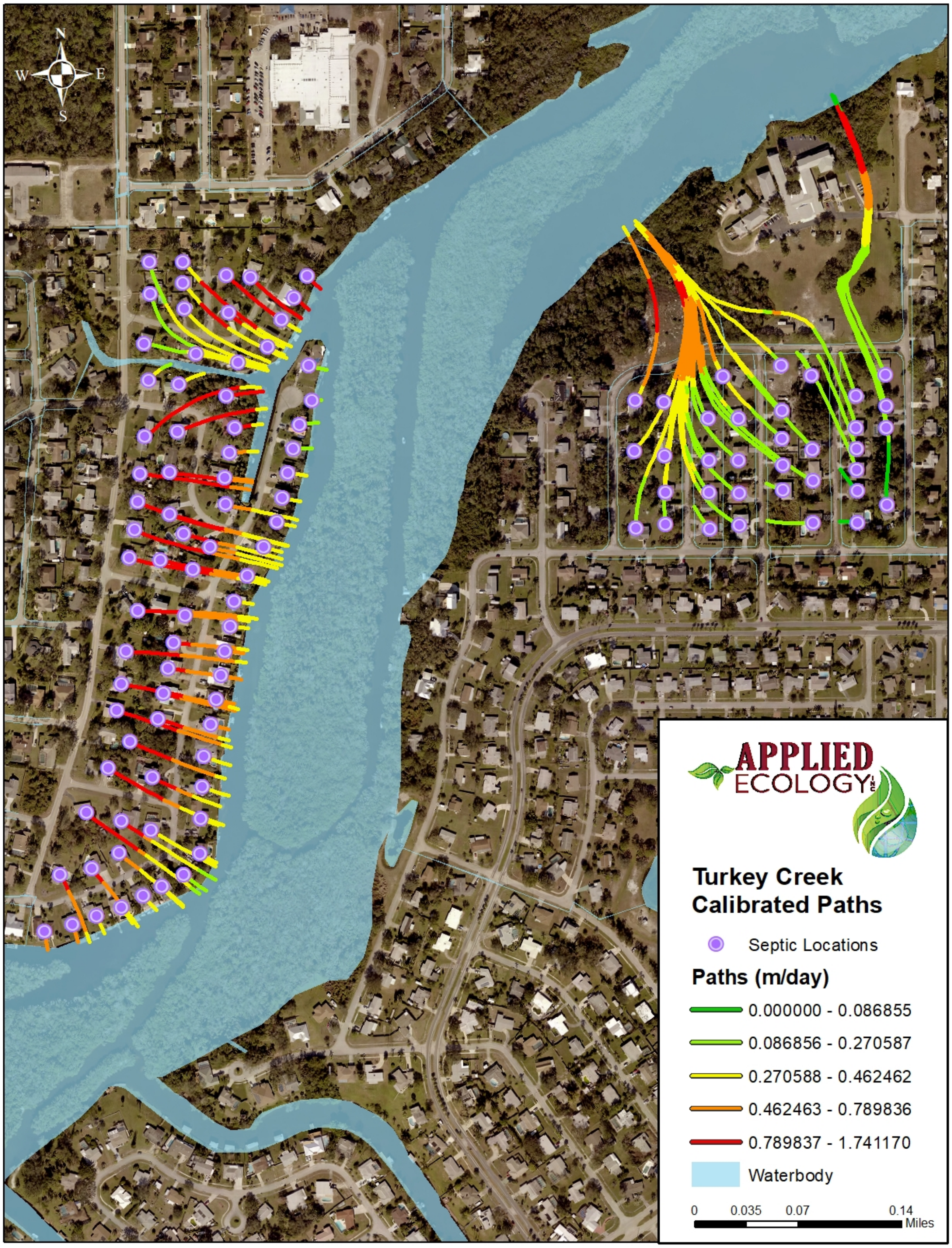


Figure 21: Turkey Creek study area ArcNLET particle tracking. Paths with higher velocities are characterized by red/orange lines while slower velocities are characterized by green lines.

The second step in the ArcNLET model calibration is to perform the Particle Tracking module. This step utilizes layers created in the groundwater flow step and creates the path along which the nitrate and/or the ammonia move from the septic tanks to the waterbodies in the model area (Figure 20). The direction and velocity of the paths is critical in predicting how much of the input OSTDs loading reached the surface water (in this case, Turkey Creek); higher velocities provide little to no time for nitrification and subsequent denitrification to take place, and often indicate greater input loading reaching the surface water.

The third step in the ArcNLET model calibration is the Transport module. This step requires several parameters to be adjusted to force best fit between the measured nitrate and ammonia nutrient concentrations and the predicted modeled plume values at the installed well locations. Parameters that can be refined to allow calibration of the predicted nutrient plumes include the decay coefficient of denitrification (K) used for NO_3, the decay coefficient of nitrification (K) used for NH_3, the source load/plan concentration (C_O), and the horizontal (αL) and longitudinal dispersivities (αTH) (Rios *et al.*, 2011). All these input parameters interact with each other, and often calibration requires changes in several of these. The values used by the modified ArcNLET model to yield the best predictions of the measured concentrations of nitrate and ammonia are provided in Table 28.

Table 28: Calibration values for each parameter used in the ArcNLET model.

Parameter	Module	Nitrate	Ammonia
Smoothing Factor	GW Flow	5	5
C0 (mg/L)	GW Transport	20	6
αL (m)	GW Transport	0.700	1.100
αTH (m)	GW Transport	0.600	0.080
K (1/T)	GW Transport	0.0160	0.0002

Figure 21 and Figure 22 provide a visual assessment of the best fit between the modeled nitrate and ammonia concentrations (yellow points), the measured median concentrations (blue points), and the distribution of the field measured concentration data (grey boxplots). The goal of the calibration is to be able to have the model predict the nutrient concentrations as closely as possible to the measured median nutrient concentrations. In most cases, the model is successfully calibrated if most of the predicted data is within the 25-75th percentile of the measured concentration data (i.e. the yellow points would be within the grey box or near the blue dot). This was achieved for all well locations using the nitrate concentration data, but not for one of the three wells when calibrating for ammonia. Overall, calibration was performed to best fit most of the measured well concentration data throughout the area of interest.

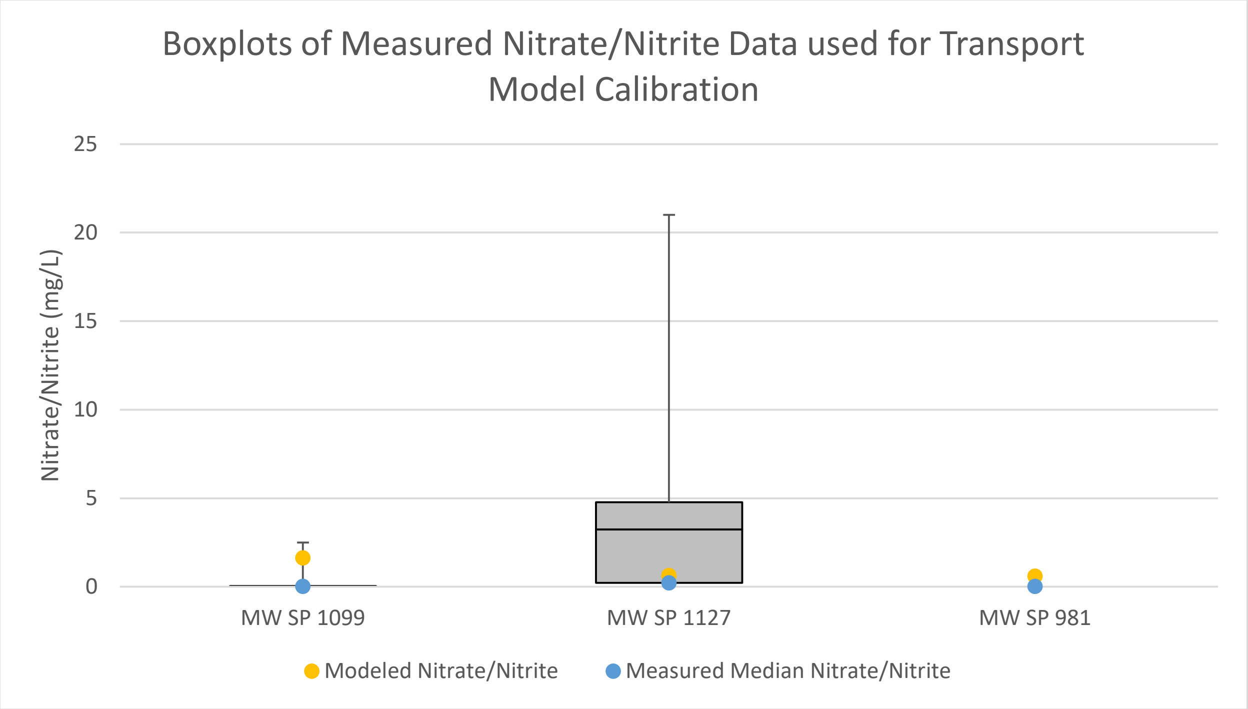


Figure 22: ArcNLET transport calibration for nitrate. The grey box shows the 25-75% of the measured data. The blue dots represent the median measured values at the sample location and the yellow dot represents the modeled output for that location.

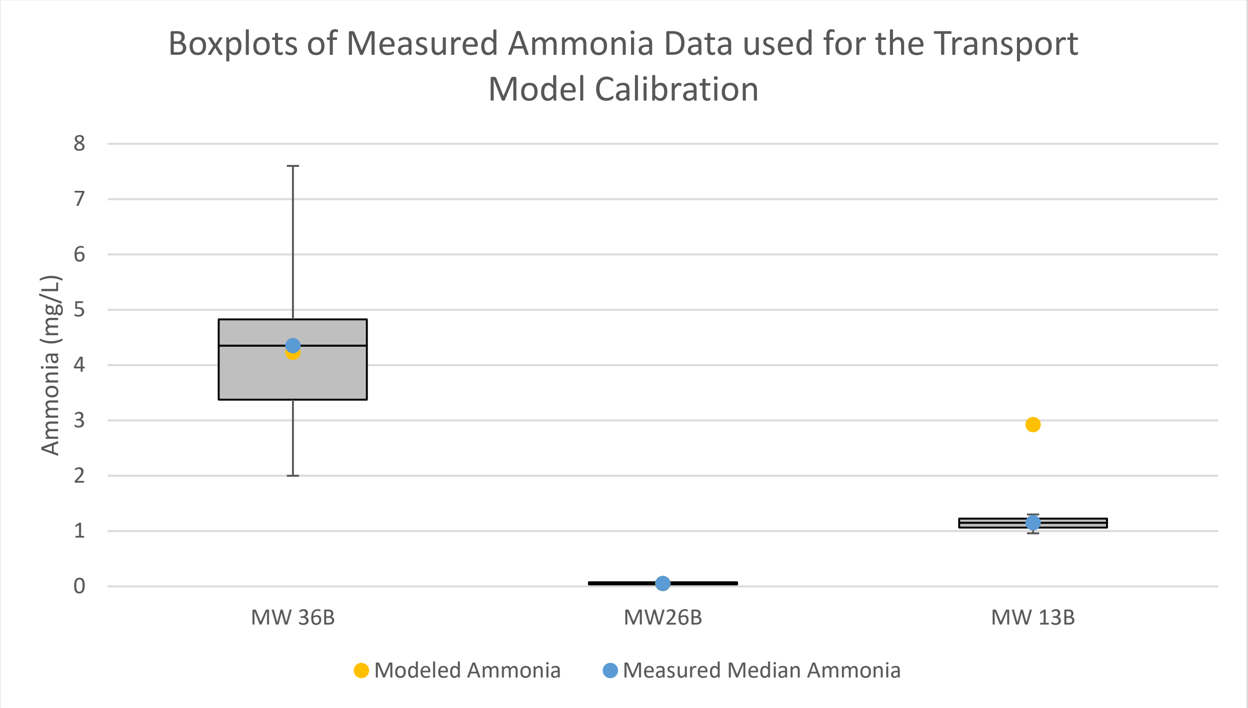


Figure 23: ArcNLET transport calibration for ammonia. The grey box shows the 25-75% of the measured data. The blue dots represent the median measured values at the sample location and the yellow dot represents the modeled output for that location

Once calibrated, the predicted modeled plumes for nitrate and ammonia have greater magnitudes at greater distances from the source than the original uncalibrated model runs (Figure 23 and Figure 24). While literature values often cite typical plume lengths ranging between 20 and 60 m (Ming *et al*., 2017), many of the plume lengths modeled for the Turkey Creek community are well above this range. Simulated plume lengths are often a result of soil type, particularly hydroconductivity and porosity characteristics which can vary between locations. Prior to calibrating and monitoring the concentrations in these types of communities, only OSTDs adjacent to waterbodies of concern were considered to have any pollution potential to the Lagoon. Static distances of 50-55-m were historically used in prioritizing septic tanks for upgrade or connection to sewer lines. High hydraulic conductance, particularly when coupled with high hydraulic head, might mean that septic systems further away from the Lagoon have a significant pollution potential and should not be dismissed.

Overall, eventually, plumes do decrease in pollutant concentration intensity with distance from the septic tank, with much higher plumes observed for nitrate than ammonia. The calibrated model, unlike the uncalibrated version, predicted that a good portion of the ammonia plumes to be nitrified to nitrate, particularly for the septic tanks located upgradient from the monitored location. However, for the plumes located closest to the Turkey Creek, the ammonia plumes have higher concentration intensities, likely due to the shallow water tables and high velocity, reducing the ability for nitrification processes to take place. Most of the septic tanks in these communities adjacent to Turkey Creek are predicted to have an impact on the water quality, even those located well beyond the 55-m distance to the Creek.

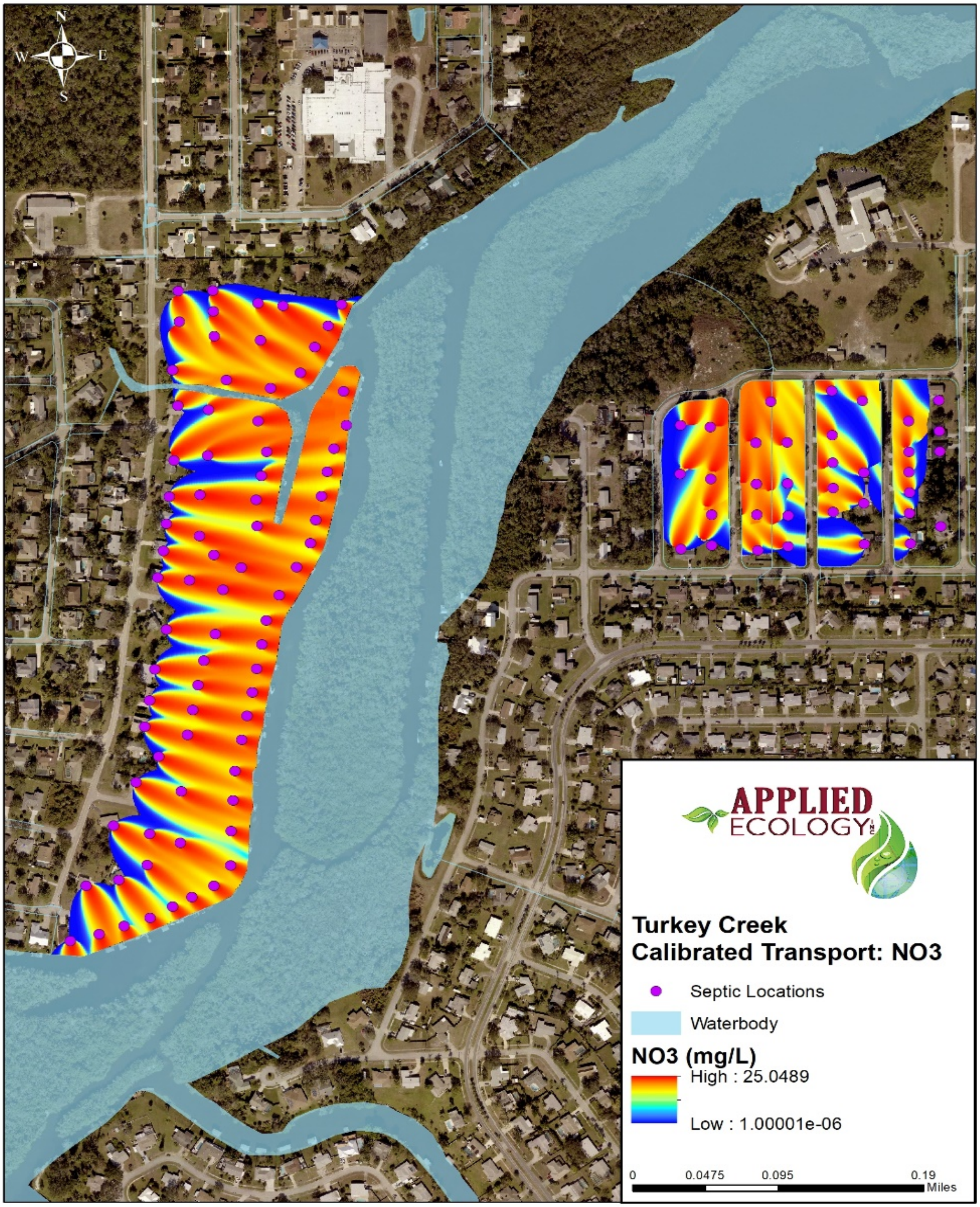


Figure 24: ArcNLET Model output after calibration with measured data shows NO_3 contaminant plumes that reach Turkey Creek. Plume direction and intensity is provided with concentrations ranging from 1×10^{-6} mg/L in blue to 25.1 mg/L in red.

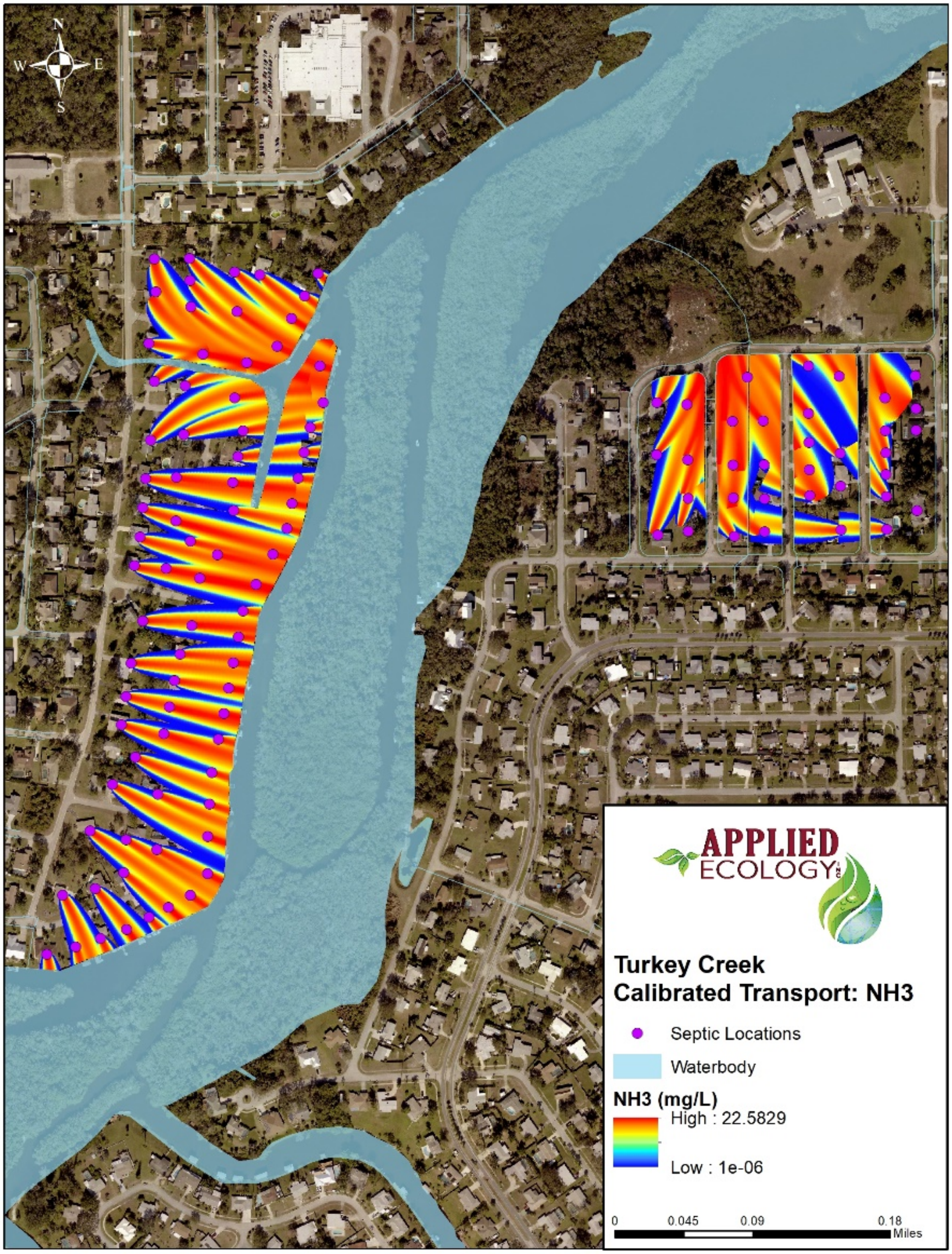


Figure 25: NH_3 plumes for the Turkey Creek study area. ArcNLET Model output after calibration with measured data shows NH_3 contaminant plumes that reach Turkey Creek. Plume direction and intensity is provided with concentrations ranging from 1 x 10^{-6} mg/L in blue to 22.6 mg/L in red.

The final step in ArcNLET calibration is to run the Load Estimation module for the Turkey Creek area of interest. The model was calibrated using the sampled data for depth to water and source loading (nitrate/nitrite and ammonia). The output from the calibrated ArcNLET run yielded a total daily output of nitrate into the Lagoon of 3,799 g/day, which corresponds to 8.38 lbs/day or 3,057 lbs of nitrate per year. In addition, the model estimated 683 g/day of ammonia would reach the Lagoon, which corresponds to a total of 549 lbs of ammonia per year. Overall, nitrogen loading (in the form of nitrate and ammonia combined) is predicted to be a total of **3,600 lbs per year**. This total corresponds to an estimated 14.1 g/septic tank/day. However, the ArcNLET model does not include other organic nitrogen compounds like urea and other biological amines. More monitoring would be needed to calculate the total loading.

Conclusion

Field research can be very challenging, especially at the watershed scale because there are so many confounding variables, extenuating circumstances, seasonal variations, and weather extremes to take into account. More time and replicates would enable greater confidence that our findings in this study are reliable and representative. The research demonstrates a method that is being replicated throughout Brevard County to inform watershed management strategies.

There has been a great deal of focus on septic tank communities (OSTDSs) as the ones likely to be polluting the most. The Source to Slime Study did not find this to be case. In Turkey Creek, all three residential communities (septic, sewer, and sewer with reclaimed irrigation) were polluting about the same amount of Total Nitrogen to the aquifer. We found that nitrogen species (organic vs inorganic nitrogen) differed significantly between communities, but that the total nitrogen did not. With the limited sampling regime in this project, it is difficult to know if this is related to the wastewater source or possible structural or ecological variations.

A second interesting finding was the extremely high levels of nitrate (NO_3) found in the community that had reclaimed irrigation water. It appears that the high concentration of nitrate in the irrigation water is percolating through the inorganic, sandy soils of that community with little to no denitrification occurring. Wastewater managers may want to consider soil type before permitting reclaimed water for irrigation, or at least consider the receiving landscape soils when deciding the discharge nitrogen concentrations that should be permitted.

The high level of organic nitrogen (NH_3 and TKN) was surprising to find in the sewer community. Considering the building materials used at the time the community was built (~1970) was vitrified clay, it is highly likely that the sewer lines are compromised and leaking. Other land uses that could cause high levels of ammonia and organic nitrogen in the groundwater such as farming activities are not taking place in this community. This is reinforced by the extraordinarily high $\delta^{15}N$ values in the sewer nitrate ($71^0/_{00}$, $38^0/_{00}$) indicative of high denitrification. One would expect high levels of denitrification to occur in aging wastewater pipes, where years of bacterial growth and carbon have proliferated. Denitrification would result in the emission of nitrogen gases and the concentration of heavy nitrate being left in solution. When considering new development or hooking existing septic tanks to sewer lines, it is important to consider the age and reliability of the existing infrastructure to which those homes will be connecting. Leaking sewer lines are no better than failing septic tanks, and in fact may be worse.

It was interesting that nitrogen concentrations differed temporally by treatment type. Seasonal variability was greatest in the reuse and the septic tank communities. Reuse treatments had the greatest variability in nitrogen concentrations, with a standard deviation of 8.4 mg/L followed by septic tank communities that had a standard deviation of 4.5 mg/L. Capturing temporal variation requires long-term monitoring to represent seasonal fluctuations. The number and placement of the wells in reuse and septic communities is key to capturing the contaminant plume.

Lastly, our study found that septic tanks in the Turkey Creek study area are contributing 3,057 lbs./year of nitrate and 549 lbs./year of ammonia to Turkey Creek. Based on the monitoring data, nitrate-nitrite and ammonia account for about 78.5% of total nitrogen. Since the current FDEP accepted model doesn’t predict urea, a bioreactive organic form of nitrogen, the total loading from septic tanks could significantly be underpredicted by the calibrated model run. Based on the measured data, total nitrogen loading into the Turkey Creek is likely at least 4,623 lbs./year or 14 lbs/year of total Nitrogen per household. Furthermore, we found that nitrogen plumes extended well beyond the 20 to 60 m reported in the literature (Ming *et al*., 2017), indicating that distance from an OSTDS to the receiving waterway shouldn’t be the only indicator used to predict loading potential.

An expanded study is being conducted that will replicate this design in 4 more areas of the county, providing much more data to calibrate the loading model and confirm the findings. Future efforts will examine relationships between rainfall, groundwater levels, and nitrogen concentrations. The groundwater sampling and isotopes contribute important source characteristics that should be duplicated in other studies to better understand nitrogen dynamics in the watershed. Adding phosphorus to the sampling regime will also be conducted to better understand source contributions.

Future research results will be able to help refine the current Watershed Loading Model for the Indian River Lagoon (SWIL model), particularly the baseflow component. Currently, the SWIL model predicts baseflow loading based on “one size fits all” estimated TN and TP concentrations for all land use and soil types. Exploring residential communities and comparing these by treatment type (septic, sewer, reclaimed) might be the first critical step in developing more robust groundwater loading estimates for the Lagoon’s watershed. In addition, expanding the extremely limited groundwater water quality database in the IRL area also allows ArcNLET to be better calibrated for other future projects. Being able to prioritize septic areas for retrofit, or even implementing policy on OSTDS needs to be justified based on relevant field collected data.

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Appendices

Appendix A

Property Access Agreement

PROPERTY ACCESS AGREEMENT

This CONDITIONAL PROPERTY ACCESS AGREEMENT (the “Agreement”) is made as of the <> day of <>, by and between PROPERTY OWNER, having an address of <> and Universal Engineering Sciences, Inc., a Florida corporation (“Consultant”) having an address of 820 Brevard Ave, Rockledge, FL 32955.

RECITALS

WHEREAS, Owner owns the certain parcels of real property located at <>, Palm Bay, FL 32905 (the “Property”), depicted on the attached legal description as Exhibit “A”; and

NOW, THEREFORE, in consideration of the mutual agreements contained herein, and other valuable consideration, the receipt and sufficiency of which is hereby acknowledged, Owner and Consultant hereby agree as follows:

1. **Grant of Access**. Owner hereby conditionally grants to Consultant, it’s agents, employees, consultants, contractors, and subcontractors (collectively “Consultant’s Agents”) a limited right of access to enter upon the Property for the sole purpose of installing groundwater monitoring wells, recovery wells, piping, etc. (hereby collectively referred to as monitoring wells) below the ground surface and collecting groundwater samples from the wells and make soil borings and taking soil samples from borings (the “Work”). Consultant shall cause the proper abandonment of the monitoring wells and restore the Property to the condition existing immediately prior to the commencement of the Work. Said work shall be at no cost to Owner.

2. **Duration and Termination of Access**. Conditional access shall be allowed upon the execution of this Agreement. This Agreement shall continue for twenty-four (24) months at which time it will expire unless extended in writing by Owner. In the event Consultant breaches any covenant or obligation under this Agreement and such breach is not cured to the reasonable satisfaction of Owner within five (5) days after receipt of notice thereof, Owner may terminate this Agreement and revoke the access granted herein upon delivery of notice to Consultant, and take all other action authorized by law or pursuant to this Agreement to remedy said breach.

3. **Covenants of Consultant.**

a. The cost of the Work and related activities shall not be born by Owner. Consultant shall obtain all licenses, approvals, certificates and permits for the performance of the Work. The Work undertaken at the Property shall be conducted in accordance with standards customarily employed in the industry and in an expeditious, safe and diligent manner. The Work shall be performed in accordance with all Environmental Laws (as defined below) and all applicable federal, state and local laws, ordinances, rules and regulations now in force and effect during the implementation and completion of the Work. By execution of this Agreement, Owner is not providing any consent or agreement to the Contamination (as defined below) or conditions at the Property, and Owner does not waive any rights or remedies in connection with any Contamination at the Property.

b. Consultant shall deliver notice to Owner at least seventy-two (72) hours' prior to every entry onto the Property, which notice shall describe in reasonable detail the Work to be performed, its location on the Property, and an estimate of the duration of the Work. Access shall be scheduled by Owner at times convenient to Owner's and Owner's Tenants. Owner shall have the right to have a representative present and accompany Consultant on the Property during access events.

c. Consultant shall control the dust, noise and other effects of the Work and related activities using appropriate methods customarily utilized in order to control the deleterious effects thereof, to Owner's satisfaction.

d. Consultant shall minimize any disruption or inconvenience caused by the Work and related activities to Owner, Owner's business and residential operations and tenants, including but not limited to location of the groundwater monitoring wells and collection of the groundwater and soil samples. The Work shall not interfere with Owner's or its tenants access to or egress from the Property.

e. Consultant shall perform the Work at locations which do not interfere with business or residential activities of Owner, its Tenants, vendors and employees during working hours.

f. Consultant shall allow Owner or its representatives to observe and monitor the performance of the Work. Owner shall have the right to obtain split samples to be provided by Consultant.

g. Consultant shall dispose of soil cuttings, any work materials and water generated during the Work in accordance with Environmental Laws and such soil cuttings and water shall be owned and controlled by Consultant as the generator of such materials. All soil cuttings, waste materials and development water generated during the Work shall be promptly removed from the Property.

h. Consultant shall repair any damage caused by the Work undertaken on the Property and restore the Property to the condition existing prior to the Work.

i. Pursuant to the provisions of Section 2 of this Agreement, Consultant shall permanently abandon the groundwater monitoring wells installed by Consultant on the Property in strict conformance with the requirements of the St. Johns River Water Management District. Consultant shall provide Owner a copy of the Well Abandonment Report confirming the proper abandonment of the groundwater monitoring wells.

4. **Covenants of the Property Owner**. Owner shall notify the Contractor in accordance with Section 9(f) of this agreement prior to commencement of any construction or other site work that may damage or destroy any part of the monitoring well(s) installed at the Property so that the Contractor has an opportunity to take necessary actions to remove, protect, properly abandon and/or repair or replace the well(s), as applicable, at no cost to the Owner. Such actions are necessary to ensure that damaged wells or borings are not left to act as open conduits that may spread contamination from all sources and violate well permits.

5. **Information Sharing**. Consultant shall provide Owner with all data collected by Consultant and Consultant's Agents, including but not limited to laboratory analysis, chain of custody records, notes, and reports reflecting sampling and analysis resulting from the Work. Consultant and Consultant's Agents shall provide such data to Owner by providing Owner a copy of the laboratory test results promptly upon receipt and a copy of the report submitted to the Agency, at no cost to Owner.

6. **Insurance**. Prior to commencing and at all times during the performance of the Work, Consultant shall maintain insurance (and shall cause their subcontractors to maintain) the following insurance coverage: Worker's Compensation and Employer's Liability Insurance at the statutory amount; Commercial General Liability ("CGL") Insurance with combined single limits of One Million Dollars ($1,000,000.00) per occurrence and Two Million Dollars ($2,000,000.00) in the aggregate; Comprehensive Automobile Liability Insurance (owned, non-owned and hired) with a combined single limit of Five Hundred Thousand Dollars ($500,000.00); and Professional Errors and Omissions Insurance with limits of One Million Dollars ($1,000,000.00) per incident and in the aggregate. Owner shall be added as an additional insured to the CGL policy and such policy shall be considered primary insurance without recourse to or contribution from any similar insurance carried by Owner. The insurance certificate shall contain a provision that coverage afforded under the policy evidenced by such certificate will not be cancelled or changed without at least thirty (30) days prior written notice to the Owner. Consultant shall deliver certificates of insurance to Owner evidencing the existence of such policy prior to the commencement of any Work.

7. **Indemnity**. Consultant shall indemnify, hold harmless and defend Owner from and against any and all claims, demands, liabilities, causes of action, losses, costs, damages and expenses (including reasonable attorney's fees and expenses and court costs) that may be asserted against or incurred by Owner in any way related to, caused by or arising out of or in connection with (i) the acts or omissions of Consultant or any agents of either of them in connection with the Work undertaken on the Property, (ii) violations or liens that may be filed against the Property as a result of the performance of the Work, (iii) personal injury, wrongful death, costs, expenses or property damage resulting from the performance of the Work or Contamination at the Property, and (iv) injunctive relief or other claims sought by any governmental authorities or third parties as a result of the Work or Contamination at the Property. Consultant shall not be required to indemnify Owner for claims, liabilities, damages, losses or expenses caused by wrongful acts or omission of Owner. The provisions of this paragraph shall survive the termination of this Agreement.

8. **No Admission.** The granting of the limited right of access herein by Owner is not intended, and shall not be construed, as an admission of liability on the part of Owner or the Owner's successors and assigns for any Contamination which may be discovered on the Property.

9. **Miscellaneous**.

(a) Entire Agreement. This Agreement shall constitute the entire agreement between the parties regarding the conditional grant of access to Consultant for the purposes herein. No modification, amendment or waiver of the terms and conditions of this Agreement shall be binding upon Owner or Consultant unless approved in writing by an authorized representative of Owner and Consultant.

(b) Governing Law; Venue. This Agreement shall be governed by and construed in accordance with the laws of the State of Florida. Venue for any action or proceeding arising from or relating to this Agreement shall be in the appropriate Florida court having jurisdiction located in Leon County, Florida.

(c) Severability. Any provision of this Agreement that is prohibited or unenforceable shall be ineffective to the extent of such prohibition or unenforceability without invalidating the remaining provisions hereof.

(d) No Third Party Beneficiaries. This Agreement is solely for the benefit of the parties hereto and their respective successors and assigns and shall not be deemed to confer upon third parties any remedy, claim, liability, or reimbursement, claim of action or other right.

(e) Representations. Each of the parties hereto represents and warrants to the other that the party executing this Agreement has the authority to do so knowing that each of the other parties to this Agreement are acting in reliance upon such representation. The provisions of this Section shall survive the termination of this Agreement.

(f) Notices. Any notice, demand, request, payment or other communication which any party hereto maybe required or may desire to give hereunder shall be in writing and shall be deemed to have been properly given (a) if hand received, (b) if received via United States mail service or other reliable express courier service, or (c) if sent via facsimile or e-mail to the addresses set forth below:

Notice to Owner: ________________________

With a copy to: ________________________

Notice to Consultant: ______________________

IN WITNESS WHEREOF, the parties have executed this Property Access Agreement under the seal of the date first above written.

“OWNER”

By:___________________________________

Print Name:____________________________

As its: Manager

“CONSULTANT”

By: ___________________________________

Print Name:____________________________

As its: ________________________________

EXHIBIT “A”
LEGAL DESCRIPTION OF PROPERTY

Appendix B

Well Completion Logs

Form FD 9000-24
GROUNDWATER SAMPLING LOG

SITENAME Turkey Creek	SITELOCATION: Palm Bay FL

WELL NO: MW TC 1	SAMPLE ID MW TC 1	DATE: 6/15/17

PURGING DATA

WELL DIAMETER (inches): 1.5	TUBING DIAMETER (inches): 1/4	WELL SCREEN INTERVAL DEPTH: feet to feet	STATIC DEPTH TO WATER (feet): 22.35	PURGE PUMP TYPE OR BAILER: PP

WELL VOLUME PURGE: **1 WELL VOLUME** = (TOTAL WELL DEPTH – STATIC DEPTH TO WATER) X WELL CAPACITY
(only fill out if applicable)
1.65 = (24 feet – 22.35 feet) X .06 gallons/foot = ,099 gallons

EQUIPMENT VOLUME PURGE: **1 EQUIPMENT VOL.** = PUMP VOLUME + (TUBING CAPACITY X TUBING LENGTH) + FLOW CELL VOLUME
(only fill out if applicable)
= gallons + (gallons/foot X feet) + gallons = gallons

INITIAL PUMP OR TUBING DEPTH IN WELL (feet): 23	FINAL PUMP OR TUBING DEPTH IN WELL (feet): 23	PURGING INITIATED AT: 9:28	PURGING ENDED AT: 10:09	TOTAL VOLUME PURGED (gallons): 3.25

TIME	VOLUME PURGED (gallons)	CUMUL. VOLUME PURGED (gallons)	PURGE RATE (gpm)	DEPTH TO WATER (feet)	pH (standard units)	TEMP. (°C)	COND. (circle units) μmhos/cm or μS/cm	DISSOLVED OXYGEN (circle units) mg/L or % saturation	TURBIDITY (NTUs)	COLOR (describe)	ODOR (describe)
9:40	1.0	1.0	.083	22.30	7.60	24.66	.976	44% 3.63	51.9	Brown	no
9:52	1.0	2.0	↓	↓	7.61	24.84	.996	37.5% 3.11	47.3	↓	↓
10:00	.5	2.5	↓	↓	7.59	24.95	.992	43.5% 3.58	32.4	LT Brown	↓
10:03	.25	2.75	↓	↓	7.58	25.10	.988	41.9% 3.44	25.2	cl	no
10:09	.5	3.25	↓	↓	7.59	25.07	.991	39.3% 3.24	19.9	↓	↓

WELL CAPACITY (Gallons Per Foot): **0.75"** = 0.02; **1"** = 0.04; **1.25"** = 0.06; **2"** = 0.16; **3"** = 0.37; **4"** = 0.65; **5"** = 1.02; **6"** = 1.47; **12"** = 5.88
TUBING INSIDE DIA. CAPACITY (Gal./Ft.): **1/8"** = 0.0006; **3/16"** = 0.0014; **1/4"** = 0.0026; **5/16"** = 0.004; **3/8"** = 0.006; **1/2"** = 0.010; **5/8"** = 0.016

PURGING EQUIPMENT CODES: **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **PP** = Peristaltic Pump; **O** = Other (Specify)

SAMPLING DATA

SAMPLED BY (PRINT) / AFFILIATION: Brandon Selph Universal Engineering	SAMPLER(S) SIGNATURE(S):	SAMPLING INITIATED AT: 10:09	SAMPLING ENDED AT: 10:16

PUMP OR TUBING DEPTH IN WELL (feet): 23	TUBING MATERIAL CODE: **PE**	FIELD-FILTERED: Y [✓ N] FILTER SIZE: _____ μm Filtration Equipment Type:

FIELD DECONTAMINATION: PUMP Y [✓ N] TUBING Y [✓ N (replaced)] DUPLICATE: Y [✓ N]

SAMPLE CONTAINER SPECIFICATION				SAMPLE PRESERVATION			INTENDED ANALYSIS AND/OR METHOD	SAMPLING EQUIPMENT CODE	SAMPLE PUMP FLOW RATE (mL per minute)
SAMPLE ID CODE	# CONTAINERS	MATERIAL CODE	VOLUME	PRESERVATIVE USED	TOTAL VOL ADDED IN FIELD (mL)	FINAL pH			
MWTC1	1	P	250ml	H2SO4	None		LAB	APP	< 100ml pm
	1	P	100ml	—					—

REMARKS:

MATERIAL CODES: **AG** = Amber Glass; **CG** = Clear Glass; **PE** = Polyethylene; **PP** = Polypropylene; **S** = Silicone; **T** = Teflon; **O** = Other (Specify)

SAMPLING EQUIPMENT CODES: **APP** = After Peristaltic Pump; **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **RFPP** = Reverse Flow Peristaltic Pump; **SM** = Straw Method (Tubing Gravity Drain); **O** = Other (Specify)

NOTES: 1. **The above do not constitute all of the information required by Chapter 62-160, F.A.C.**
2. STABILIZATION CRITERIA FOR RANGE OF VARIATION OF LAST THREE CONSECUTIVE READINGS (SEE FS 2212, SECTION 3)
pH: ± 0.2 units **Temperature:** ± 0.2 °C **Specific Conductance:** ± 5% **Dissolved Oxygen:** all readings ≤ 20% saturation (see Table FS 2200-2); optionally, ± 0.2 mg/L or ± 10% (whichever is greater) **Turbidity:** all readings ≤ 20 NTU; optionally ± 5 NTU or ± 10% (whichever is greater)

Revision Date: February 12, 2009

Florida Department of Environmental Protection - Division of Waste Management - Bureau of Petroleum Storage Systems

WELL CONSTRUCTION AND DEVELOPMENT LOG

WELL CONSTRUCTION DATA

Well Number: MWTC-1

Site Name: Turkey creek

FDEP Facility I.D. Number:

Well Install Date(s): 6/13/17

Well Location and Type (check appropriate boxes): ☑ On-Site ☐ Right-of-Way ☐ Off-Site Private Property ☐ Above Grade (AG) ☐ Flush-to-Grade

If AG, list feet of riser above land surface:

Well Purpose: ☑ Perched Monitoring ☐ Shallow (Water-Table) Monitoring ☐ Intermediate or Deep Monitoring ☐ Remediation or Other (describe)

Well Install Method: Geoprobe

Surface Casing Install Method:

Borehole Depth (feet): 22

Well Depth (feet): 24

Borehole Diameter (inches): 4"

Manhole Diameter (inches): 4"

Well Pad Size: 16" feet by 16" feet

Riser Diameter and Material: 1.5 PVC

Riser/Screen Connections: ☑ Flush-Threaded ☐ Other (describe)

Riser Length: 14 feet from 0 feet to 14 feet

Screen Diameter and Material: 1.5 PVC

Screen Slot Size: 10

Screen Length: 10 feet from 14 feet to 24 feet

1st Surface Casing Material: also check: ☑ Permanent ☐ Temporary

1st Surface Casing I.D. (inches):

1st Surface Casing Length: ____ feet from 0 feet to ____ feet

2nd Surface Casing Material: also check: ☐ Permanent ☐ Temporary

2nd Surface Casing I.D. (inches):

2nd Surface Casing Length: ____ feet from 0 feet to ____ feet

3rd Surface Casing Material: also check: ☐ Permanent ☐ Temporary

3rd Surface Casing I.D. (inches):

3rd Surface Casing Length: ____ feet from 0 feet to ____ feet

Filter Pack Material and Size:

Prepacked Filter Around Screen (check one): ☑ Yes ☐ No

Filter Pack Length: 10 feet from 14 feet to 24 feet

Filter Pack Seal Material and Size: 30/65

Filter Pack Seal Length: 2 feet from 12 feet to 14 feet

Surface Seal Material: Grout

Surface Seal Length: 12 feet from 0 feet to 12 feet

WELL DEVELOPMENT DATA

Well Development Date: 6/14/17

Well Development Method (check one): ☐ Surge/Pump ☑ Pump ☐ Compressed Air ☐ Other (describe)

Development Pump Type (check): ☐ Centrifugal ☑ Peristaltic ☐ Submersible ☐ Other (describe)

Depth to Groundwater (before developing in feet): 22.4

Pumping Rate (gallons per minute): .125

Maximum Drawdown of Groundwater During Development (feet): .5

Well Purged Dry (check one): ☐ Yes ☑ No

Pumping Condition (check one): ☑ Continuous ☐ Intermittent

Total Development Water Removed (gallons): 7.5

Development Duration (minutes): 60

Development Water Drummed (check one): ☐ Yes ☐ No

Water Appearance (color and odor) At Start of Development:

Water Appearance (color and odor) At End of Development:

WELL CONSTRUCTION OR DEVELOPMENT REMARKS

9:20 to 10:20

22.6 Ending NTUs

UNIVERSAL
ENGINEERING SCIENCES
WELL COMPLETION LOG

PROJECT NO:
REPORT NO:
PAGE:

PROJECT: Turkey Creek
CLIENT: Applied Ecology Inc. DATE: 6-13-17
WELL NUMBER: MWTC-1 LOCATION: Palm Bay FL
INSTALLED BY: BMS

FIELD LOG OF BORING

DEPTH	LOG	CLASSIFICATION OF MATERIAL
1	↓	LT Brown sands
2		S1
3		
4	4.0	
5		
6	↓	S2
7		
8	8.0	
9		
10		11.0 Gray brown clayey
11		
12	12.0	Sands S3
13		
14		S4 LT Brown sands
15		+ clay
16		S5
17	16.0	17.0 LT Brown clayey sands
18		
19		S5
20	20.0	
21		
22		6
23		
24		7
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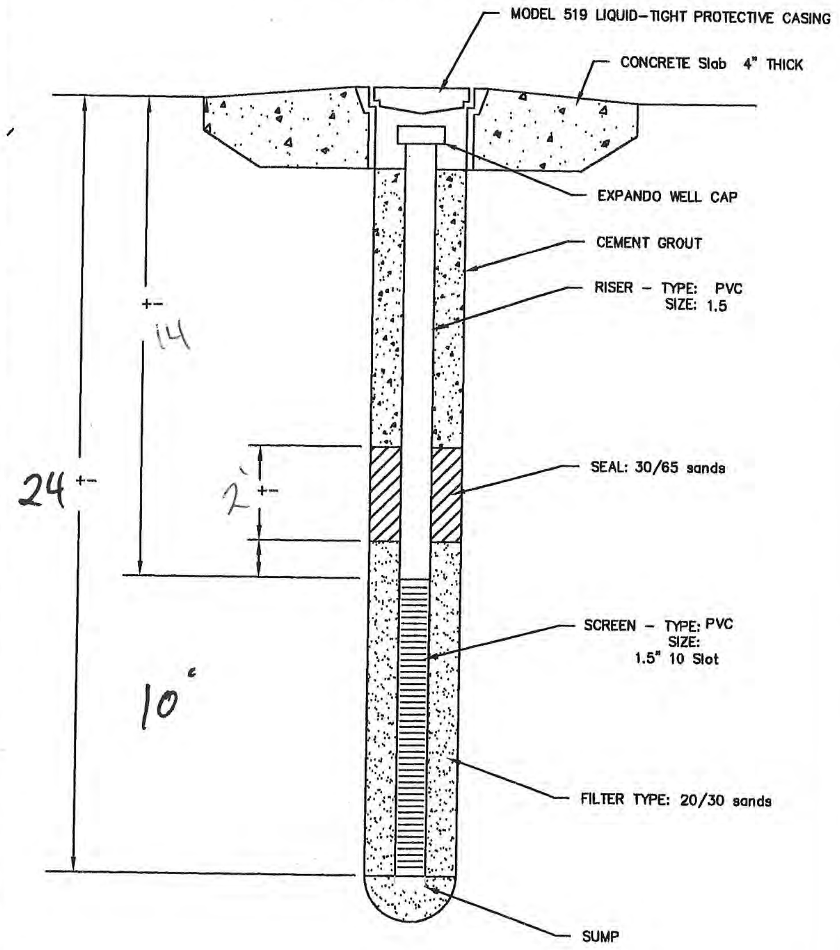
WELL DIAGRAM – NOT TO SCALE



\# 1 BAGS OF SAND
\# 2.5 BAGS OF GROUT
\# 2 BAGS OF CONCRETE
\# 0 SOIL DRUMS
\# 0 WATER DRUMS

DATE OF BORING
6/13/17
WATER TABLE
17.5 22.4
TOTAL DEPTH OF BORING
24

FORM: WC09

Form FD 9000-24

GROUNDWATER SAMPLING LOG

SITENAME: Turkey Creek
SITELOCATION: Palm Bay
WELL NO: MW TC 2
SAMPLE ID: MWTC 2
DATE: 6/15/14

PURGING DATA

WELL DIAMETER (inches): 1.5
TUBING DIAMETER (inches): 1/4
WELL SCREEN INTERVAL DEPTH: 8 feet to 18 feet
STATIC DEPTH TO WATER (feet): 12.45
PURGE PUMP TYPE OR BAILER: PP

WELL VOLUME PURGE: 1 WELL VOLUME = (TOTAL WELL DEPTH – STATIC DEPTH TO WATER) X WELL CAPACITY
(only fill out if applicable)
5.55 = (18 feet – 12.45 feet) X .06 gallons/foot = .33 gallons

EQUIPMENT VOLUME PURGE: 1 EQUIPMENT VOL. = PUMP VOLUME + (TUBING CAPACITY X TUBING LENGTH) + FLOW CELL VOLUME
(only fill out if applicable)
= gallons + (gallons/foot X feet) + gallons = gallons

INITIAL PUMP OR TUBING DEPTH IN WELL (feet): 16
FINAL PUMP OR TUBING DEPTH IN WELL (feet): 16
PURGING INITIATED AT: 8:11
PURGING ENDED AT: 8:39
TOTAL VOLUME PURGED (gallons): 4.5

TIME	VOLUME PURGED (gallons)	CUMUL. VOLUME PURGED (gallons)	PURGE RATE (gpm)	DEPTH TO WATER (feet)	pH (standard units)	TEMP. (°C)	COND. (circle units) μmhos/cm or μS/cm	DISSOLVED OXYGEN (circle units) mg/L or % saturation	TURBIDITY (NTUs)	COLOR (describe)	ODOR (describe)
8:13	.50	.50	.125	13.8	8.09	23.65	1.324	46 1/382	67.3	LT Brn	no
8:15	.5	1.0	↓	↓	↓	23.64	1.325	38.2% 4.04	124	↓	no
8:19	1.0	2.0	↓	↓	8.11	23.62	1.326	48% 4.3	95	↓	↓
8:23	.5	2.5	.125	13.6	8.11	23.64	1.326	38% 3.23	59.1	↓	↓
8:27	.5	3.0	↓	↓	↓	23.67	1.327	32.1% .27	48.8	↓	↓
8:31	.5	3.5	↓	↓	↓	23.67	1.315	31.2 2.62	33.9	↓ <1	↓
8:35	.5	4.0	↓	↓	8.12	23.69	1.337	26.7 2.25	25.7	<1	no
8:39	.5	4.5	↓	↓	↓	23.66	1.328	24.1 2.12	13.8	↓	↓

WELL CAPACITY (Gallons Per Foot): **0.75"** = 0.02; **1"** = 0.04; **1.25"** = 0.06; **2"** = 0.16; **3"** = 0.37; **4"** = 0.65; **5"** = 1.02; **6"** = 1.47; **12"** = 5.88
TUBING INSIDE DIA. CAPACITY (Gal./Ft.): **1/8"** = 0.0006; **3/16"** = 0.0014; **1/4"** = 0.0026; **5/16"** = 0.004; **3/8"** = 0.006; **1/2"** = 0.010; **5/8"** = 0.016

PURGING EQUIPMENT CODES: B = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **PP** = Peristaltic Pump; **O** = Other (Specify)

SAMPLING DATA

SAMPLED BY (PRINT) / AFFILIATION: Brandon Selph Universal Engineering
SAMPLER(S) SIGNATURE(S): BS
SAMPLING INITIATED AT: 8:39
SAMPLING ENDED AT: 8:43
PUMP OR TUBING DEPTH IN WELL (feet): 16
TUBING MATERIAL CODE: PE
FIELD-FILTERED: Y [✓ N]
FILTER SIZE: _____ μm
Filtration Equipment Type:
FIELD DECONTAMINATION: PUMP Y [✓ N] TUBING Y N [✓ (replaced)]
DUPLICATE: Y [✓ N]

SAMPLE CONTAINER SPECIFICATION				SAMPLE PRESERVATION			INTENDED ANALYSIS AND/OR METHOD	SAMPLING EQUIPMENT CODE	SAMPLE PUMP FLOW RATE (mL per minute)
SAMPLE ID CODE	# CONTAINERS	MATERIAL CODE	VOLUME	PRESERVATIVE USED	TOTAL VOL ADDED IN FIELD (mL)	FINAL pH			
MW TC2	1	250 P	250ml	H2SO4			LAB	APP	< 100ml pm
	1	100 P	100ml	–	NONE				

REMARKS:

MATERIAL CODES: AG = Amber Glass; **CG** = Clear Glass; **PE** = Polyethylene; **PP** = Polypropylene; **S** = Silicone; **T** = Teflon; **O** = Other (Specify)

SAMPLING EQUIPMENT CODES: APP = After Peristaltic Pump; **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **RFPP** = Reverse Flow Peristaltic Pump; **SM** = Straw Method (Tubing Gravity Drain); **O** = Other (Specify)

NOTES: 1. The above do not constitute all of the information required by Chapter 62-160, F.A.C.
2. STABILIZATION CRITERIA FOR RANGE OF VARIATION OF LAST THREE CONSECUTIVE READINGS (SEE FS 2212, SECTION 3)
pH: ± 0.2 units **Temperature:** ± 0.2 °C **Specific Conductance:** ± 5% **Dissolved Oxygen:** all readings ≤ 20% saturation (see Table FS 2200-2); optionally, ± 0.2 mg/L or ± 10% (whichever is greater) **Turbidity:** all readings ≤ 20 NTU; optionally ± 5 NTU or ± 10% (whichever is greater)

Revision Date: February 12, 2009

Florida Department of Environmental Protection - Division of Waste Management - Bureau of Petroleum Storage Systems

WELL CONSTRUCTION AND DEVELOPMENT LOG

WELL CONSTRUCTION DATA

Well Number: MWTC2

Site Name: TurkeyCreek

FDEP Facility I.D. Number:

Well Install Date(s): 6/13/17

Well Location and Type (check appropriate boxes):
☑ On-Site ☐ Right-of-Way
☐ Off-Site Private Property
☐ Above Grade (AG) ☐ Flush-to-Grade
If AG, list feet of riser above land surface:

Well Purpose:
☑ Perched Monitoring
☐ Shallow (Water-Table) Monitoring
☐ Intermediate or Deep Monitoring
☐ Remediation or Other (describe)

Well Install Method: Geoprobe

Surface Casing Install Method:

Borehole Depth (feet): 18

Well Depth (feet): 18

Borehole Diameter (inches): 4"

Manhole Diameter (inches): 4"

Well Pad Size: 16" feet by 16" feet

Riser Diameter and Material: 1.5 PVC

Riser/Screen Connections: ☑ Flush-Threaded ☐ Other (describe)

Riser Length: 8 feet from 0 feet to 8 feet

Screen Diameter and Material: 1.5 PVC

Screen Slot Size: 10

Screen Length: 10 feet from 8 feet to 18 feet

1st Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

1st Surface Casing I.D. (inches):

1st Surface Casing Length: ____ feet from 0 feet to ____ feet

2nd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

2nd Surface Casing I.D. (inches):

2nd Surface Casing Length: ____ feet from 0 feet to ____ feet

3rd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

3rd Surface Casing I.D. (inches):

3rd Surface Casing Length: ____ feet from 0 feet to ____ feet

Filter Pack Material and Size:

Prepacked Filter Around Screen (check one): ☑ Yes ☐ No

Filter Pack Length: 10 feet from 8 feet to 18 feet

Filter Pack Seal Material and Size: 30/65 sands

Filter Pack Seal Length: 2 feet from 6 feet to 8 feet

Surface Seal Material: Grout

Surface Seal Length: 6 feet from 0 feet to 6 feet

WELL DEVELOPMENT DATA

Well Development Date: 6/14/17

Well Development Method (check one): ☐ Surge/Pump ☑ Pump ☐ Compressed Air ☐ Other (describe)

Development Pump Type (check): ☐ Centrifugal ☑ Peristaltic ☐ Submersible ☐ Other (describe)

Depth to Groundwater (before developing in feet): 12.6

Pumping Rate (gallons per minute): .25

Maximum Drawdown of Groundwater During Development (feet): 1.1

Well Purged Dry (check one): ☐ Yes ☐ No

Pumping Condition (check one): ☐ Continuous ☐ Intermittent

Total Development Water Removed (gallons): 10

Development Duration (minutes): 40

Development Water Drummed (check one): ☐ Yes ☐ No

Water Appearance (color and odor) At Start of Development:

Water Appearance (color and odor) At End of Development:

WELL CONSTRUCTION OR DEVELOPMENT REMARKS

816 to 856 18.6 Ending NTUs

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WELL COMPLETION LOG

PROJECT NO:
REPORT NO:
PAGE:

PROJECT: Turkey Creek
CLIENT: Applied Ecology Inc DATE: 6/13/17
WELL NUMBER: MWTC 2 LOCATION: Palm Bay FL
INSTALLED BY:

FIELD LOG OF BORING

DEPTH	LOG	CLASSIFICATION OF MATERIAL
1		Brown sands 51
2	2.5	LT Brown sands 52
3		
4	4.0	
5		53
6	6.0	
7		Brown sands 54
8		
9	8.0	
10		55
11		
12	11.0	Grey/Brown clayey sands
13		
14		56
15		
16		
17	13.0 wet	57
18		Grey/Brown sands
19		
20		
21		
22		
23	18.0	
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
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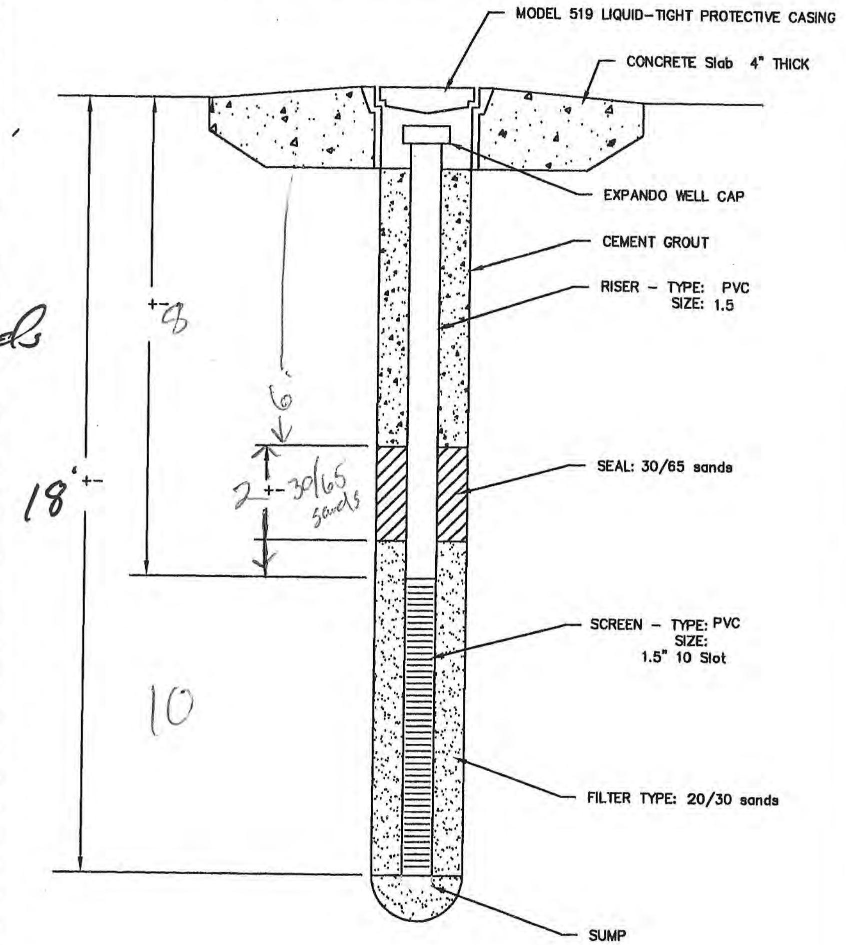
49		
50		

WELL DIAGRAM – NOT TO SCALE



FORM: WC09

1 BAGS OF SAND
2 BAGS OF GROUT
2 BAGS OF CONCRETE
0 SOIL DRUMS
0 WATER DRUMS

DATE OF BORING
6/13/17
WATER TABLE
13.7 13.0
TOTAL DEPTH OF BORING
18'

Form FD 9000-24

GROUNDWATER SAMPLING LOG

SITENAME: Turkey Creek
SITELOCATION: Palm Bay
WELL NO: MWSP1127
SAMPLE ID: MWSP1127
DATE: 6/16/17

PURGING DATA

WELL DIAMETER (inches): 1.5
TUBING DIAMETER (inches): 1/4
WELL SCREEN INTERVAL DEPTH: feet to feet
STATIC DEPTH TO WATER (feet): 3.65
PURGE PUMP TYPE OR BAILER: PP

WELL VOLUME PURGE: **1 WELL VOLUME** = (TOTAL WELL DEPTH – STATIC DEPTH TO WATER) X WELL CAPACITY
(only fill out if applicable)
8.35 = (12 feet – 3.65 feet) X .06 gallons/foot = .50 gallons

EQUIPMENT VOLUME PURGE: **1 EQUIPMENT VOL.** = PUMP VOLUME + (TUBING CAPACITY X TUBING LENGTH) + FLOW CELL VOLUME
(only fill out if applicable)
= gallons + (gallons/foot X feet) + gallons = gallons

INITIAL PUMP OR TUBING DEPTH IN WELL (feet): 8.5
FINAL PUMP OR TUBING DEPTH IN WELL (feet): 8.5
PURGING INITIATED AT: 9:48
PURGING ENDED AT: 10:00
TOTAL VOLUME PURGED (gallons): 3.0

TIME	VOLUME PURGED (gallons)	CUMUL. VOLUME PURGED (gallons)	PURGE RATE (gpm)	DEPTH TO WATER (feet)	pH (standard units)	TEMP. (°C)	COND. (circle units) µmhos/cm or µS/cm	DISSOLVED OXYGEN (circle units) mg/L or % saturation	TURBIDITY (NTUs)	COLOR (describe)	ODOR (describe)
9:52	1.0	1.0	.25	4.3	8.05	26.54	.066	30.5% 2.3	217	LT Gray	no
9:56	1.0	2.0	↓	↓	8.03	26.53	.064	21.8% 1.73	25.9	C	1
10:00	1.0	3.0	↓	↓	8.02	26.51	.064	15.4% 1.23	15.4	↓	↓

WELL CAPACITY (Gallons Per Foot): **0.75"** = 0.02; **1"** = 0.04; **1.25"** = 0.06; **2"** = 0.16; **3"** = 0.37; **4"** = 0.65; **5"** = 1.02; **6"** = 1.47; **12"** = 5.88
TUBING INSIDE DIA. CAPACITY (Gal./Ft.): **1/8"** = 0.0006; **3/16"** = 0.0014; **1/4"** = 0.0026; **5/16"** = 0.004; **3/8"** = 0.006; **1/2"** = 0.010; **5/8"** = 0.016
PURGING EQUIPMENT CODES: **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **PP** = Peristaltic Pump; **O** = Other (Specify)

SAMPLING DATA

SAMPLED BY (PRINT) / AFFILIATION: Brandon Selph Universal Engineering
SAMPLER(S) SIGNATURE(S):
SAMPLING INITIATED AT: 10:00
SAMPLING ENDED AT: 10:05
PUMP OR TUBING DEPTH IN WELL (feet): 8.5
TUBING MATERIAL CODE: PE
FIELD-FILTERED: Y [✓ N]
FILTER SIZE: _____ µm
Filtration Equipment Type:
FIELD DECONTAMINATION: PUMP Y [✓ N] TUBING Y [✓ N (replaced)]
DUPLICATE: Y [✓ N]

SAMPLE CONTAINER SPECIFICATION				SAMPLE PRESERVATION			INTENDED ANALYSIS AND/OR METHOD	SAMPLING EQUIPMENT CODE	SAMPLE PUMP FLOW RATE (mL per minute)
SAMPLE ID CODE	# CONTAINERS	MATERIAL CODE	VOLUME	PRESERVATIVE USED	TOTAL VOL ADDED IN FIELD (mL)	FINAL pH			
SP1127	1	P	250 mL	yes	none		LAB	APP	<100ml/pm
↓	1	P	100 mL	~				~	~

REMARKS:

MATERIAL CODES: **AG** = Amber Glass; **CG** = Clear Glass; **PE** = Polyethylene; **PP** = Polypropylene; **S** = Silicone; **T** = Teflon; **O** = Other (Specify)

SAMPLING EQUIPMENT CODES: **APP** = After Peristaltic Pump; **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **RFPP** = Reverse Flow Peristaltic Pump; **SM** = Straw Method (Tubing Gravity Drain); **O** = Other (Specify)

NOTES: 1. **The above do not constitute all of the information required by Chapter 62-160, F.A.C.**
2. STABILIZATION CRITERIA FOR RANGE OF VARIATION OF LAST THREE CONSECUTIVE READINGS (SEE FS 2212, SECTION 3)
pH: ± 0.2 units **Temperature:** ± 0.2 °C **Specific Conductance:** ± 5% **Dissolved Oxygen:** all readings ≤ 20% saturation (see Table FS 2200-2); optionally, ± 0.2 mg/L or ± 10% (whichever is greater) **Turbidity:** all readings ≤ 20 NTU; optionally ± 5 NTU or ± 10% (whichever is greater)

Revision Date: February 12, 2009

Florida Department of Environmental Protection - Division of Waste Management - Bureau of Petroleum Storage Systems

WELL CONSTRUCTION AND DEVELOPMENT LOG

WELL CONSTRUCTION DATA

Well Number: MWSP1127

Site Name: Turkey Creek

FDEP Facility I.D. Number:

Well Install Date(s): 6/02/17

Well Location and Type (check appropriate boxes):
☑ On-Site ☐ Right-of-Way
☐ Off-Site Private Property
☐ Above Grade (AG) ☐ Flush-to-Grade

If AG, list feet of riser above land surface:

Well Purpose: ☑ Perched Monitoring
☐ Shallow (Water-Table) Monitoring
☐ Intermediate or Deep Monitoring
☐ Remediation or Other (describe)

Well Install Method: Geoprobe

Surface Casing Install Method:

Borehole Depth (feet): 12

Well Depth (feet): 12

Borehole Diameter (inches): 4"

Manhole Diameter (inches): 4"

Well Pad Size: 16" feet by 16" feet

Riser Diameter and Material: 1.5

Riser/Screen Connections: ☑ Flush-Threaded ☐ Other (describe)

Riser Length: 2 feet
from 0 feet to 2 feet

Screen Diameter and Material: 1.5 PVC

Screen Slot Size: 10

Screen Length: 10' feet
from 2' feet to 10' feet

1st Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

1st Surface Casing I.D. (inches):

1st Surface Casing Length: ____ feet
from 0 feet to ____ feet

2nd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

2nd Surface Casing I.D. (inches):

2nd Surface Casing Length: ____ feet
from 0 feet to ____ feet

3rd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

3rd Surface Casing I.D. (inches):

3rd Surface Casing Length: ____ feet
from 0 feet to ____ feet

Filter Pack Material and Size:

Prepacked Filter Around Screen (check one): ☑ Yes ☐ No

Filter Pack Length: 10 feet
from 2 feet to 12 feet

Filter Pack Seal Material and Size: 30/65/sands

Filter Pack Seal Length: 1 feet
from 1 feet to 2 feet

Surface Seal Material: Grout

Surface Seal Length: 1 feet
from 0 feet to 1 feet

WELL DEVELOPMENT DATA

Well Development Date: 6/14/17

Well Development Method (check one): ☐ Surge/Pump ☑ Pump ☐ Compressed Air
☐ Other (describe)

Development Pump Type (check): ☐ Centrifugal ☑ Peristaltic
☐ Submersible ☐ Other (describe)

Depth to Groundwater (before developing in feet): 4'

Pumping Rate (gallons per minute): .25

Maximum Drawdown of Groundwater During Development (feet): .5

Well Purged Dry (check one): ☐ Yes ☑ No

Pumping Condition (check one): ☑ Continuous ☐ Intermittent

Total Development Water Removed (gallons): 4

Development Duration (minutes): 16

Development Water Drummed (check one): ☐ Yes ☑ No

Water Appearance (color and odor) At Start of Development: Brown

Water Appearance (color and odor) At End of Development: clear

WELL CONSTRUCTION OR DEVELOPMENT REMARKS

1:38 to 1:54

18.4 Ending NTUs

UNIVERSAL
ENGINEERING SCIENCES

WELL COMPLETION LOG

PROJECT NO:

REPORT NO:

PAGE:

PROJECT: Turkey Creek

CLIENT: Applied Ecology Inc.

DATE: 6/12/17

WELL NUMBER: MWSP 1127

LOCATION: Palm Bay FL

INSTALLED BY: BMS

FIELD LOG OF BORING

DEPTH	LOG	CLASSIFICATION OF MATERIAL
1		Grays w Brown sands S1
2		S2 S3
3	4.0	wet Brown sands S4
4		
5	6	
6		
7	7	
8		LT Brown sands S5
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19	10.5	
20		
21		Gray Brown sands & clay
22		S6
23		
24	12.0	EOB
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		
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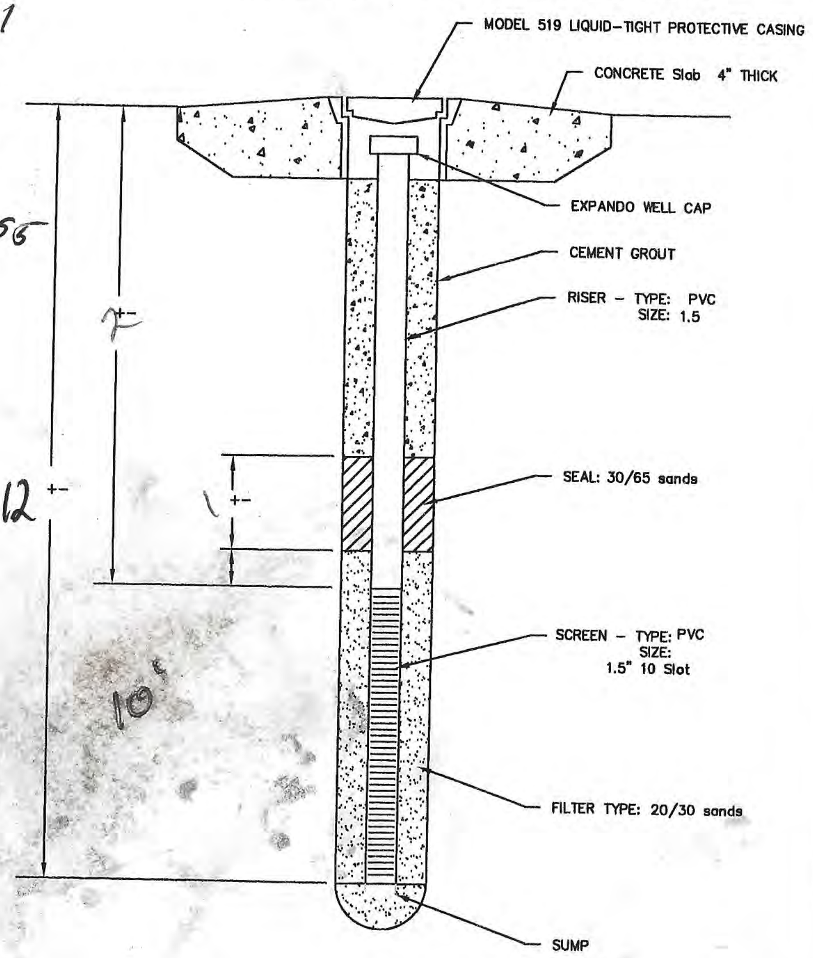
50		

WELL DIAGRAM – NOT TO SCALE



\# ½ BAGS OF SAND

\# ½ BAGS OF GROUT

\# 2 BAGS OF CONCRETE

\# 0 SOIL DRUMS

\# 0 WATER DRUMS

DATE OF BORING
6/12/17

WATER TABLE
4 3.9

TOTAL DEPTH OF BORING
12'

FORM: WC09

Form FD 9000-24

GROUNDWATER SAMPLING LOG

SITENAME: Turkey Creek
SITELOCATION: Palm Bay
WELL NO: MWSP 1099
SAMPLE ID: MW SP 1099
DATE: 6/16/17

PURGING DATA

WELL DIAMETER (inches): 1.5
TUBING DIAMETER (inches): 1/4
WELL SCREEN INTERVAL DEPTH: feet to feet
STATIC DEPTH TO WATER (feet): 2.2
PURGE PUMP TYPE OR BAILER: PP

WELL VOLUME PURGE: 1 WELL VOLUME = (TOTAL WELL DEPTH – STATIC DEPTH TO WATER) X WELL CAPACITY
(only fill out if applicable)
9.8 = (12' feet – 2.7 feet) X .06 gallons/foot = .58 gallons

EQUIPMENT VOLUME PURGE: 1 EQUIPMENT VOL. = PUMP VOLUME + (TUBING CAPACITY X TUBING LENGTH) + FLOW CELL VOLUME
(only fill out if applicable)
= gallons + (gallons/foot X feet) + gallons = gallons

INITIAL PUMP OR TUBING DEPTH IN WELL (feet): 8'
FINAL PUMP OR TUBING DEPTH IN WELL (feet): 8'
PURGING INITIATED AT: 10:15
PURGING ENDED AT: 10:21
TOTAL VOLUME PURGED (gallons): 1.5

TIME	VOLUME PURGED (gallons)	CUMUL. VOLUME PURGED (gallons)	PURGE RATE (gpm)	DEPTH TO WATER (feet)	pH (standard units)	TEMP. (°C)	COND. (circle units) µmhos/cm or µS/cm	DISSOLVED OXYGEN (circle units) mg/L or % saturation	TURBIDITY (NTUs)	COLOR (describe)	ODOR (describe)
10:17	.5	.5	.25	2.4	8.18	25.72	.064	10.9%.99	13.2	Cl	no
10:19	.5	1.0	↓	↓	8.17	25.70	.064	11.9%.96	20.0	–	–
10:21	.5	1.5	↓	↓	8.22	25.60	.066	15.7%.129	16.5	–	–

WELL CAPACITY (Gallons Per Foot): **0.75"** = 0.02; **1"** = 0.04; **1.25"** = 0.06; **2"** = 0.16; **3"** = 0.37; **4"** = 0.65; **5"** = 1.02; **6"** = 1.47; **12"** = 5.88
TUBING INSIDE DIA. CAPACITY (Gal./Ft.): **1/8"** = 0.0006; **3/16"** = 0.0014; **1/4"** = 0.0026; **5/16"** = 0.004; **3/8"** = 0.006; **1/2"** = 0.010; **5/8"** = 0.016

PURGING EQUIPMENT CODES: **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **PP** = Peristaltic Pump; **O** = Other (Specify)

SAMPLING DATA

SAMPLED BY (PRINT) / AFFILIATION: Brandon Selph Universal Engineering
SAMPLER(S) SIGNATURE(S):
SAMPLING INITIATED AT: 10:21
SAMPLING ENDED AT: 10:26

PUMP OR TUBING DEPTH IN WELL (feet): 8'
TUBING MATERIAL CODE: PE
FIELD-FILTERED: Y [✓ N]
FILTER SIZE: _____ µm
Filtration Equipment Type:

FIELD DECONTAMINATION: PUMP Y [✓ N] TUBING Y [✓ N (replaced)]
DUPLICATE: Y [✓ N]

SAMPLE CONTAINER SPECIFICATION				SAMPLE PRESERVATION			INTENDED ANALYSIS AND/OR METHOD	SAMPLING EQUIPMENT CODE	SAMPLE PUMP FLOW RATE (mL per minute)
SAMPLE ID CODE	# CONTAINERS	MATERIAL CODE	VOLUME	PRESERVATIVE USED	TOTAL VOL ADDED IN FIELD (mL)	FINAL pH			
MWSP 1099	1	P	250	YES	NONE		LHB	APP	<100ml/m
	1	P	100					–	–

REMARKS:

MATERIAL CODES: **AG** = Amber Glass; **CG** = Clear Glass; **PE** = Polyethylene; **PP** = Polypropylene; **S** = Silicone; **T** = Teflon; **O** = Other (Specify)

SAMPLING EQUIPMENT CODES: **APP** = After Peristaltic Pump; **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **RFPP** = Reverse Flow Peristaltic Pump; **SM** = Straw Method (Tubing Gravity Drain); **O** = Other (Specify)

NOTES: 1. **The above do not constitute all of the information required by Chapter 62-160, F.A.C.**
2. STABILIZATION CRITERIA FOR RANGE OF VARIATION OF LAST THREE CONSECUTIVE READINGS (SEE FS 2212, SECTION 3)
pH: ± 0.2 units **Temperature:** ± 0.2 °C **Specific Conductance:** ± 5% **Dissolved Oxygen:** all readings ≤ 20% saturation (see Table FS 2200-2); optionally, ± 0.2 mg/L or ± 10% (whichever is greater) **Turbidity:** all readings ≤ 20 NTU; optionally ± 5 NTU or ± 10% (whichever is greater)

Revision Date: February 12, 2009

Florida Department of Environmental Protection - Division of Waste Management - Bureau of Petroleum Storage Systems

WELL CONSTRUCTION AND DEVELOPMENT LOG

WELL CONSTRUCTION DATA

Well Number: MW SP1099

Site Name: TurkeyCreek

FDEP Facility I.D. Number:

Well Install Date(s): 6/12/17

Well Location and Type (check appropriate boxes):
☑ On-Site ☐ Right-of-Way
☐ Off-Site Private Property
☐ Above Grade (AG) ☐ Flush-to-Grade
If AG, list feet of riser above land surface:

Well Purpose:
☑ Perched Monitoring
☐ Shallow (Water-Table) Monitoring
☐ Intermediate or Deep Monitoring
☐ Remediation or Other (describe)

Well Install Method: Geoprobe

Surface Casing Install Method:

Borehole Depth (feet): 12'

Well Depth (feet): 12'

Borehole Diameter (inches): 4"

Manhole Diameter (inches): 4"

Well Pad Size: 16" feet by 16" feet

Riser Diameter and Material: 1.5

Riser/Screen Connections: ☑ Flush-Threaded ☐ Other (describe)

Riser Length: 2 feet from 0 feet to 2 feet

Screen Diameter and Material: 1.5 PVC

Screen Slot Size: 10

Screen Length: 10 feet from 2' feet to 12' feet

1st Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

1st Surface Casing I.D. (inches):

1st Surface Casing Length: ____ feet from 0 feet to ____ feet

2nd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

2nd Surface Casing I.D. (inches):

2nd Surface Casing Length: ____ feet from 0 feet to ____ feet

3rd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

3rd Surface Casing I.D. (inches):

3rd Surface Casing Length: ____ feet from 0 feet to ____ feet

Filter Pack Material and Size:

Prepacked Filter Around Screen (check one): ☑ Yes ☐ No

Filter Pack Length: 10' feet from 2 feet to 12 feet

Filter Pack Seal Material and Size: 30/65 sands

Filter Pack Seal Length: 1 feet from 1 feet to 2' feet

Surface Seal Material: Grout

Surface Seal Length: 1 feet from 0 feet to 1 feet

WELL DEVELOPMENT DATA

Well Development Date: 6/12/17

Well Development Method (check one): ☐ Surge/Pump ☑ Pump ☐ Compressed Air ☐ Other (describe)

Development Pump Type (check): ☐ Centrifugal ☑ Peristaltic ☐ Submersible ☐ Other (describe)

Depth to Groundwater (before developing in feet): 3.25

Pumping Rate (gallons per minute): .25

Maximum Drawdown of Groundwater During Development (feet): 4.5

Well Purged Dry (check one): ☐ Yes ☑ No

Pumping Condition (check one): ☑ Continuous ☐ Intermittent

Total Development Water Removed (gallons): 2.5

Development Duration (minutes): 10

Development Water Drummed (check one): ☐ Yes ☑ No

Water Appearance (color and odor) At Start of Development: DK Gray/Brown

Water Appearance (color and odor) At End of Development: LT Gray/Brown NO

WELL CONSTRUCTION OR DEVELOPMENT REMARKS

4:10
4:20

Ending NTU 15.9

UNIVERSAL ENGINEERING SCIENCES

WELL COMPLETION LOG

PROJECT NO:
REPORT NO:
PAGE:

PROJECT: Turkey Creek
CLIENT: Applied Ecology Inc DATE: 6/12/17
WELL NUMBER: MWSP1099 LOCATION: Palm Bay FL
INSTALLED BY: BMS

FIELD LOG OF BORING

DEPTH	LOG	CLASSIFICATION OF MATERIAL
1		Grasses
2		Brown sands S1
3		
4		↓
5		
6	40	wet
7		S2
8		
9		
10		S3 w Wood
11		
12		
13		
14	120	
15		EOB
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
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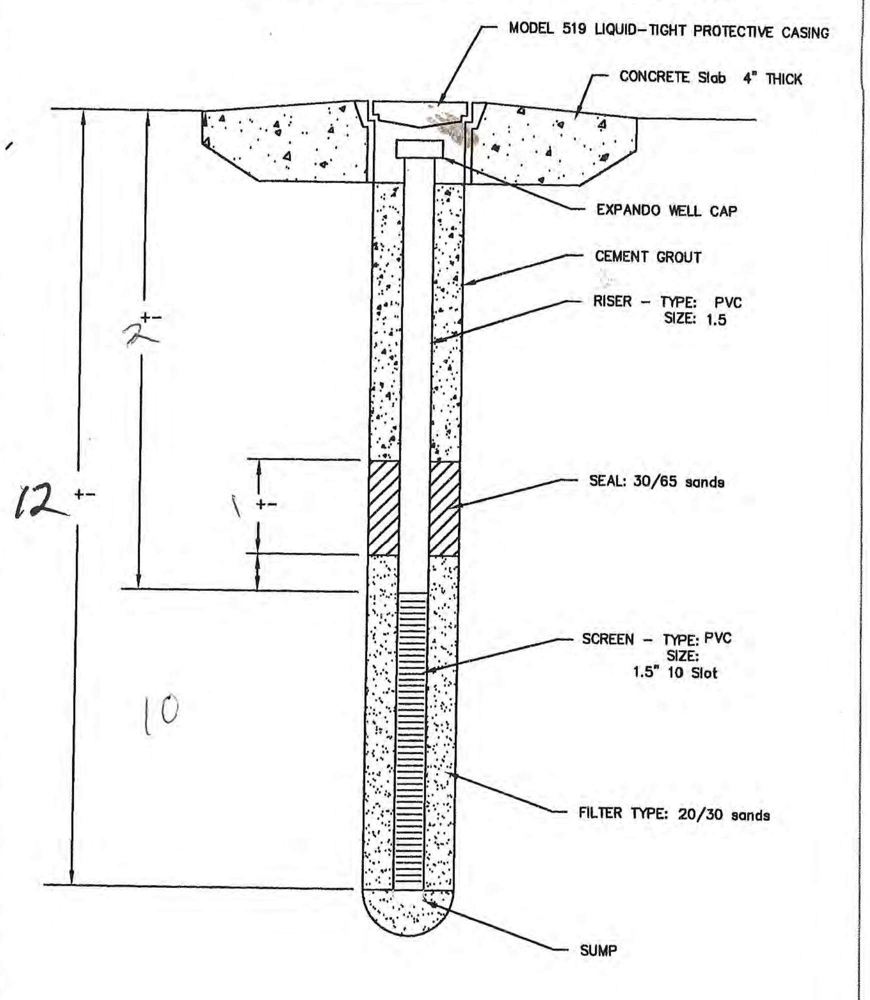
50		

WELL DIAGRAM - NOT TO SCALE



\# ½ BAGS OF SAND
\# ½ BAGS OF GROUT
\# 2 BAGS OF CONCRETE
\# 0 SOIL DRUMS
\# 0 WATER DRUMS

DATE OF BORING
6/12/17
WATER TABLE
4' 3.25
TOTAL DEPTH OF BORING
12'

FORM: WC09

Form FD 9000-24

GROUNDWATER SAMPLING LOG

SITENAME Turkey Creek

SITELOCATION:

WELL NO: MW RE2456

SAMPLE ID MW RE2456

DATE: 6/15/17

PURGING DATA

WELL DIAMETER (inches): 1.5

TUBING DIAMETER (inches): 1/4

WELL SCREEN INTERVAL DEPTH: 8 feet to 18 feet

STATIC DEPTH TO WATER (feet): 12.05

PURGE PUMP TYPE OR BAILER: PP

WELL VOLUME PURGE: 1 WELL VOLUME = (TOTAL WELL DEPTH – STATIC DEPTH TO WATER) X WELL CAPACITY
(only fill out if applicable)
5.95 = (18 feet – 12.05 feet) X .06 gallons/foot = .357 gallons

EQUIPMENT VOLUME PURGE: 1 EQUIPMENT VOL. = PUMP VOLUME + (TUBING CAPACITY X TUBING LENGTH) + FLOW CELL VOLUME
(only fill out if applicable)
= gallons + (gallons/foot X feet) + gallons = gallons

INITIAL PUMP OR TUBING DEPTH IN WELL (feet): 10

FINAL PUMP OR TUBING DEPTH IN WELL (feet): 16

PURGING INITIATED AT: 10:38

PURGING ENDED AT: 10:54

TOTAL VOLUME PURGED (gallons): 4.0

TIME	VOLUME PURGED (gallons)	CUMUL. VOLUME PURGED (gallons)	PURGE RATE (gpm)	DEPTH TO WATER (feet)	pH (standard units)	TEMP. (°C)	COND. (circle units) µmhos/cm or µS/cm	DISSOLVED OXYGEN (circle units) mg/L or % saturation	TURBIDITY (NTUs)	COLOR (describe)	ODOR (describe)
10:42	1.0	1.0	.25	14.9	7.96	26.44	1.073	63.4%6.5	432	LT Brown	NO
10:46	1.0	2.0	↓	↓	7.94	26.52	1.107	58.9/4.7	214	↓	↓
10:50	1.0	3.0	↓	↓	7.92	26.41	1.132	61.9%4.8	75.6	↓	↓
10:54	1.0	4.0	↓	↓	7.93	26.26	1.125	62.9%5.0	20.6	↓	↓

WELL CAPACITY (Gallons Per Foot): **0.75"** = 0.02; **1"** = 0.04; **1.25"** = 0.06; **2"** = 0.16; **3"** = 0.37; **4"** = 0.65; **5"** = 1.02; **6"** = 1.47; **12"** = 5.88
TUBING INSIDE DIA. CAPACITY (Gal./Ft.): **1/8"** = 0.0006; **3/16"** = 0.0014; **1/4"** = 0.0026; **5/16"** = 0.004; **3/8"** = 0.006; **1/2"** = 0.010; **5/8"** = 0.016

PURGING EQUIPMENT CODES: **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **PP** = Peristaltic Pump; **O** = Other (Specify)

SAMPLING DATA

SAMPLED BY (PRINT) / AFFILIATION: Brandon Selph Universal Engineering

SAMPLER(S) SIGNATURE(S):

SAMPLING INITIATED AT: 9:54

SAMPLING ENDED AT: 9:59

PUMP OR TUBING DEPTH IN WELL (feet): 16

TUBING MATERIAL CODE: **PE**

FIELD-FILTERED: Y [✓ N]

Filtration Equipment Type:

FILTER SIZE: _____ µm

FIELD DECONTAMINATION: PUMP Y [✓ N] TUBING Y [✓ N (replaced)]

DUPLICATE: Y [✓ N]

SAMPLE CONTAINER SPECIFICATION				SAMPLE PRESERVATION			INTENDED ANALYSIS AND/OR METHOD	SAMPLING EQUIPMENT CODE	SAMPLE PUMP FLOW RATE (mL per minute)
SAMPLE ID CODE	# CONTAINERS	MATERIAL CODE	VOLUME	PRESERVATIVE USED	TOTAL VOL ADDED IN FIELD (mL)	FINAL pH			
MwRE	1	P	250ml	H2SO4	None		LAB		<100ml/
2456	1	P	100ml	~					

REMARKS:

MATERIAL CODES: **AG** = Amber Glass; **CG** = Clear Glass; **PE** = Polyethylene; **PP** = Polypropylene; **S** = Silicone; **T** = Teflon; **O** = Other (Specify)

SAMPLING EQUIPMENT CODES: **APP** = After Peristaltic Pump; **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **RFPP** = Reverse Flow Peristaltic Pump; **SM** = Straw Method (Tubing Gravity Drain); **O** = Other (Specify)

NOTES: 1. **The above do not constitute all of the information required by Chapter 62-160, F.A.C.**

2. STABILIZATION CRITERIA FOR RANGE OF VARIATION OF LAST THREE CONSECUTIVE READINGS (SEE FS 2212, SECTION 3)

pH: ± 0.2 units **Temperature:** ± 0.2 °C **Specific Conductance:** ± 5% **Dissolved Oxygen:** all readings ≤ 20% saturation (see Table FS 2200-2); optionally, ± 0.2 mg/L or ± 10% (whichever is greater) **Turbidity:** all readings ≤ 20 NTU; optionally ± 5 NTU or ± 10% (whichever is greater)

Revision Date: February 12, 2009

Florida Department of Environmental Protection - Division of Waste Management - Bureau of Petroleum Storage Systems

WELL CONSTRUCTION AND DEVELOPMENT LOG

WELL CONSTRUCTION DATA

Well Number: MWRE2456

Site Name: TurkeyCreek

FDEP Facility I.D. Number:

Well Install Date(s): 6/13/17

Well Location and Type (check appropriate boxes):
☑ On-Site ☐ Right-of-Way
☐ Off-Site Private Property
☐ Above Grade (AG) ☐ Flush-to-Grade
If AG, list feet of riser above land surface:

Well Purpose:
☑ Perched Monitoring
☐ Shallow (Water-Table) Monitoring
☐ Intermediate or Deep Monitoring
☐ Remediation or Other (describe)

Well Install Method: Geoprobe

Surface Casing Install Method:

Borehole Depth (feet): 18

Well Depth (feet): 18

Borehole Diameter (inches): 4"

Manhole Diameter (inches): 4"

Well Pad Size: 16" feet by 16" feet

Riser Diameter and Material: 1.5

Riser/Screen Connections: ☑ Flush-Threaded ☐ Other (describe)

Riser Length: 8 feet from 0 feet to 8 feet

Screen Diameter and Material: 1.5 PVC

Screen Slot Size: 10

Screen Length: 10 feet from 8 feet to 18 feet

1st Surface Casing Material:
also check: ☑ Permanent ☐ Temporary

1st Surface Casing I.D. (inches):

1st Surface Casing Length: ____ feet from 0 feet to ____ feet

2nd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

2nd Surface Casing I.D. (inches):

2nd Surface Casing Length: ____ feet from 0 feet to ____ feet

3rd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

3rd Surface Casing I.D. (inches):

3rd Surface Casing Length: ____ feet from 0 feet to ____ feet

Filter Pack Material and Size: 20/30 sands

Prepacked Filter Around Screen (check one): ☑ Yes ☐ No

Filter Pack Length: 10 feet from 8 feet to 18 feet

Filter Pack Seal Material and Size: 30/65 sands

Filter Pack Seal Length: 2 feet from 6 feet to 8 feet

Surface Seal Material: grout

Surface Seal Length: 6 feet from 0 feet to 6 feet

WELL DEVELOPMENT DATA

Well Development Date: 6/13/17

Well Development Method (check one): ☐ Surge/Pump ☑ Pump ☐ Compressed Air ☐ Other (describe)

Development Pump Type (check): ☐ Centrifugal ☑ Peristaltic ☐ Submersible ☐ Other (describe)

Depth to Groundwater (before developing in feet): 11.7

Pumping Rate (gallons per minute): .25

Maximum Drawdown of Groundwater During Development (feet): 3.1

Well Purged Dry (check one): ☐ Yes ☑ No

Pumping Condition (check one): ☑ Continuous ☐ Intermittent

Total Development Water Removed (gallons): 7.85

Development Duration (minutes): 31

Development Water Drummed (check one): ☐ Yes ☑ No

Water Appearance (color and odor) At Start of Development: Lt Brown

Water Appearance (color and odor) At End of Development: Clear NO

WELL CONSTRUCTION OR DEVELOPMENT REMARKS

1:35 to 2:06

UNIVERSAL
ENGINEERING SCIENCES
WELL COMPLETION LOG

PROJECT NO:
REPORT NO:
PAGE:

PROJECT: Turke Creek
CLIENT: Applied Ecology, Inc DATE: 6/13/17
WELL NUMBER: MWRE 2454 LOCATION:
INSTALLED BY: BMS

FIELD LOG OF BORING

DEPTH	LOG	CLASSIFICATION OF MATERIAL
1		
2		LT Brown sands S1
3	4.0	LT Gray sands S2
4		
5		
6		
7		S3
8		
9		
10		
11		S4
12		
13		
14		
15		
16	18.0	Gray clayey sands
17		
18		
19	20.0	
20		EOB
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
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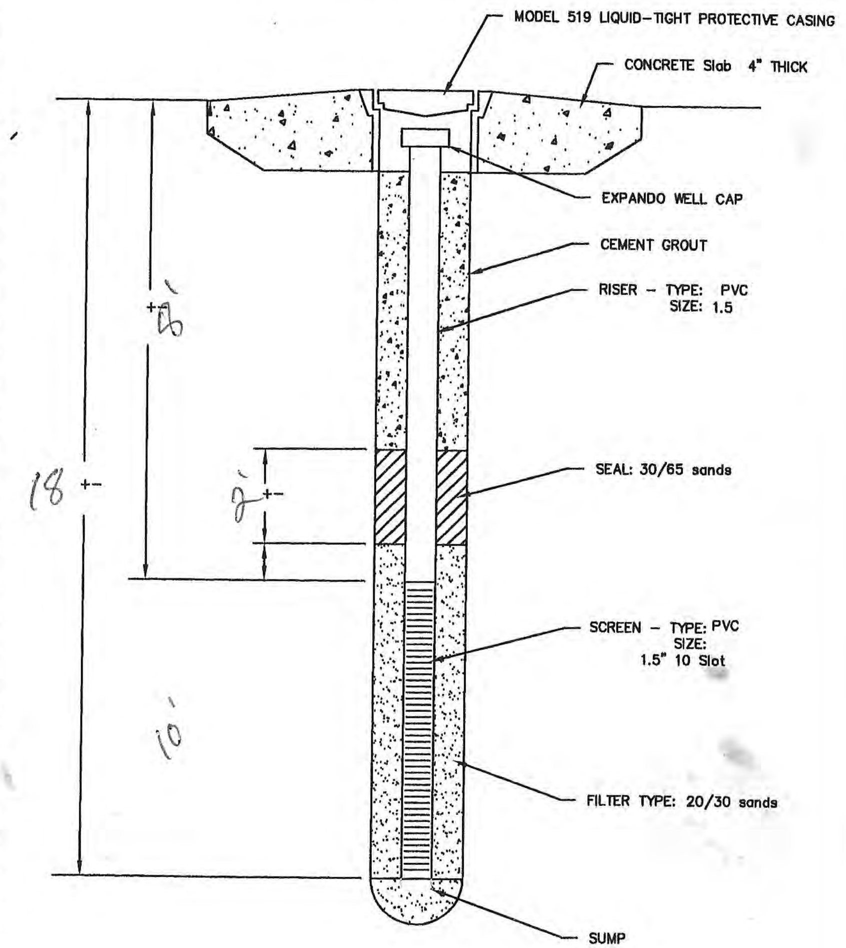
WELL DIAGRAM – NOT TO SCALE



\# 1 BAGS OF SAND
\# 1 BAGS OF GROUT
\# 2 BAGS OF CONCRETE
\# 0 SOIL DRUMS
\# 0 WATER DRUMS

DATE OF BORING
6/13/17
WATER TABLE
12' 17.4
TOTAL DEPTH OF BORING
20'

Form FD 9000-24

GROUNDWATER SAMPLING LOG

SITENAME: Turkey Creek
SITELOCATION: Palm Bay
WELL NO: MWSE 841
SAMPLE ID: MWSE 841
DATE: 6/16/17

PURGING DATA

WELL DIAMETER (inches): 1.5
TUBING DIAMETER (inches): 1/4
WELL SCREEN INTERVAL DEPTH: feet to feet
STATIC DEPTH TO WATER (feet): 11.5
PURGE PUMP TYPE OR BAILER: PP

WELL VOLUME PURGE: 1 WELL VOLUME = (TOTAL WELL DEPTH – STATIC DEPTH TO WATER) X WELL CAPACITY
(only fill out if applicable)
65 = (18 feet – 11.5 feet) X .06 gallons/foot = 0.39 gallons

EQUIPMENT VOLUME PURGE: 1 EQUIPMENT VOL. = PUMP VOLUME + (TUBING CAPACITY X TUBING LENGTH) + FLOW CELL VOLUME
(only fill out if applicable)
= gallons + (gallons/foot X feet) + gallons = gallons

INITIAL PUMP OR TUBING DEPTH IN WELL (feet): 15.5
FINAL PUMP OR TUBING DEPTH IN WELL (feet): 15.5
PURGING INITIATED AT: 8:13
PURGING ENDED AT: 8:25
TOTAL VOLUME PURGED (gallons): 1.5

TIME	VOLUME PURGED (gallons)	CUMUL. VOLUME PURGED (gallons)	PURGE RATE (gpm)	DEPTH TO WATER (feet)	pH (standard units)	TEMP. (°C)	COND. (circle units) µmhos/cm or µS/cm	DISSOLVED OXYGEN (circle units) mg/L or % saturation	TURBIDITY (NTUs)	COLOR (describe)	ODOR (describe)
8:17	.5	.5	.125	12.65	8.29	23.98	5.396	49% 4.01	11.5	DkGray	NO
8:21	.5	1.0	↓	↓	8.26	24.10	5.493	124% 10	18.1	LtGray	no
8:25	.5	1.5	↓	↓	8.22	24.13	5.512	220% .19	6.27	~	~

WELL CAPACITY (Gallons Per Foot): **0.75"** = 0.02; **1"** = 0.04; **1.25"** = 0.06; **2"** = 0.16; **3"** = 0.37; **4"** = 0.65; **5"** = 1.02; **6"** = 1.47; **12"** = 5.88
TUBING INSIDE DIA. CAPACITY (Gal./Ft.): **1/8"** = 0.0006; **3/16"** = 0.0014; **1/4"** = 0.0026; **5/16"** = 0.004; **3/8"** = 0.006; **1/2"** = 0.010; **5/8"** = 0.016
PURGING EQUIPMENT CODES: **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **PP** = Peristaltic Pump; **O** = Other (Specify)

SAMPLING DATA

SAMPLED BY (PRINT) / AFFILIATION: Brandon Selph Universal Engineering
SAMPLER(S) SIGNATURE(S):
SAMPLING INITIATED AT: 8:25
SAMPLING ENDED AT: 8:36
PUMP OR TUBING DEPTH IN WELL (feet): 15.5
TUBING MATERIAL CODE: PE
FIELD-FILTERED: Y [✓ N] FILTER SIZE: _____ µm
Filtration Equipment Type:
FIELD DECONTAMINATION: PUMP Y [✓ N] TUBING Y [✓ N (replaced)]
DUPLICATE: Y [✓ N]

SAMPLE CONTAINER SPECIFICATION				SAMPLE PRESERVATION			INTENDED ANALYSIS AND/OR METHOD	SAMPLING EQUIPMENT CODE	SAMPLE PUMP FLOW RATE (mL per minute)
SAMPLE ID CODE	# CONTAINERS	MATERIAL CODE	VOLUME	PRESERVATIVE USED	TOTAL VOL ADDED IN FIELD (mL)	FINAL pH			
MWSE 841	1	2PO	250mL	yes	none		LHB	APP	< 100mL pm
↓	1	P	100mL	—				—	—

REMARKS:

MATERIAL CODES: **AG** = Amber Glass; **CG** = Clear Glass; **PE** = Polyethylene; **PP** = Polypropylene; **S** = Silicone; **T** = Teflon; **O** = Other (Specify)

SAMPLING EQUIPMENT CODES: **APP** = After Peristaltic Pump; **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **RFPP** = Reverse Flow Peristaltic Pump; **SM** = Straw Method (Tubing Gravity Drain); **O** = Other (Specify)

NOTES: 1. The above do not constitute all of the information required by Chapter 62-160, F.A.C.
2. STABILIZATION CRITERIA FOR RANGE OF VARIATION OF LAST THREE CONSECUTIVE READINGS (SEE FS 2212, SECTION 3)
pH: ± 0.2 units **Temperature:** ± 0.2 °C **Specific Conductance:** ± 5% **Dissolved Oxygen:** all readings ≤ 20% saturation (see Table FS 2200-2); optionally, ± 0.2 mg/L or ± 10% (whichever is greater) **Turbidity:** all readings ≤ 20 NTU; optionally ± 5 NTU or ± 10% (whichever is greater)

Revision Date: February 12, 2009

Florida Department of Environmental Protection - Division of Waste Management - Bureau of Petroleum Storage Systems

WELL CONSTRUCTION AND DEVELOPMENT LOG

WELL CONSTRUCTION DATA

Well Number: NWSP 841

Site Name: Turkey Creek

FDEP Facility I.D. Number:

Well Install Date(s): 6-12-17

Well Location and Type (check appropriate boxes): ☑ On-Site ☐ Right-of-Way ☐ Off-Site Private Property ☐ Above Grade (AG) ☐ Flush-to-Grade

If AG, list feet of riser above land surface:

Well Purpose: ☑ Perched Monitoring ☐ Shallow (Water-Table) Monitoring ☐ Intermediate or Deep Monitoring ☐ Remediation or Other (describe)

Well Install Method:

Surface Casing Install Method:

Borehole Depth (feet): 18

Well Depth (feet): 18

Borehole Diameter (inches): 4"

Manhole Diameter (inches): 4"

Well Pad Size: 16" feet by 16" feet

Riser Diameter and Material: 1.25 PVC

Riser/Screen Connections: ☑ Flush-Threaded ☐ Other (describe)

Riser Length: 8 feet from 0 feet to 8 feet

Screen Diameter and Material: 1.25 PVC

Screen Slot Size: 10

Screen Length: 10 feet from 8 feet to 18 feet

1st Surface Casing Material: also check: ☑ Permanent ☐ Temporary

1st Surface Casing I.D. (inches):

1st Surface Casing Length: ____ feet from 0 feet to ____ feet

2nd Surface Casing Material: also check: ☐ Permanent ☐ Temporary

2nd Surface Casing I.D. (inches):

2nd Surface Casing Length: ____ feet from 0 feet to ____ feet

3rd Surface Casing Material: also check: ☐ Permanent ☐ Temporary

3rd Surface Casing I.D. (inches):

3rd Surface Casing Length: ____ feet from 0 feet to ____ feet

Filter Pack Material and Size:

Prepacked Filter Around Screen (check one): ☑ Yes ☐ No

Filter Pack Length: 10 feet from 8 feet to 18 feet

Filter Pack Seal Material and Size: 30/65 sands

Filter Pack Seal Length: 2 feet from 6 feet to 8 feet

Surface Seal Material: Grout

Surface Seal Length: 6 feet from 0 feet to 6 feet

WELL DEVELOPMENT DATA

Well Development Date: 6/14/17

Well Development Method (check one): ☐ Surge/Pump ☑ Pump ☐ Compressed Air ☐ Other (describe)

Development Pump Type (check): ☐ Centrifugal ☑ Peristaltic ☐ Submersible ☐ Other (describe)

Depth to Groundwater (before developing in feet): 11.38

Pumping Rate (gallons per minute): .25

Maximum Drawdown of Groundwater During Development (feet): 1.57

Well Purged Dry (check one): ☐ Yes ☑ No

Pumping Condition (check one): ☑ Continuous ☐ Intermittent

Total Development Water Removed (gallons): 2.25

Development Duration (minutes): 9

Development Water Drummed (check one): ☐ Yes ☑ No

Water Appearance (color and odor) At Start of Development: Black

Water Appearance (color and odor) At End of Development: Clear

WELL CONSTRUCTION OR DEVELOPMENT REMARKS

2:15 to 2:24

FORM: WC09

UNIVERSAL
ENGINEERING SCIENCES
WELL COMPLETION LOG

PROJECT NO:
REPORT NO:
PAGE:

PROJECT: Turkey creek
CLIENT: Applied Ecology, Inc
DATE: 6-12-17
WELL NUMBER: SE 841
LOCATION: Palm Bay
INSTALLED BY:

FIELD LOG OF BORING

	DEPTH	LOG	CLASSIFICATION OF MATERIAL
	1		Grass Brown sands
AA	2	1.0	
	3		LT Brown sands Mixed
	4	4.0	
DP	5		51
	6		
	7		
	8		52
soft	9		
	10	8.5	
	11		53 Dk Brown
	12		sands
	13		
	14	10.0	
	15		
	16		
	17	13.0	
	18		Brown Mixed Sands
	19		w/Roots
	20		
	21		54 55
	22		
	23	18.0	
	24		Dk Brown silt w Roots
	25		
	26		56
	27		
	28	19.0	
	29		EOB
	30		
	31		
	32		
	33		
	34		
	35		
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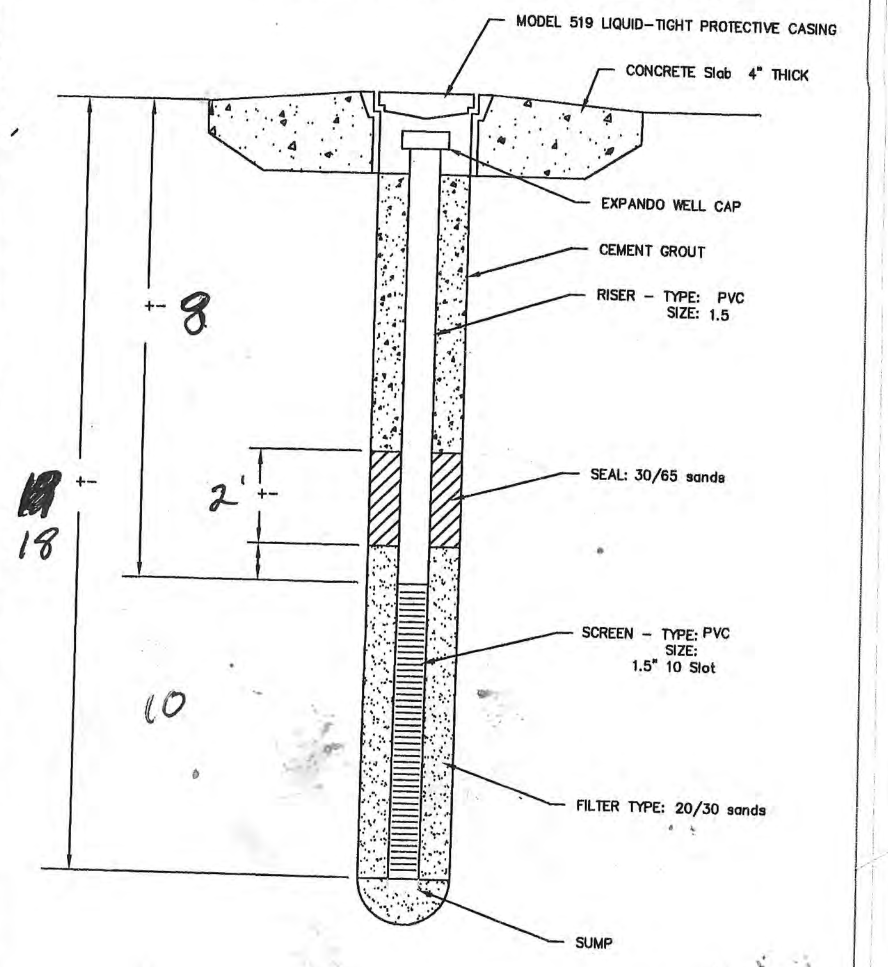
WELL DIAGRAM - NOT TO SCALE



2 BAGS OF SAND
1 BAGS OF GROUT
2 BAGS OF CONCRETE
0 SOIL DRUMS
0 WATER DRUMS

DATE OF BORING
6/12/17
WATER TABLE
13'+- 11.5
TOTAL DEPTH OF BORING
19'

Form FD 9000-24

GROUNDWATER SAMPLING LOG

SITENAME: Turkey Creek
SITELOCATION:
WELL NO: MW REC
SAMPLE ID: MWREC
DATE: 6/15/17

PURGING DATA

WELL DIAMETER (inches): 1.5
TUBING DIAMETER (inches): 1/4
WELL SCREEN INTERVAL DEPTH: feet to feet
STATIC DEPTH TO WATER (feet): 12.75
PURGE PUMP TYPE OR BAILER: PP

WELL VOLUME PURGE: **1 WELL VOLUME** = (TOTAL WELL DEPTH – STATIC DEPTH TO WATER) X WELL CAPACITY
(only fill out if applicable)
6.25 = (24 feet – 12.75 feet) X .06 gallons/foot = .375 gallons

EQUIPMENT VOLUME PURGE: **1 EQUIPMENT VOL.** = PUMP VOLUME + (TUBING CAPACITY X TUBING LENGTH) + FLOW CELL VOLUME
(only fill out if applicable)
= gallons + (gallons/foot X feet) + gallons = gallons

INITIAL PUMP OR TUBING DEPTH IN WELL (feet): 20.5
FINAL PUMP OR TUBING DEPTH IN WELL (feet): 20.5
PURGING INITIATED AT: 11:20
PURGING ENDED AT: 11:32
TOTAL VOLUME PURGED (gallons): 1.5

TIME	VOLUME PURGED (gallons)	CUMUL. VOLUME PURGED (gallons)	PURGE RATE (gpm)	DEPTH TO WATER (feet)	pH (standard units)	TEMP. (°C)	COND. (circle units) μmhos/cm or μS/cm	DISSOLVED OXYGEN (circle units) mg/L or % saturation	TURBIDITY (NTUs)	COLOR (describe)	ODOR (describe)
11:24	.5	.5	.125	12.9	7.82	24.73	1.392	326 2.69	64.9	LT Brown	no
11:28	.5	1.0	↓	↓	7.78	24.57	1.333	29.6% 2.4	20.3	↓	↓
11:32	.5	1.5			7.98	24.52	1.277	29.1% 2.3	14.6		

WELL CAPACITY (Gallons Per Foot): **0.75"** = 0.02; **1"** = 0.04; **1.25"** = 0.06; **2"** = 0.16; **3"** = 0.37; **4"** = 0.65; **5"** = 1.02; **6"** = 1.47; **12"** = 5.88
TUBING INSIDE DIA. CAPACITY (Gal./Ft.): **1/8"** = 0.0006; **3/16"** = 0.0014; **1/4"** = 0.0026; **5/16"** = 0.004; **3/8"** = 0.006; **1/2"** = 0.010; **5/8"** = 0.016
PURGING EQUIPMENT CODES: **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **PP** = Peristaltic Pump; **O** = Other (Specify)

SAMPLING DATA

SAMPLED BY (PRINT) / AFFILIATION: Brandon Selph Universal Engineering
SAMPLER(S) SIGNATURE(S): BS
SAMPLING INITIATED AT: 11:32
SAMPLING ENDED AT: 11:38
PUMP OR TUBING DEPTH IN WELL (feet): 20.5
TUBING MATERIAL CODE: **PE**
FIELD-FILTERED: Y [✓ N]
Filtration Equipment Type:
FILTER SIZE: ______ μm
FIELD DECONTAMINATION: PUMP Y [✓ N] TUBING Y ~~N~~ [✓ (replaced)]
DUPLICATE: Y [✓ N]

SAMPLE CONTAINER SPECIFICATION				SAMPLE PRESERVATION			INTENDED ANALYSIS AND/OR METHOD	SAMPLING EQUIPMENT CODE	SAMPLE PUMP FLOW RATE (mL per minute)
SAMPLE ID CODE	# CONTAINERS	MATERIAL CODE	VOLUME	PRESERVATIVE USED	TOTAL VOL ADDED IN FIELD (mL)	FINAL pH			
MWREC	1	P	250	[illegible]	NONE		AHB	APP	< 100ml
	1	P	100						

REMARKS:

MATERIAL CODES: **AG** = Amber Glass; **CG** = Clear Glass; **PE** = Polyethylene; **PP** = Polypropylene; **S** = Silicone; **T** = Teflon; **O** = Other (Specify)
SAMPLING EQUIPMENT CODES: **APP** = After Peristaltic Pump; **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **RFPP** = Reverse Flow Peristaltic Pump; **SM** = Straw Method (Tubing Gravity Drain); **O** = Other (Specify)

NOTES: 1. **The above do not constitute all of the information required by Chapter 62-160, F.A.C.**
2. STABILIZATION CRITERIA FOR RANGE OF VARIATION OF LAST THREE CONSECUTIVE READINGS (SEE FS 2212, SECTION 3)
pH: ± 0.2 units **Temperature:** ± 0.2 °C **Specific Conductance:** ± 5% **Dissolved Oxygen:** all readings ≤ 20% saturation (see Table FS 2200-2); optionally, ± 0.2 mg/L or ± 10% (whichever is greater) **Turbidity:** all readings ≤ 20 NTU; optionally ± 5 NTU or ± 10% (whichever is greater)

Revision Date: February 12, 2009

Florida Department of Environmental Protection - Division of Waste Management - Bureau of Petroleum Storage Systems

WELL CONSTRUCTION AND DEVELOPMENT LOG

WELL CONSTRUCTION DATA

Well Number: MW REC

Site Name: Turkey Creek

FDEP Facility I.D. Number:

Well Install Date(s): 6/13/17

Well Location and Type (check appropriate boxes):
☑ On-Site ☐ Right-of-Way
☐ Off-Site Private Property
☐ Above Grade (AG) ☐ Flush-to-Grade
If AG, list feet of riser above land surface:

Well Purpose:
☑ Perched Monitoring
☐ Shallow (Water-Table) Monitoring
☐ Intermediate or Deep Monitoring
☐ Remediation or Other (describe)

Well Install Method: Geoprobe

Surface Casing Install Method:

Borehole Depth (feet): 24

Well Depth (feet): 23.6

Borehole Diameter (inches):

Manhole Diameter (inches): 4"

Well Pad Size: 16" feet by 16" feet

Riser Diameter and Material: 1.5 PVC

Riser/Screen Connections: ☑ Flush-Threaded ☐ Other (describe)

Riser Length: 13.6 feet from 0 feet to 13.6 feet

Screen Diameter and Material: 1.5 PVC

Screen Slot Size: 10

Screen Length: 10 feet from 13.6 feet to 23.6 feet

1st Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

1st Surface Casing I.D. (inches):

1st Surface Casing Length: ___ feet from 0 feet to ___ feet

2nd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

2nd Surface Casing I.D. (inches):

2nd Surface Casing Length: ___ feet from 0 feet to ___ feet

3rd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

3rd Surface Casing I.D. (inches):

3rd Surface Casing Length: ___ feet from 0 feet to ___ feet

Filter Pack Material and Size: 20/30

Prepacked Filter Around Screen (check one): ☑ Yes ☐ No

Filter Pack Length: 10 feet from 13.6 feet to 23.6 feet

Filter Pack Seal Material and Size: ~~20/30 sands~~ 30/65

Filter Pack Seal Length: 10 feet from 11 ~~13.6~~ feet to ~~23.6~~ 13.6 feet

Surface Seal Material: Grout

Surface Seal Length: 11 feet from 0 feet to 11 feet

WELL DEVELOPMENT DATA

Well Development Date: 6/13/17

Well Development Method (check one): ☐ Surge/Pump ☑ Pump ☐ Compressed Air ☐ Other (describe)

Development Pump Type (check): ☐ Centrifugal ☑ Peristaltic ☐ Submersible ☐ Other (describe)

Depth to Groundwater (before developing in feet):

Pumping Rate (gallons per minute): .25

Maximum Drawdown of Groundwater During Development (feet): 1'

Well Purged Dry (check one): ☐ Yes ☑ No

Pumping Condition (check one): ☑ Continuous ☐ Intermittent

Total Development Water Removed (gallons): 16

Development Duration (minutes): 64

Development Water Drummed (check one): ☐ Yes ☑ No

Water Appearance (color and odor) At Start of Development: Orange to Lt Brown

Water Appearance (color and odor) At End of Development: clear

WELL CONSTRUCTION OR DEVELOPMENT REMARKS

2:00 to 3:04

Ending NTUs 13.6

UNIVERSAL
ENGINEERING SCIENCES
WELL COMPLETION LOG

PROJECT NO:
REPORT NO:
PAGE:

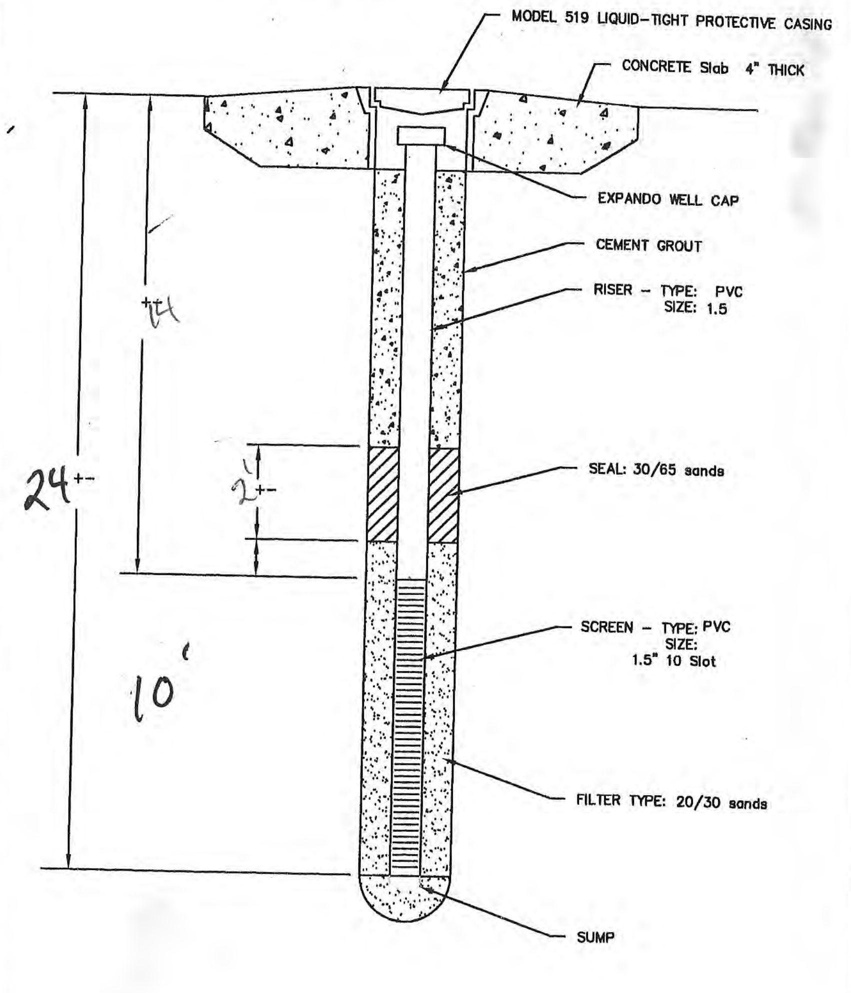
PROJECT: Turkey Creek
CLIENT: Applied Ecology
DATE: 6/13/17
WELL NUMBER: MWREC
LOCATION:
INSTALLED BY: B.M.S

FIELD LOG OF BORING

DEPTH	LOG	CLASSIFICATION OF MATERIAL
1		
2		Grass
3	HD	Lt Brown sands
4		S1
5	4.0	
6		
7		
8		S2
9	8.0	
10		
11		
12		S3
13		
14	16.5	
15		Gray/Brown & layers
16		Sands/ S4
17		
18		
19		
20		S5
21	16.0	
22		
23		S6
24		
25		
26	18.0	wot
27		Gray sands
28		w/clay S7
29	20.0	
30		
31		Lt Gray sands S8
32		
33		
34		
35		
36	24.0	
37		
38		
39		
40		
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		

FORM: WC09

WELL DIAGRAM – NOT TO SCALE



\# 1 BAGS OF SAND
\# 2 BAGS OF GROUT
\# 2 BAGS OF CONCRETE
\# 0 SOIL DRUMS
\# 0 WATER DRUMS

DATE OF BORING
6/13/17
WATER TABLE
18
TOTAL DEPTH OF BORING
24

Form FD 9000-24

GROUNDWATER SAMPLING LOG

SITENAME: Turkey Creek
SITELOCATION: Palm Bay
WELL NO: MW SE849
SAMPLE ID: MW5E849
DATE: 10/14/17

PURGING DATA

WELL DIAMETER (inches): 1.5
TUBING DIAMETER (inches): 1/4
WELL SCREEN INTERVAL DEPTH: feet to feet
STATIC DEPTH TO WATER (feet): 10.5
PURGE PUMP TYPE OR BAILER: PP

WELL VOLUME PURGE: **1 WELL VOLUME** = (TOTAL WELL DEPTH – STATIC DEPTH TO WATER) X WELL CAPACITY
(only fill out if applicable)
8.05 = (18.55 feet – 10.5 feet) X .06 gallons/foot = .483 gallons

EQUIPMENT VOLUME PURGE: **1 EQUIPMENT VOL.** = PUMP VOLUME + (TUBING CAPACITY X TUBING LENGTH) + FLOW CELL VOLUME
(only fill out if applicable)
= gallons + (gallons/foot X feet) + gallons = gallons

INITIAL PUMP OR TUBING DEPTH IN WELL (feet): 16.5
FINAL PUMP OR TUBING DEPTH IN WELL (feet): 16.5
PURGING INITIATED AT: 8:49
PURGING ENDED AT: 9:15
TOTAL VOLUME PURGED (gallons): 4.5

TIME	VOLUME PURGED (gallons)	CUMUL. VOLUME PURGED (gallons)	PURGE RATE (gpm)	DEPTH TO WATER (feet)	pH (standard units)	TEMP. (°C)	COND. (circle units) µmhos/cm or µS/cm	DISSOLVED OXYGEN (circle units) mg/L or % saturation	TURBIDITY (NTUs)	COLOR (describe)	ODOR (describe)
8:51	.5	.5	.25	14.1	8.05	24.36	.362	725% Cal	351	Gray	no
8:55	1.0	1.5	↓	↓	8.04	24.39	.354	84.8% 7.1	308	↓	↓
8:59	1.0	2.5	↓	↓	7.86	24.70	.343	↓	155		
9:03	.5	3.0	.125	↓	7.85	24.75	.343	↓	142	↓	↓
9:07	.5	3.5	↓	↓	7.79	24.88	.344	↓	77	↓	↓
9:11	.5	4.0	↓	↓	7.75	24.71	.347	↓	47		
9:15	.5	4.5	↓	↓	7.75	24.68	.343	84.8% 7.1	45.6	↓	↓

WELL CAPACITY (Gallons Per Foot): **0.75"** = 0.02; **1"** = 0.04; **1.25"** = 0.06; **2"** = 0.16; **3"** = 0.37; **4"** = 0.65; **5"** = 1.02; **6"** = 1.47; **12"** = 5.88
TUBING INSIDE DIA. CAPACITY (Gal./Ft.): **1/8"** = 0.0006; **3/16"** = 0.0014; **1/4"** = 0.0026; **5/16"** = 0.004; **3/8"** = 0.006; **1/2"** = 0.010; **5/8"** = 0.016
PURGING EQUIPMENT CODES: **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **PP** = Peristaltic Pump; **O** = Other (Specify)

SAMPLING DATA

SAMPLED BY (PRINT) / AFFILIATION: Brandon Selph Universal Engineering
SAMPLER(S) SIGNATURE(S):
SAMPLING INITIATED AT: 9:15
SAMPLING ENDED AT: 9:20
PUMP OR TUBING DEPTH IN WELL (feet): 16.5
TUBING MATERIAL CODE: **PE**
FIELD-FILTERED: Y [✓ N] Filtration Equipment Type:
FILTER SIZE: _____ µm
FIELD DECONTAMINATION: PUMP Y [✓ N] TUBING Y [✓ N (replaced)]
DUPLICATE: Y [✓ N]

SAMPLE CONTAINER SPECIFICATION				SAMPLE PRESERVATION			INTENDED ANALYSIS AND/OR METHOD	SAMPLING EQUIPMENT CODE	SAMPLE PUMP FLOW RATE (mL per minute)
SAMPLE ID CODE	# CONTAINERS	MATERIAL CODE	VOLUME	PRESERVATIVE USED	TOTAL VOL ADDED IN FIELD (mL)	FINAL pH			
MW5E849	1	P	250ml	yes			LAB	APP	<100ml/min
↓	1	P	100ml	—	None			—	—

REMARKS:

MATERIAL CODES: **AG** = Amber Glass; **CG** = Clear Glass; **PE** = Polyethylene; **PP** = Polypropylene; **S** = Silicone; **T** = Teflon; **O** = Other (Specify)

SAMPLING EQUIPMENT CODES: **APP** = After Peristaltic Pump; **B** = Bailer; **BP** = Bladder Pump; **ESP** = Electric Submersible Pump; **RFPP** = Reverse Flow Peristaltic Pump; **SM** = Straw Method (Tubing Gravity Drain); **O** = Other (Specify)

NOTES: 1. **The above do not constitute all of the information required by Chapter 62-160, F.A.C.**
2. STABILIZATION CRITERIA FOR RANGE OF VARIATION OF LAST THREE CONSECUTIVE READINGS (SEE FS 2212, SECTION 3)
pH: ± 0.2 units **Temperature:** ± 0.2 °C **Specific Conductance:** ± 5% **Dissolved Oxygen:** all readings ≤ 20% saturation (see Table FS 2200-2); optionally, ± 0.2 mg/L or ± 10% (whichever is greater) **Turbidity:** all readings ≤ 20 NTU; optionally ± 5 NTU or ± 10% (whichever is greater)

Revision Date: February 12, 2009

Florida Department of Environmental Protection - Division of Waste Management - Bureau of Petroleum Storage Systems

WELL CONSTRUCTION AND DEVELOPMENT LOG

WELL CONSTRUCTION DATA

Well Number: MW SE 849

Site Name: Turkey Creek

FDEP Facility I.D. Number:

Well Install Date(s): 6-12-17

Well Location and Type (check appropriate boxes):
☑ On-Site ☐ Right-of-Way
☐ Off-Site Private Property
☐ Above Grade (AG) ☐ Flush-to-Grade

If AG, list feet of riser above land surface:

Well Purpose:
☑ Perched Monitoring
☐ Shallow (Water-Table) Monitoring
☐ Intermediate or Deep Monitoring
☐ Remediation or Other (describe)

Well Install Method: Geoprobe

Surface Casing Install Method:

Borehole Depth (feet): 18.55

Well Depth (feet): 18.55

Borehole Diameter (inches): 4"

Manhole Diameter (inches): 4"

Well Pad Size: 16" feet by 16" feet

Riser Diameter and Material: 1.5 PVC

Riser/Screen Connections: ☑ Flush-Threaded ☐ Other (describe)

Riser Length: 855 feet
from 0 feet to 1855 feet

Screen Diameter and Material: 1.5 PVC

Screen Slot Size: 10

Screen Length: 10 feet
from 8.55 feet to 1855 feet

1st Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

1st Surface Casing I.D. (inches):

1st Surface Casing Length: ____ feet
from 0 feet to ____ feet

2nd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

2nd Surface Casing I.D. (inches):

2nd Surface Casing Length: ____ feet
from 0 feet to ____ feet

3rd Surface Casing Material:
also check: ☐ Permanent ☐ Temporary

3rd Surface Casing I.D. (inches):

3rd Surface Casing Length: ____ feet
from 0 feet to ____ feet

Filter Pack Material and Size:

Prepacked Filter Around Screen (check one): ☑ Yes ☐ No

Filter Pack Length: 10 feet
from 855 feet to 1855 feet

Filter Pack Seal Material and Size: 30/65 Sand

Filter Pack Seal Length: 2 feet
from 655 feet to 855 feet

Surface Seal Material: Grout

Surface Seal Length: 655 feet
from 0 feet to 6.55 feet

WELL DEVELOPMENT DATA

Well Development Date: 6/14/17

Well Development Method (check one): ☐ Surge/Pump ☑ Pump ☐ Compressed Air
☐ Other (describe)

Development Pump Type (check): ☐ Centrifugal ☑ Peristaltic
☐ Submersible ☐ Other (describe)

Depth to Groundwater (before developing in feet): 10.6

Pumping Rate (gallons per minute): .125

Maximum Drawdown of Groundwater During Development (feet):

Well Purged Dry (check one): ☐ Yes ☑ No

Pumping Condition (check one): ☑ Continuous ☐ Intermittent

Total Development Water Removed (gallons): 7.5

Development Duration (minutes): 60

Development Water Drummed (check one): ☐ Yes ☑ No

Water Appearance (color and odor) At Start of Development: Dk Brown

Water Appearance (color and odor) At End of Development: Clear

WELL CONSTRUCTION OR DEVELOPMENT REMARKS

2:38 to

Ending NTUs 34.3

UNIVERSAL
ENGINEERING SCIENCES
WELL COMPLETION LOG

PROJECT NO:
REPORT NO:
PAGE:

PROJECT: Turkey Creek
CLIENT: Applied Ecology, Inc DATE: 6/12/17
WELL NUMBER: SE 849 LOCATION:
INSTALLED BY:

FIELD LOG OF BORING

DEPTH	LOG	CLASSIFICATION OF MATERIAL
1	1.0	Grass Brown sands S1
2		Brown sands S2
3		
4		
5		S3
6	4.0	
7		Mixed Brown silty
8		sands
9		
10	10.0	S4
11		
12		
13		S5
14		
15		
16		
17	18.0	
18		
19		Gray clayey sands
20		w/Roots
21		S6
22	20.0	EOB
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
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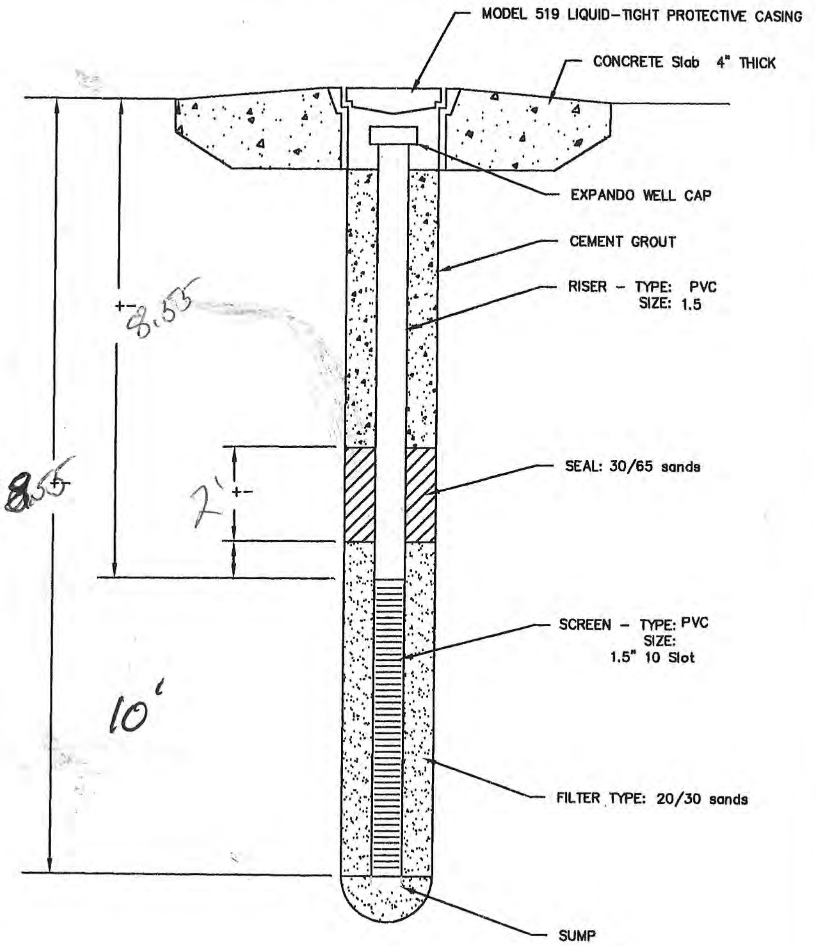
WELL DIAGRAM - NOT TO SCALE



\# 1 BAGS OF SAND
\# 1 BAGS OF GROUT
\# 2 BAGS OF CONCRETE
\# 0 SOIL DRUMS
\# 0 WATER DRUMS

DATE OF BORING
6/12/17
WATER TABLE
14.0 16.1
TOTAL DEPTH OF BORING
20'

FORM: WC09

Boldly "X" this box if there is qualified data on this page.

Form FD9000-8 CALIBRATION LOG (FDEP SOP FT 1000-FT 1500, FD 1000-FD 4000) 11-10-05

Project/Site: Turkey Creek Date: Meter # 13A100061 *For Date of Last Temperature Verification see* ______ *in log book* ______

Temperature (Quarterly)

Dissolved Oxygen	**DEP SOP FT 1500**	Initials	Date	Time	Probe Charge	Probe Gain	mg/L	Temp °C	% DO	Saturation mg/L (from chart)	Pass *or* Fail
									Acceptance Criteria:+/-0.3mg/l		
[✓ CAL] ICV CCV		BS	6/15/17	7:10			1.591	27.7	8.24	1.574	[✓ P] F
CAL ICV [✓ CCV]		BS	↓	5:30			2.05	21.91	23.4	1.752	[✓ P] F
CAL ICV CCV											P F
CAL ICV CCV											P F
CAL ICV CCV											P F
CAL ICV CCV											P F
CAL ICV CCV											P F

Specific Conductance	**DEP SOP FT 1200**	Initials	Date	Time	Standard *µmhos/cm*	Exp. Date	Lot #	Bottle #	Cell Constant	Reading *µmhos/cm*	Pass *or* Fail
									Acceptance Criteria: +/- 5%		
[✓ CAL] ICV CCV		BS	6/15/17	7:20	1.413	5-17	G6E113			1.413	[✓ P] F
CAL ICV [✓ CCV]		↓	↓	4:00	↓	↓	↓			1.444	[✓ P] F
CAL ICV CCV											P F
CAL ICV CCV											P F
CAL ICV CCV											P F
CAL ICV CCV											P F
CAL ICV CCV											P F

pH	**DEP SOP FT 1100**	Initials	Date	Time	Standard SU	Exp. Date	Lot #	Bottle #	Slope	Reading SU	Pass *or* Fail
									Acceptance Criteria: +/- 0.2 SU		
[✓ CAL] ICV CCV		BS	6/15/17	7:30	7.0	3-19	7GC500			7.0	[✓ P] F
[✓ CAL] ICV CCV		BS	↓	↓	4.0	9-18	6G1281			4.0	[✓ P] F
[✓ CAL] ICV CCV		BS	↓	↓	10.0	4-19	76c593			10	[✓ P] F
CAL ICV [✓ CCV]		BS	↓	4:15	7.0	↓	↓			6.97	[✓ P] F
CAL ICV [✓ CCV]		BS	↓	↓	4.0	↓	↓			4.1	[✓ P] F
CAL ICV [✓ CCV]		BS	↓	↓	10.0	↓	↓			9.9	[✓ P] F
CAL ICV CCV					7.0						P F
CAL ICV CCV					4.0						P F
CAL ICV CCV					10.0						P F

Maintenance: Weekly pH Slope: ______ Specific Conductance Probe Cleaned? Yes No Dissolved Oxygen Membrane Changed: Yes No

Notes:

Perform only in Calibrate Mode:	**CAL** - Calibrate -
Perform only in Run Mode:	**ICV** - Initial Calibration Verification
Perform only in Run Mode:	**CCV** - Continuing Calibration Verification

Page ______

0340.1700050.0000
Turkey Creek

Form FD 9000-8: FIELD INSTRUMENT CALIBRATION RECORDS

INSTRUMENT (MAKE/MODEL#) HACH 2100Q **INSTRUMENT S/N#** 17030C056364

PARAMETER: *[check only one]*

☐ TEMPERATURE ☐ CONDUCTIVITY ☐ SALINITY ☐ pH ☐ ORP
☑ TURBIDITY ☐ RESIDUAL Cl ☐ DO ☐ OTHER ____________

STANDARDS: *[Specify the type(s) of standards used for calibration, the origin of the standards, the standard values, and the date the standards were prepared or purchased]*

Standard A 10
Standard B 20
Standard C 100
Standard D 800

DATE (yy/mm/dd)	TIME (hr:min)	STD (A, B, C)	STD VALUE	INSTRUMENT RESPONSE	% DEV	CALIBRATED (YES, NO)	TYPE (INIT, CONT)	SAMPLER INITIALS
6/15/17	7:00	A	10	10		Y	INIT	BS
		B	20	20.1		Y	INIT	
		C	100	99		Y	INIT	
		D	800	800		Y	INIT	
	4:15	A	10	10		Y	CONT	
		B	20	19.9		Y	CONT	
		C	100	99		Y	CONT	
		D	800	799		Y	CONT	
6/16/17	7:25	A	10	10		Y	INIT	
		B	20	20.1		Y		
		C	100	100.1		Y		
		D	800	799.1		Y		
	4:40	A	10	9.9		Y	Cont	
		B	20	20.1		Y		
		C	100	99		Y		
		D	800	800		Y		

ENCO

ENVIRONMENTAL CONSERVATION LABORATORIES CHAIN-OF-CUSTODY RECORD

10775 Central Port Dr.
Orlando, FL 32824
(407) 826-5314 Fax (407) 850-6945

4810 Executive Park Court, Suite 111
Jacksonville, FL 32216-6069
(904) 296-3007 Fax (904) 296-6210

102-A Woodwinds Industrial Ct.
Cary, NC 27511
(919) 467-3090 Fax (919) 467-3515

www.encolabs.com

Page 1 of 1

Client Name: Universal Engineering Sciences
Project Number:
Address: 820 Brevard ave
Project Name/Desc: Turkey Creek
City/ST/Zip: Rockledge FL 32955
PO # / Billing Info:
Tel: 321-638-0808
Fax: 3216380978
Reporting Contact: Ron Ausburn
Sampler(s) Name, Affiliation (Print):
Billing Contact: Ron Ausburn
Sampler(s) Signature:
Site Location / Time Zone:

Requested Analyses

- Ammonia 350.1 NOx SM4500-NO3 HTKN 351.2
- Coliform Fecal (MF)
- Nitrogen total 353 Calc

Preservation (See Codes) (Combine as necessary)

Requested Turnaround Times

Note : Rush requests subject to acceptance by the facility

✓ Standard

___ Expedited

Due ___/___/___

Lab Workorder: AA04076

Item #	Sample ID (Field Identification)	Collection Date	Collection Time	Comp / Grab	Matrix (see codes)	Total # of Containers	Ammonia 350.1 NOx SM4500-NO3 HTKN 351.2	Coliform Fecal (MF)	Nitrogen total 353 Calc	Sample Comments
1	MWSP1099	6/16/17	10:21	Grab	GW	2	X	X	X	
2	MW SP 1127	↓	10:00	↓	↓	2	X	X	X	
3	MW SE 841	↓	8:25	↓	↓	2	X	X	X	
4	MW-SE 849	↓	9:15	↓	↓	2	X	X	X	

<-- Total # of Containers

Sample Kit Prepared By:
Date/Time:

Comments/Special Reporting Requirements:

Relinquished By	Date/Time	Received By	Date/Time
	6/16/17 12:30		6/16/17 12:50

Cooler #'s & Temps on Receipt:

Condition Upon Receipt: ✓ Acceptable ___ Unacceptable

Matrix : **GW**-Groundwater **SO**-Soil **DW**-Drinking Water **SE**-Sediment **SW**-Surface Water **WW**-Wastewater **A**-Air **O**-Other (detail in comments)

Preservation: **I**-Ice **H**-HCl **N**-HNO3 **S**-H2SO4 **NO**-NaOH **O**-Other (detail in comments)

Note : All samples submitted to ENCO Labs are in accordance with the terms and conditions listed on the reverse of this form, unless prior written agreements exist

ENCO

ENVIRONMENTAL CONSERVATION LABORATORIES **CHAIN-OF-CUSTODY RECORD**

10775 Central Port Dr.
Orlando, FL 32824
(407) 826-5314 Fax (407) 850-6945

4810 Executive Park Court, Suite 111
Jacksonville, FL 32216-6069
(904) 296-3007 Fax (904) 296-6210

102-A Woodwinds Industrial Ct.
Cary, NC 27511
(919) 467-3090 Fax (919) 467-3515

www.encolabs.com

Page 1 of 1

Client Name: Universal Engineering Sciences ENV (UN004)
Project Number: [none]
Address: 820 Brevard Ave.
Project Name/Desc: Turkey Creek Groundwater Monitoring
City/ST/Zip: Rockledge, FL 32955
PO # / Billing Info:
Tel: (321) 638-0808
Fax: (321) 638-0978
Reporting Contact: Ron Ausburn
Sampler(s) Name, Affiliation (Print): Brandon Selbk
Billing Contact: Ron Ausburn
Sampler(s) Signature:
Site Location / Time Zone:

Requested Analyses

Requested Turnaround Times

Note : Rush requests subject to acceptance by the facility

✓ Standard

___ Expedited

Due ___/___/___

Lab Workorder: AA04076

Preservation (See Codes) (Combine as necessary)

Item #	Sample ID (Field Identification)	Collection Date	Collection Time	Comp / Grab	Matrix (see codes)	Total # of Containers	Ammonia 350.1,NOX SM4500-NO3 H,TKN 351.2	Coliform, Fecal (MF)	Nitrogen Total 353 Calc	Sample Comments
1	MWTC 2	6/15/17	8:39	Grb	GW	2	x	x	x	
2	MWTC 1.	↓	10:09	↓	↓	2	x	x	x	
3	MWRE 2456	↓	10:54	↓	↓	2	x	x	x	
4	MWREC	↓	11:32	↓	↓	2	x	x	x	

<-- Total # of Containers

Sample Kit Prepared By: El	Date/Time: 6-6-17	Relinquished By:	Date/Time: 6-6-17 1522	Received By:	Date/Time:
Comments/Special Reporting Requirements:		Relinquished By: Brandon Selbk	Date/Time: 6/15/17 1:15	Received By:	Date/Time: 6/15/17 1315
		Relinquished By:	Date/Time:	Received By:	Date/Time:

Cooler #'s & Temps on Receipt: Client 2.0°C

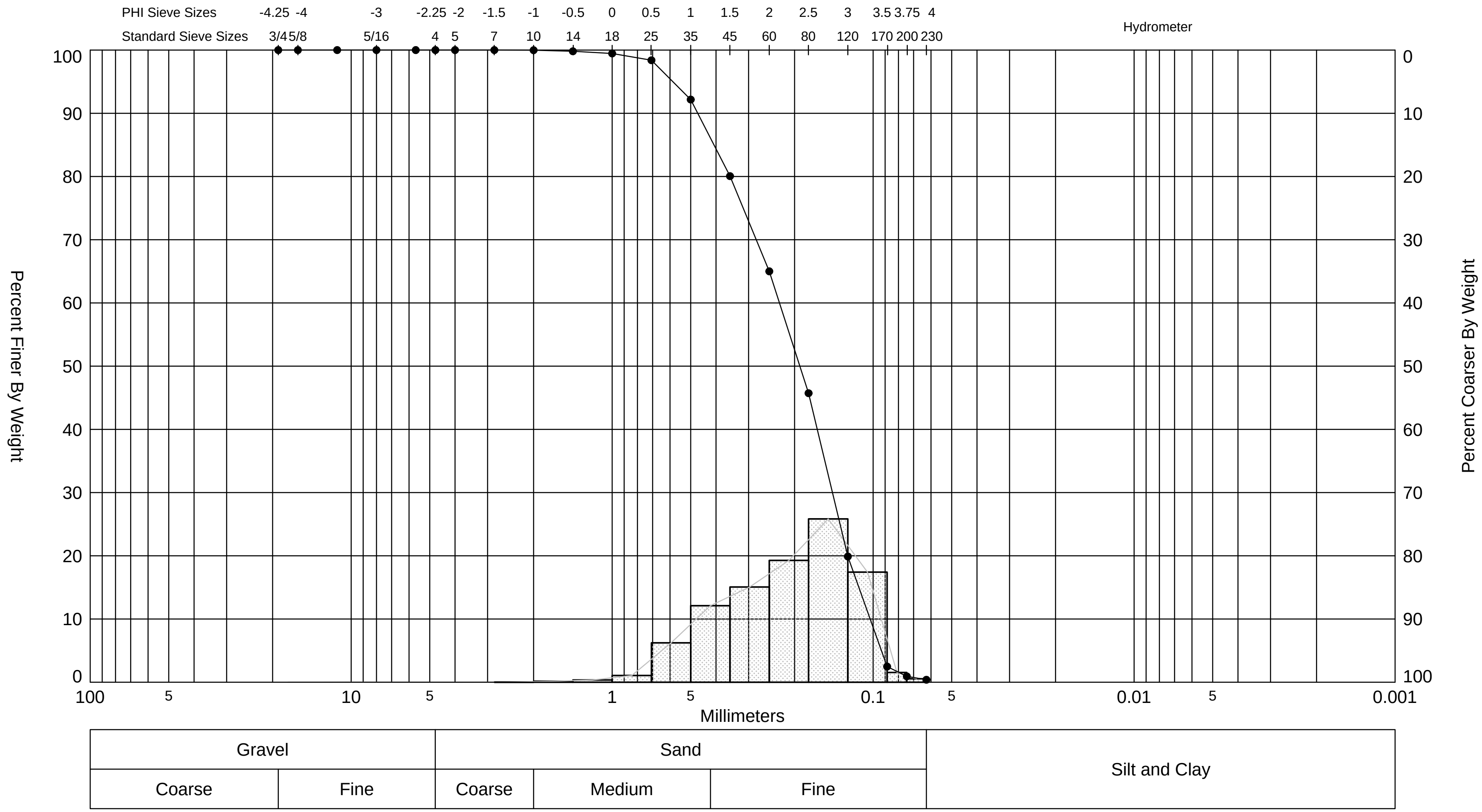
Condition Upon Receipt: ___ Acceptable ___ Unacceptable

Matrix : **GW**-Groundwater **SO**-Soil **DW**-Drinking Water **SE**-Sediment **SW**-Surface Water **WW**-Wastewater **A**-Air **O**-Other (detail in comments) **Preservation:** **I**-Ice **H**-HCl **N**-HNO3 **S**-H2SO4 **NO**-NaOH **O**-Other (detail in comments)

Note : All samples submitted to ENCO Labs are in accordance with the terms and conditions listed on the reverse of this form, unless prior written agreements exist

Appendix C

Soil Analysis Results



Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
MWRE2456	—●—		SP	#200 - 0.93 #230 - 0.39	0.36	0.28	2.39	2.26	-0.54	2.76	0.82

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	MRC
Analysis Date:	09-30-07
Analyzed By:	
Easting (X, ft):	
Northing (Y, ft):	
Horizontal System:	
Vertical System:	

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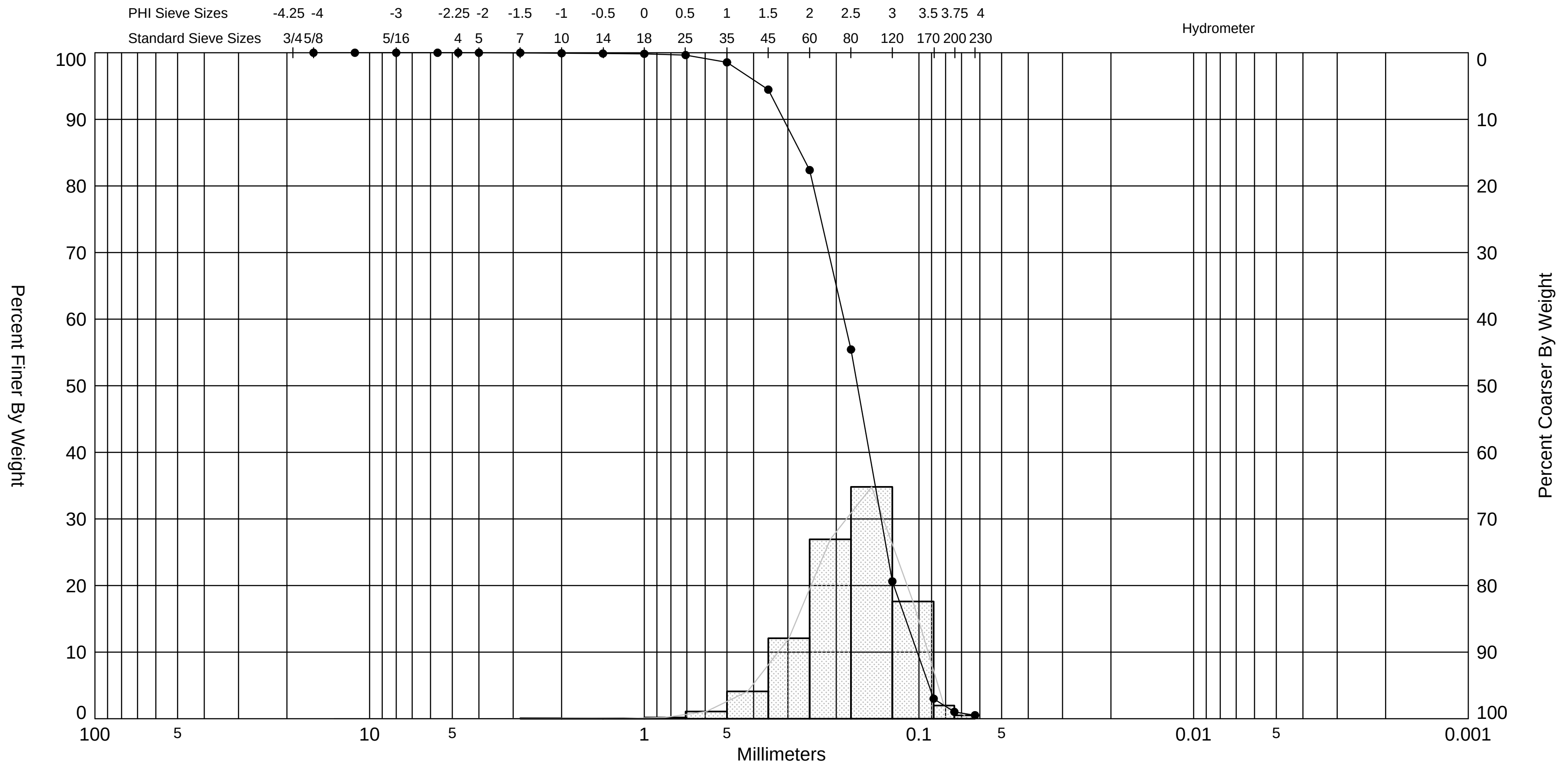
SIEVE ANALYSIS MRC.GPJ FL DEP ROSS.GDT 10/4/17



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
MWREC	─●─		SP	#200 - 1.03 #230 - 0.53	0.50	0.43	2.58	2.51	-0.76	4.64	0.61

Sample Information	
Project Name:	MRC
Analysis Date:	09-30-17
Analyzed By:	
Easting (X, ft):	
Northing (Y, ft):	
Horizontal System:	
Vertical System:	

Comments:

Depths and elevations based on measured values

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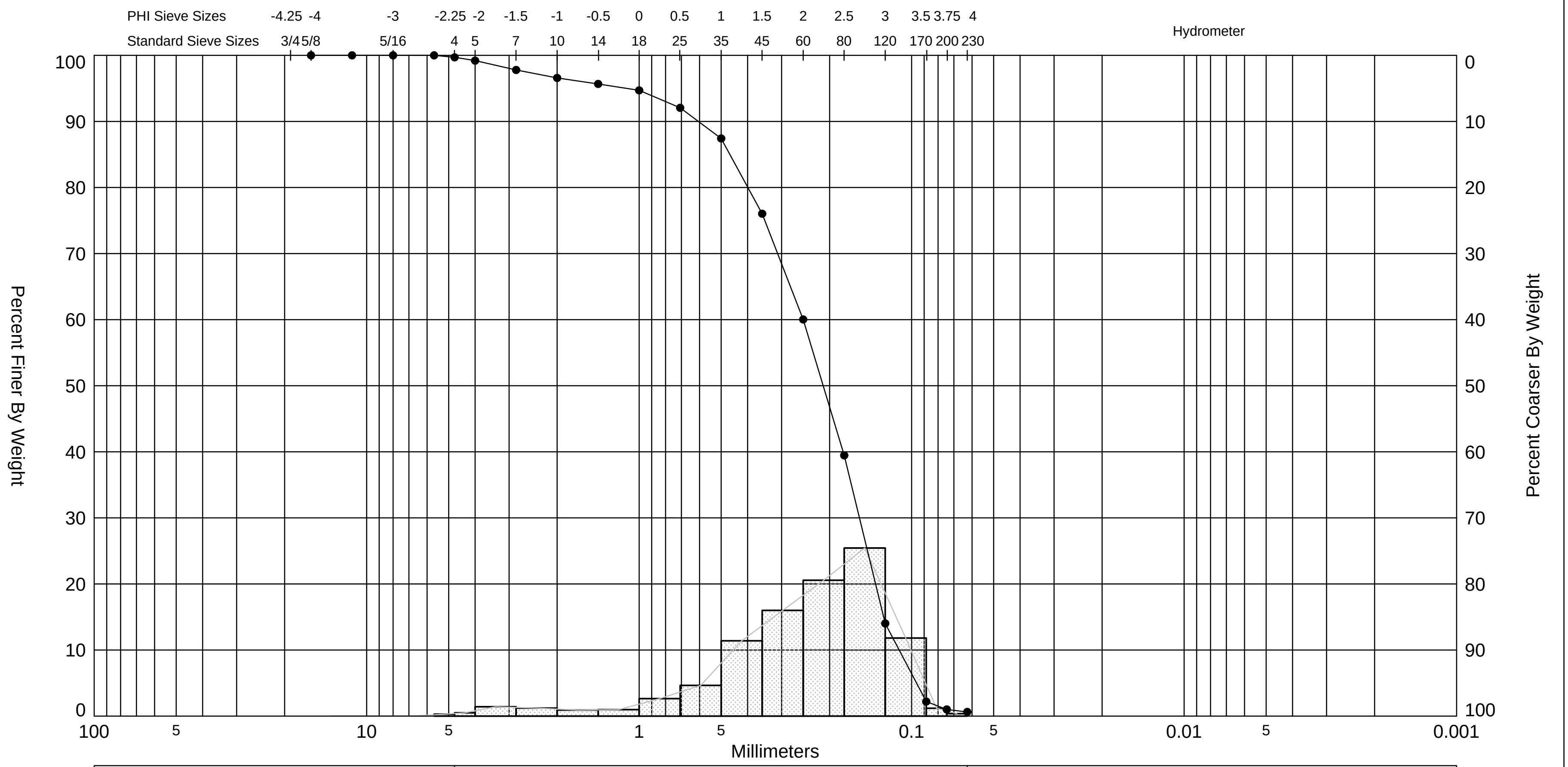

Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
MWSE841	—●—		SP	#200 - 1.01 #230 - 0.63	1.04	1.57	2.24	2.01	-1.5	5.85	1.1

Comments:

Depths and elevations based on measured values

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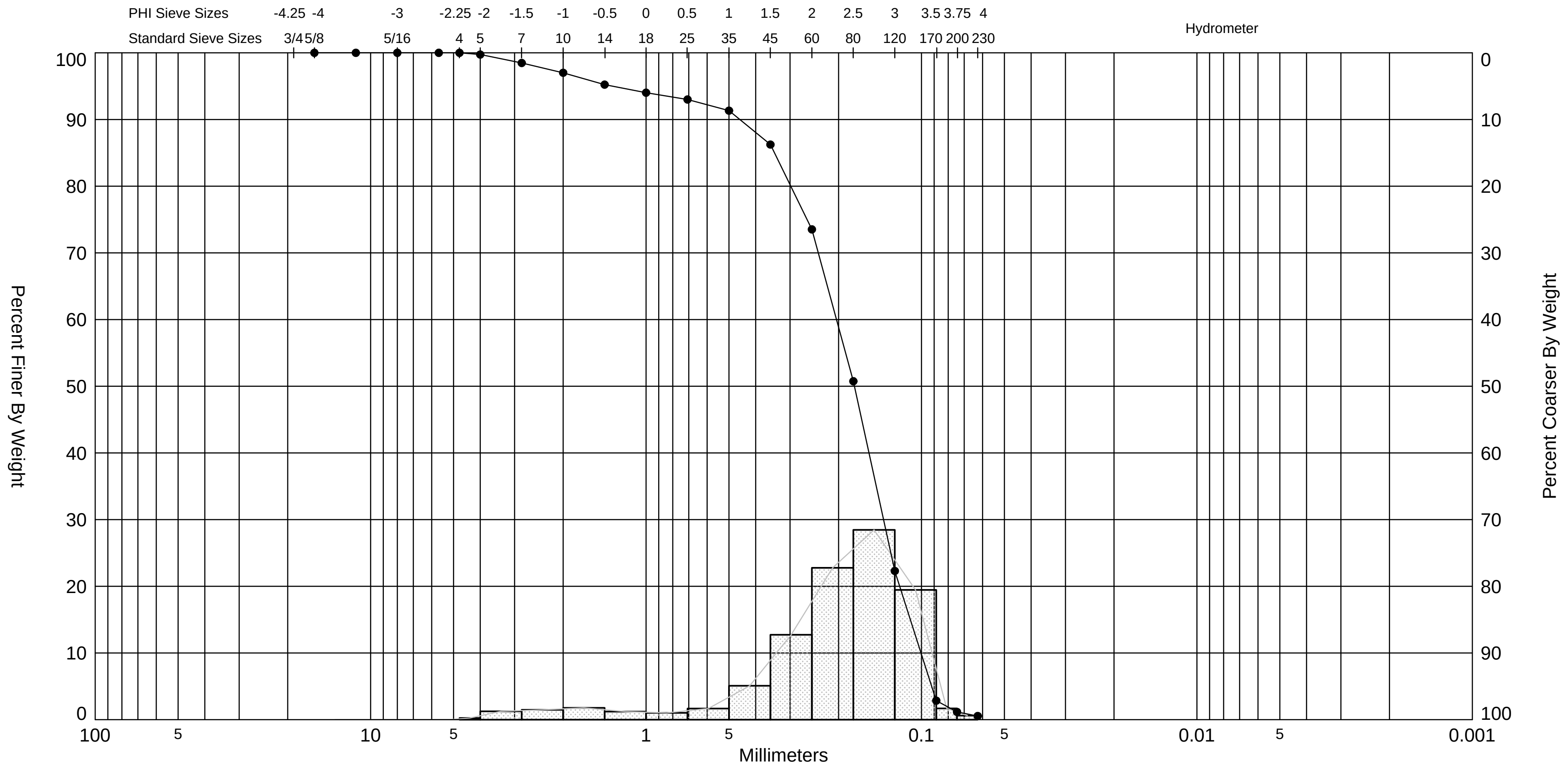
Sample Information	
Project Name:	MRC
Analysis Date:	09-30-17
Analyzed By:	
Easting (X, ft):	
Northing (Y, ft):	
Horizontal System:	
Vertical System:	



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort	Sample Information	
MWSP1099	─●─		SP	#200 - 1.16 #230 - 0.55	0.46	0.28	2.51	2.26	-1.86	6.9	1.07	Project Name:	MRC

Comments:

Depths and elevations based on measured values

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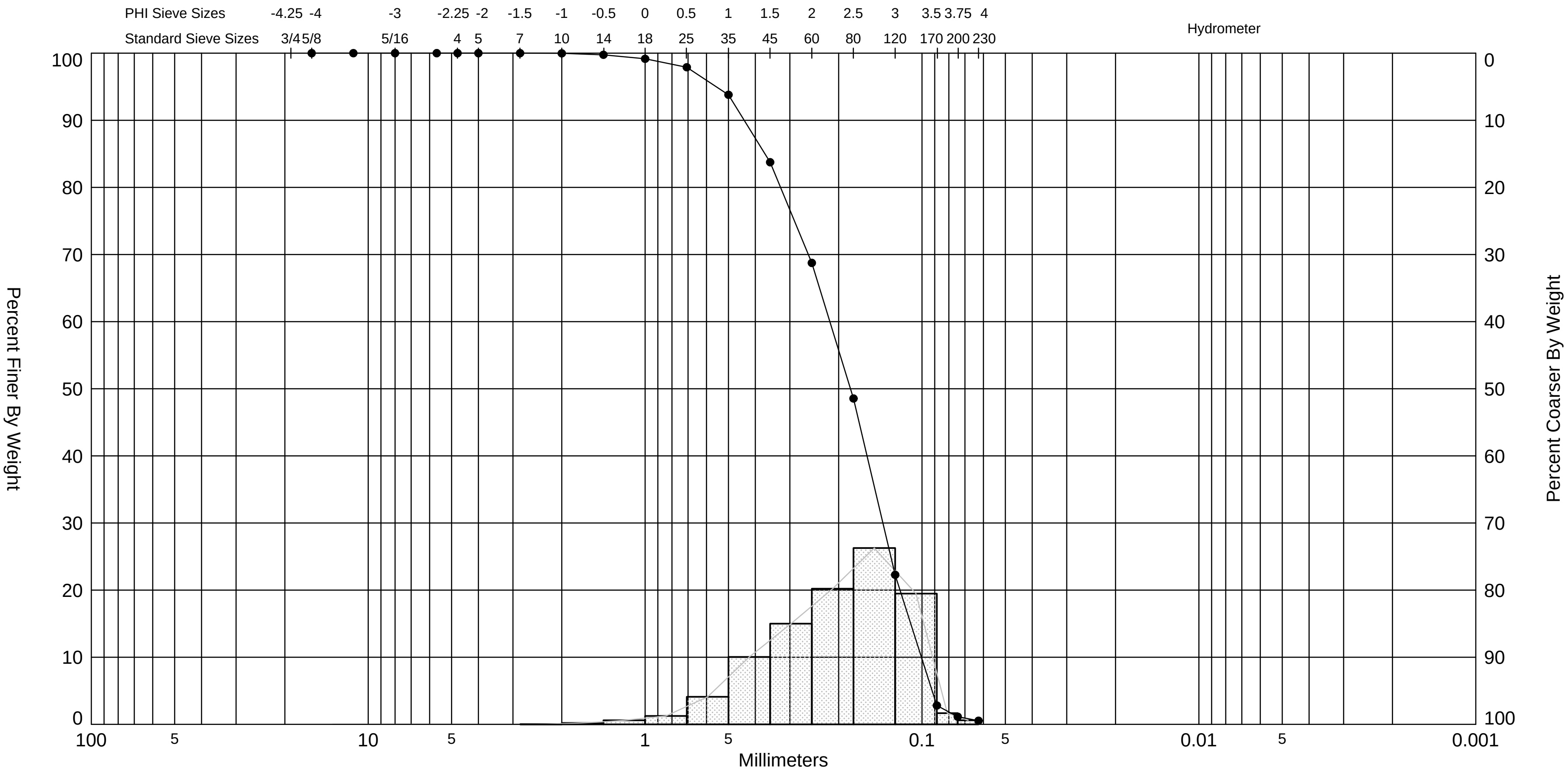
Analysis Date:	08-30-17
Analyzed By:	
Easting (X, ft):	
Northing (Y, ft):	
Horizontal System:	
Vertical System:	



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
MWSP1127	—●—		SP	#200 - 1.14 #230 - 0.54	0.83	0.22	2.46	2.32	-0.72	3.3	0.8

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	MRC
Analysis Date:	09-30-17
Analyzed By:	
Easting (X, ft):	
Northing (Y, ft):	
Horizontal System:	
Vertical System:	

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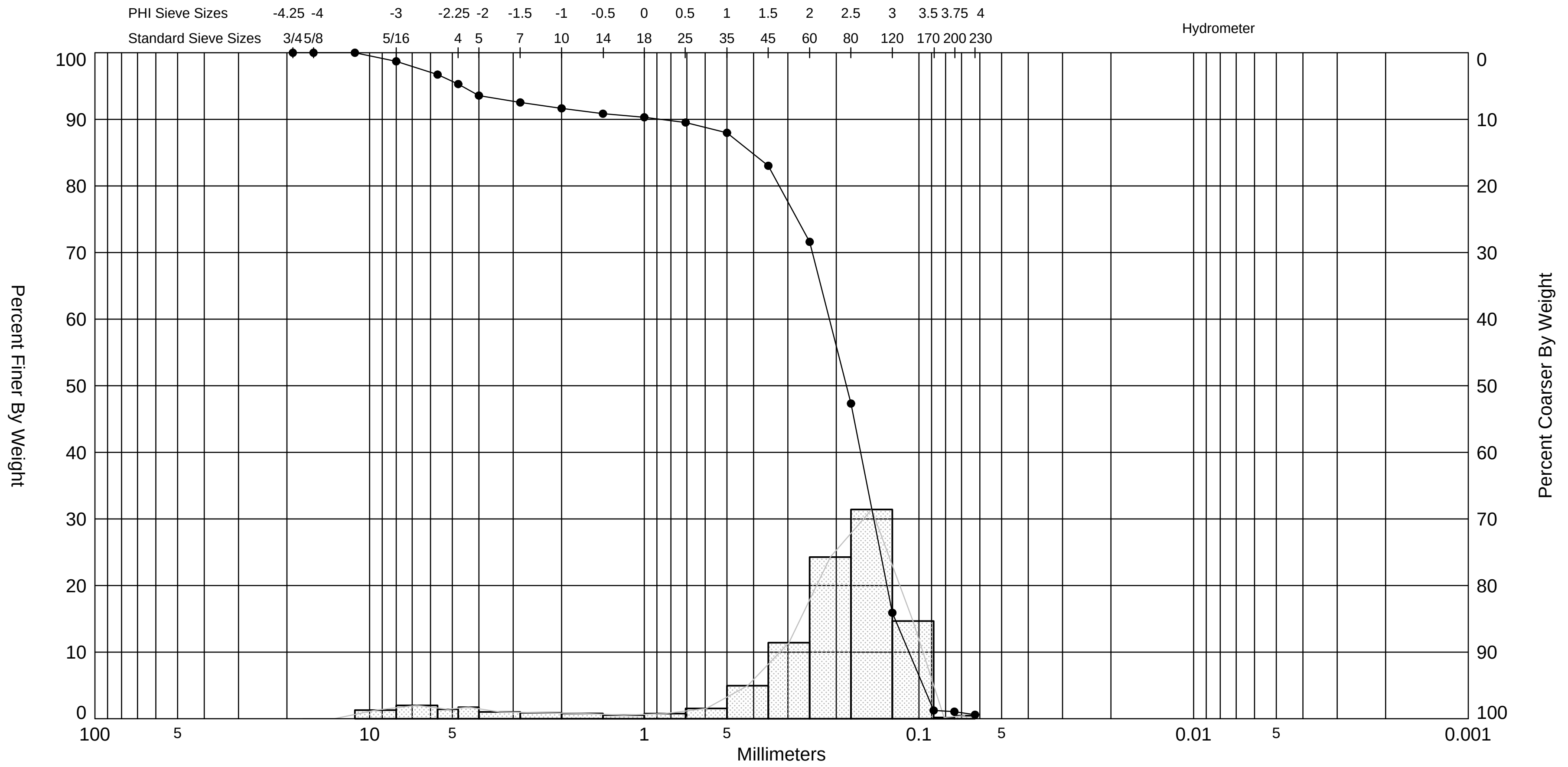

Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
MWTC-1	—●—		SP	#200 - 1.06 #230 - 0.60	0.90	0.40	2.45	2	-2.13	6.9	1.5

Comments:

Depths and elevations based on measured values

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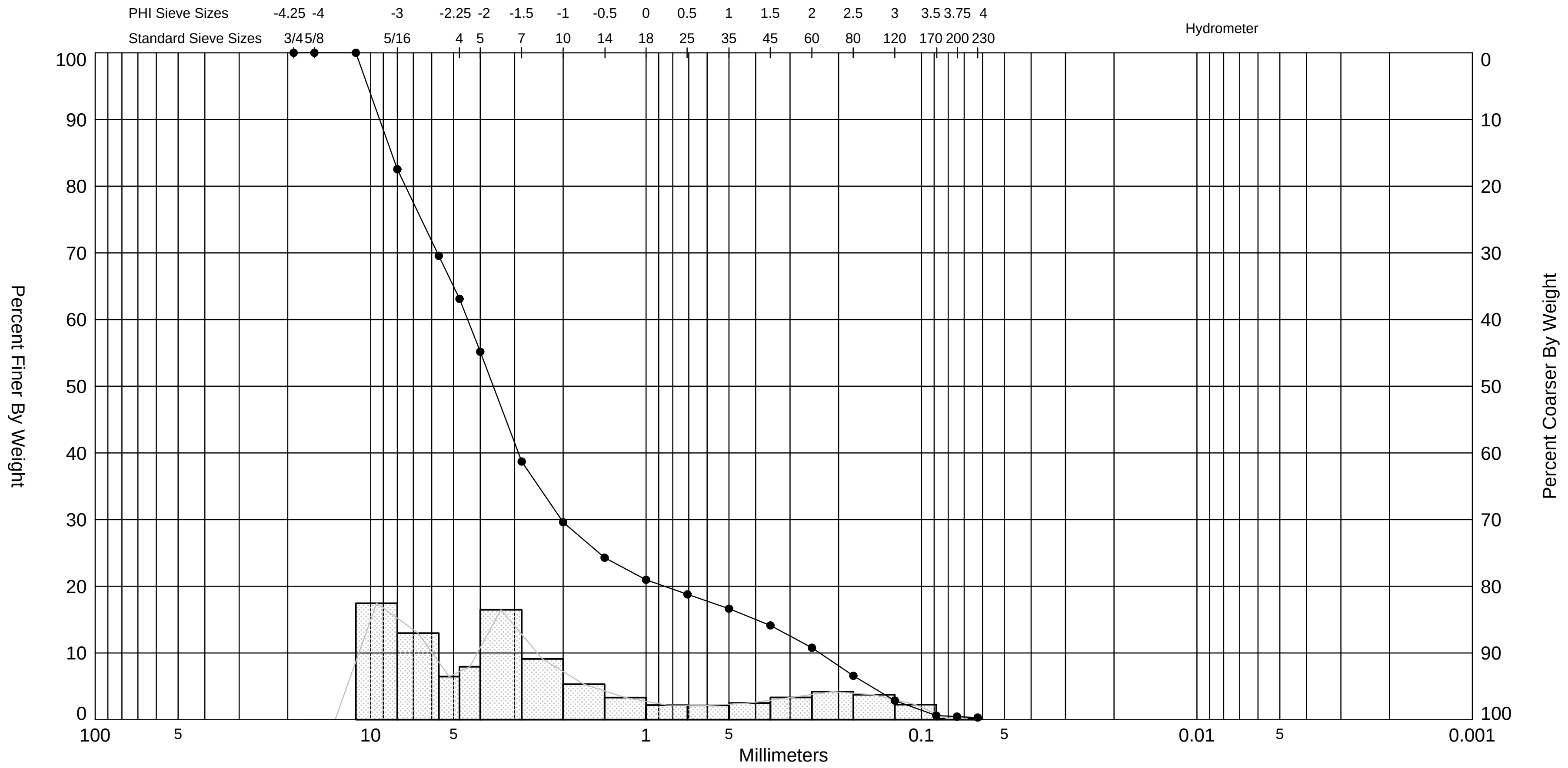
Sample Information

Project Name:	MRC
Analysis Date:	09-30-17
Analyzed By:	
Easting (X, ft):	
Northing (Y, ft):	
Horizontal System:	
Vertical System:	



Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
MWTC2	—●—		SW	#200 - 0.46 #230 - 0.32	2.35	2.90		-1.31	1.06	3.03	1.86

Comments:

Depths and elevations based on measured values

Sample Information	
Project Name:	MRC
Analysis Date:	09-30-17
Analyzed By:	
Easting (X, ft):	
Northing (Y, ft):	
Horizontal System:	
Vertical System:	

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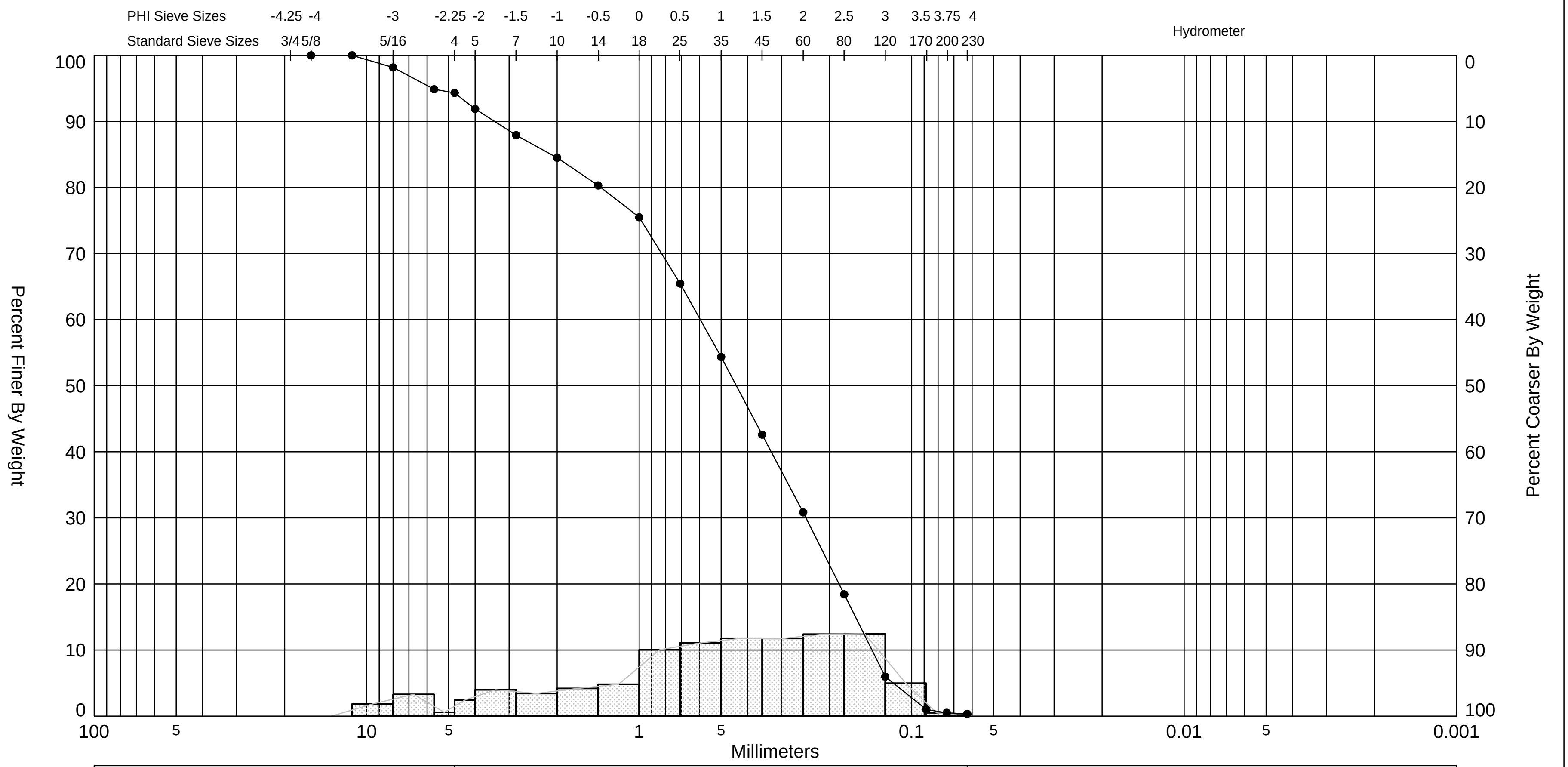

Gravel		Sand			Silt and Clay
Coarse	Fine	Coarse	Medium	Fine	

Sample	Symbol	Elev. (ft)	USCS	% Fines	% Organics	% Carbonates	Median	Mean	Skew	Kurt	Sort
SE849	—●—		SW	#200 - 0.51 #230 - 0.34	2.51	1.35	1.19	0.9	-0.69	2.71	1.67

Comments:

Depths and elevations based on measured values

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Sample Information	
Project Name:	MRC
Analysis Date:	09-30-17
Analyzed By:	
Easting (X, ft):	
Northing (Y, ft):	
Horizontal System:	
Vertical System:	