Preliminary Evaluation of Septic Tank Influences on Nutrient Loading to the Lower St. Johns River Basin and Its Tributaries

Final Report
FDEP Contract WM952

Submitted To:
The Florida Department of Environmental Protection

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TABLE OF CONTENTS

PROJECT BACKGROUND:

The Florida Department of Environmental Protection (FDEP) and stakeholders in the restoration of the Lower St. Johns River (LSJR) in the Jacksonville area are interested in obtaining information that will lead to a determination of the importance of residential septic tank (also known as on-site treatment and disposal systems [OSTDS]) nutrient and bacterial loading to the LSJR and its tributaries. Although septic tanks in Jacksonville have often been blamed for polluting waterways with both algae feeding nitrogen and coliform bacteria, there is still much uncertainty about how many homes and businesses in the city are served by septic tanks. This uncertainty exists because of the age of many homes and the limitations of record keeping in the past. Recent estimates range from 70,000 (JEA) to as many as 91,000 (FDOH). Regardless of the exact number, however, the fact remains that it is high. These OSTDS must treat an enormous amount of wastewater (190 to 200 L/day per capita) and therefore critical questions concerning the impact of septic tanks on the LSJR remain.

In view of this, FDEP contracted with Florida Institute of Technology (Florida Tech) to conduct a study to monitor representative sites in the drainage basin and provide information that will assist FDEP and the stakeholders better understand the impact of septic tanks on the LSJR. The information from this project may be used to assist FDEP, the City of Jacksonville and other stakeholders refine the LSJR Nutrient Basin Management Action Plan (B-MAP), as it will provide more information on septic tank nitrogen loadings to the river and its tributaries, relative to other sources.

The study seeks to answer several fundamental questions related to potential OSTDS impacts based on their physical location relative to surface waters, their usage history, and natural site specific factors such as soil characteristics, drainage, and groundwater flow regime.

GENERAL PROJECT OVERVIEW AND OBJECTIVES:

In this study, the attenuation of nitrogen (NH_4-N, NOx-N), phosphorus and bacteria (fecal coliform) by soil was measured at selected sites under a typical range of conditions representative of OSTDS near surface waters. This study determined nutrient and bacteria concentrations in receiving LSJR tributaries, and evaluated the relationship of nutrient detections in ground water and surface water to OSDS and other potential sources using site information and chemical tracers. Chemical indicators of OSTDS wastewater (caffeine, Triclosan®, and nitrogen isotopes (δ^{15}N and δ^{18}O in nitrate) were used to differentiate between nitrogen sources (fertilizers, OSTDS, wildlife, etc.).

This project included three sampling events that represented seasonal changes (two [2] wet season and one [1] dry season) at individual home sites located in the previously identified five general areas. The residential sites were selected to represent average conditions in the five neighborhoods and provide information on septic tank impacts and background conditions. Figure 1 illustrates the monitoring set-up at a typical home near a water body. Ground water samples were be obtained with the use of shallow small-diameter PushPoint samplers and 2-inch and 3/4-inch-diameter PVC hand-installed wells/piezometers. Ground water seepage into adjacent surface water bodies was measured with seepage meters. All sampling and data analysis procedures are outline in the FDEP approved Sampling and Analysis Plan (SAP) for this project.

SITE DESCRIPTION

Hydrogeologic Description of Study Area

Although soils in the study areas vary from well to poorly drained, much of the area is dominated by very well drained entisols with low runoff potential (Watts, 1998). Sandy and loamy sediments are present on rises, knolls and flats, while creek bottoms are usually made up of poorly drained Surrency soil types that are present in nearly level depressions and on flood plains (U.S. Dept. of Agriculture, 1998).

The geologic deposits important to this study include the shallow sediments to a depth of about 100 feet. The sediments are primarily comprised of unconsolidated fine to medium grained quartz sand with some clay, shell, and limestone. These unconsolidated sediments form the surficial aquifer system. Throughout most of Duval County, the water table is within 5 ft of land surface, but the depth to water table can reach greater than 12 ft at many local sites **(**Causey, 1975).

Underlying the surficial aquifer system are approximately 400 ft^2 of primarily fine-grained, clay sediments that also include some shell, sand and limestone. This is the intermediate confining unit. Underlying the intermediate confining unit is a thick sequence of carbonate rocks that form the artesian aquifer system or Floridan aquifer (Phelps, 1994). The amount of water that passes through the surficial aquifer to the Floridan aquifer probably is insignificant because artesian flow conditions exist in the eastern two-thirds of Duval County, and because numerous swampy areas indicate poor subsurface drainage. In most parts of the County, the majority of the water that enters the surficial aquifer system leaves the aquifer as seepage to streams or other water bodies, and by evapotranspiration. Therefore, the amount of runoff is generally the difference between rainfall and evapotranspiration (Wicklein, 2004**).**

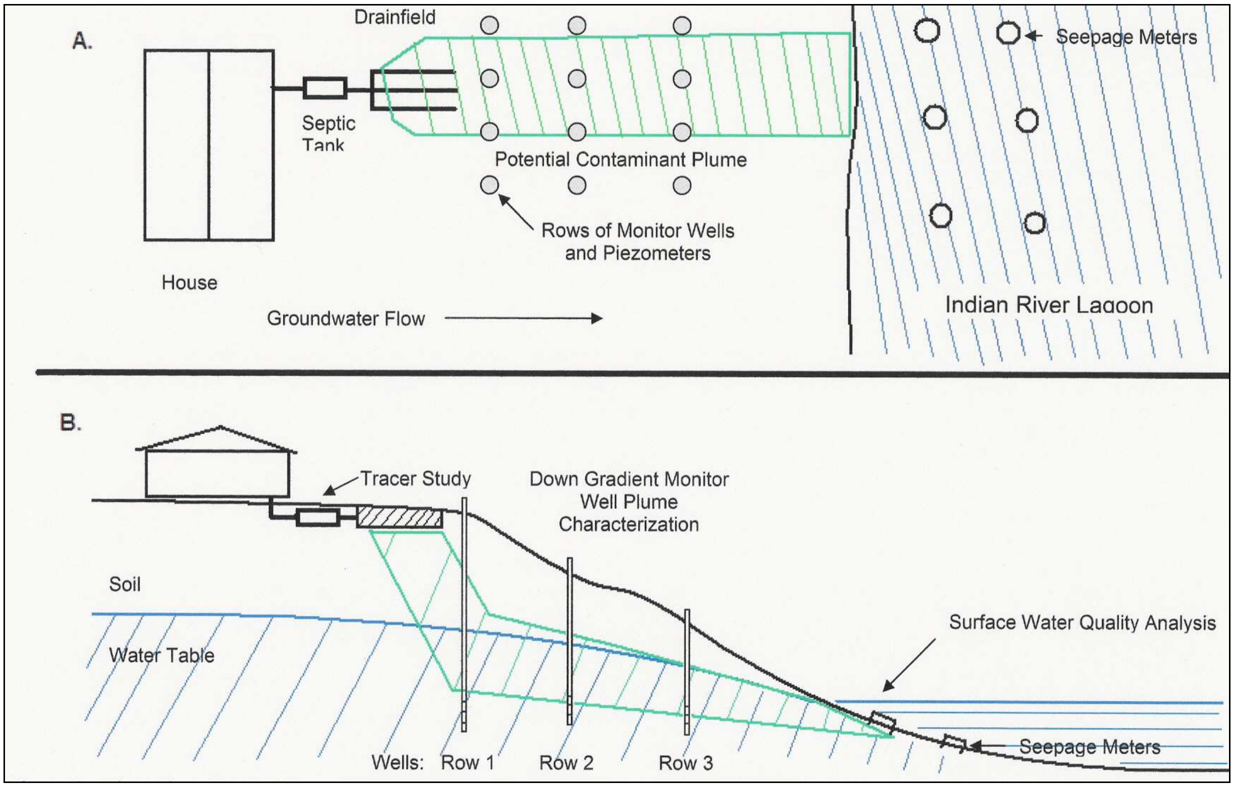


Figure 1. Typical Monitoring Set-Up

Sampling Site Descriptions

Based on a review of the existing data and the site reconnaissance survey five (5) study areas that are adjacent to LSJR tributaries were selected**.** These areas are on the Duval County Health Department's list of septic tank failure and have been identified by the City of Jacksonville as potential sources of nitrogen to the LSJR. The selected areas provided a good range of septic tank settings and physical conditions that can be used to represent other priority areas in the city. A total of fourteen (14) individual residential sites within the five (5) general areas, shown in Fig. 2, were selected for monitoring.

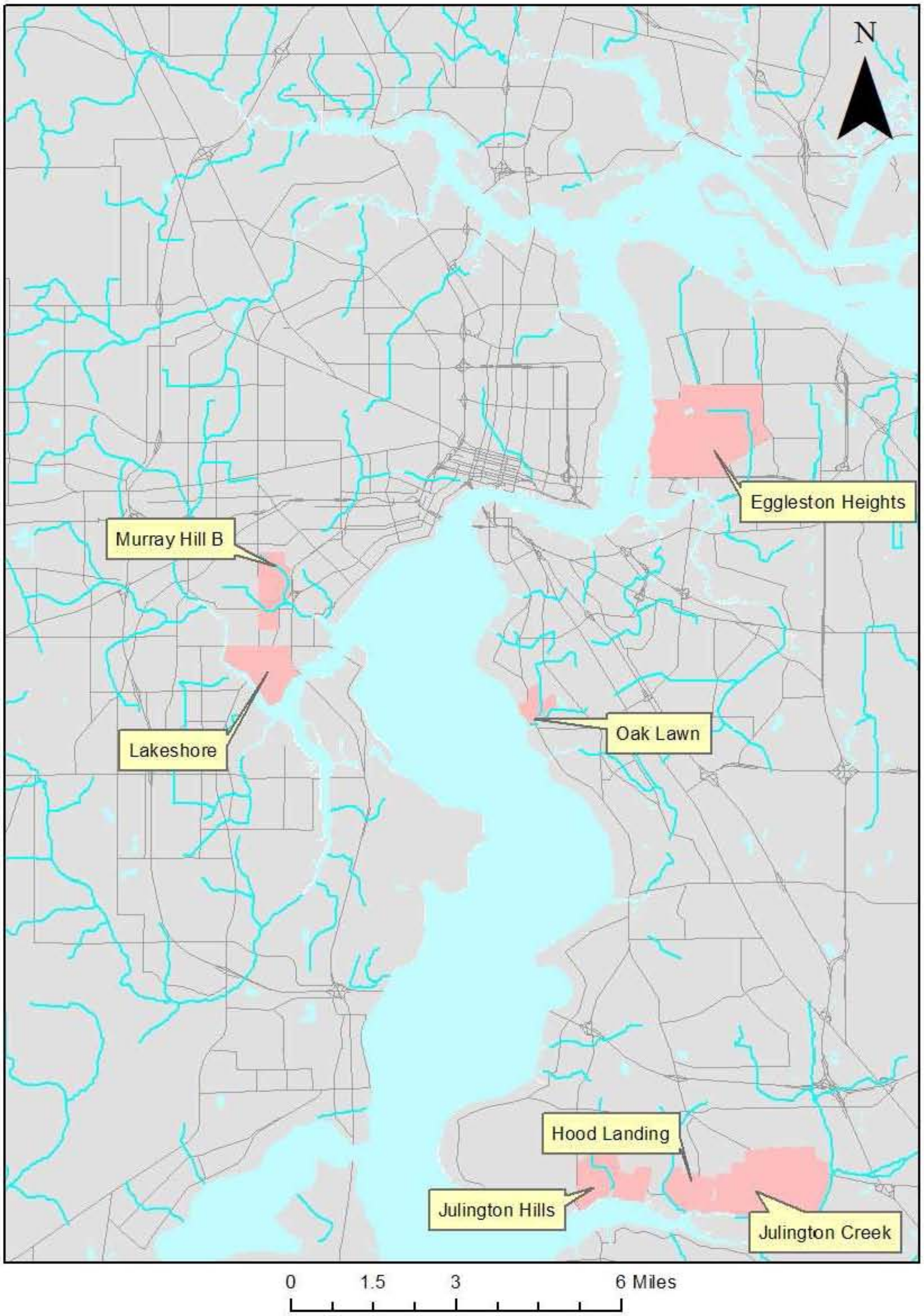


Figure 2. General Project Areas

Lakeshore (3 sites)

The Lakeshore area is characterized by a high density of older residential homes with septic tanks, poor natural drainage conditions, and mainly spodisol soils. Sampling sites included three (3) homes on Waterside Drive adjacent to the Cedar River (WBID 2262). The subdivision sampled is just north of the Lakeshore area, but conditions are very similar:

5428 Waterside, (RT)---Home built in 1951. Gray water tank in backyard, black water tank in front yard. Five people lived in the house until 1975 with two inhabitants since then. No fertilization. Backyard slopes to Cedar River.

5476 Waterside, (DE)---Two people in home since it was built in 1959. Tank located in backyard. Occasional fertilization, but only front yard. Backyard slopes to Cedar River.

5436 Waterside, (NJ)---Home built in 1960. Two inhabitants since 1980. Tank in front yard. Occasional fertilization. NJ was completely sampled only once, in June, 2010. Back yard slopes to Cedar River.

Murray Hill B (2 sites)

Murray Hill B is also an older subdivision with similar soil and drainage conditions as Lakeshore. City sewer lines were extended into this subdivision in 2004 to 2006, and now approximately 90% of the homes in the subdivision have connected to sewer. The population, number of residences and the former septic tank densities for the 465 acre Murray Hill B subdivision, which drains into South Branch Big Fishweir Creek, is 6.0 people per acre, 2.3 houses per acre and 2.7 septic tanks per acre, respectively. (Wicklein, 2004). The U.S. Geological Survey (USGS) has been monitoring surface water quality in the Big Fishweir Creek drainage into and from the neighborhood since the sewer line extension to evaluate the effects of sewer connection. This area was selected to monitor groundwater near septic tanks no longer in service to evaluate residual nutrient concentrations on a more localized scale. Two homes were selected and are located on small tributaries to Big Fishweir Creek (WBID 2280) in the downstream area that was being monitored by USGS:

4647 Yerkes, (BQ)---Home built in approximately 1970. Two occupants since 1978. Septic tank located in backyard. Home connected to city sewer in 2005. Owner does not fertilize yard. BQ was completely sampled only once, in December, 2009. Drainage is to a ditch.

4746 Glenwood, (JB)---Home has had two occupants since it was built in 1996. Tank located on east side of home. Periodic fertilization. Drainage is to Little Fishweir Creek.

Julington Hills/Julington Creek/Hood Landing (4 sites)

This area includes three (3) adjacent subdivisions on the northern shore of Julington Creek that are served by septic tank systems. Homes in these areas are somewhat newer than at Lakeshore and Murray Hill B, and soils include aflisols in the higher elevations and spodisols in the more flat areas, and drainage is somewhat better. Many homes in this area are served by private wells and several may have been contaminated by nitrate. The St. Johns River Water Management District (SJRWMD) has in-place shallow monitoring wells in these ground water contamination areas that are sampled periodically. Sampling occurred at two (2) homes on septic tanks along Cormorant Branch (WBID 2381) and two (2) newer homes at separate locations on tributaries that connect with Julington Creek (WBID 2351). Five nearby SJRWD wells were also sampled as part of this study. The residential sites were located in the Julington Hills subdivision adjacent to Julington Creek and in the Hood Landing area on Cormorant Drive adjacent to Cormorant Creek:

12827 Julington Road, (LP)---Home in Julington Creek subdivision, built in the 70's. Three occupants until 1984, two people since. Septic tank in front yard. Good slope in backyard. Occasional fertilization. Drains to a canal connected to Julington Creek.

5180 Siesta Del Rio, (CST)---Home in Julington Creek subdivision, built in 1985 and has had five occupants since that time. Owner fertilizes approximately every two months. Tank in backyard. Slope is fairly flat. Has had periodic septic tank problems. Drainfield replaced in Spring, 2010. Drains toward a wetland adjacent to a canal connected to Julington Creek.

12511 Cormorant, (MM)---Home in Julington Hills subdivision.Two people in home since it was built in 1967. Septic tank on west side of home. Owner fertilizes front yard only. Drains to Cormorant Branch.

12537 Cormorant, (DH)---Home in Julington Hils subdivision. House built in 1950. Current four occupants have been there since 1997. Two large dogs have free access to the backyard. Two tanks in backyard. No fertilization.

Eggleston Heights (3 sites plus additional surface water sampling along canals and Red Bay Branch)

Eggleston Heights is an older subdivision with a high density of septic tanks that is located on an elevated, well-drained sandy ridge. It is drained to the west by Red Bay Branch and to the south by Strawberry Creek. Homes on the east side of Red Bay Branch are similar to those in Eggleston Heights but were hooked up to city sewer more than a decade ago. There are three (3) SJRWMD shallow monitoring wells in this subdivision that were sampled for septic tank constituents. In addition, recent monitoring by the City of Jacksonville detected elevated concentrations of nitrate-nitrogen in a ditch at the source of Red Bay Branch. The residential sites studied in this area included one home on the west bank of Red Bay Branch that had been converted to city sewer more than 12 years ago (WBID 2254) and two (2) homes on the east side that are served by septic tanks. We also sampled Red Bay Branch and the ditches feeding into it, and the monitoring wells in the vicinity of the study sites:

1629 Aletha, (WH)---Home built in 1968 and has had two occupants since 1980. Septic tank is in the front yard. Fertilization occurs once per year. WH was completely sampled once, in December, 2009. Located on west bank of Red Bay Branch.

7186 King Arthur Rd, (MR).---Home built in 1970. Seven people have lived in the home since 1995. Septic tank located in the backyard, sloping to Red Bay Branch. No fertilization.

2020 Woodleigh, (CS)---Home built in the 1980's and has had three inhabitants since. Converted to city sewer in1998. Occasional fertilization. Septic tank in backyard, sloping to Red Bay Branch.

Oak Lawn (1 site)

Oak Lawn is a small subdivision on the east side of the river that is drained by New Rose Creek and the St. Johns River. The site has older residences on the western side of a segment of New Rose Creek (WBID 2306). The predominant soils in this area are spodisols, drainage is relatively poor and the water table is high. One residential site was monitored in this area:

1628 Shirl Lane, (MG)---Home built in 1975. Had four inhabitants until 1995 and two since then. Septic tank in front yard. No fertilization. MG was completely sampled only once, in December, 2009, and the groundwater was too deep in the vicinity of the drainfield to sample. Backyard slopes to impounded segment of New Rose Creek.

Additional Surface Water Sampling

A tributary to the Ortega River in the Lakeshore area, near 2105 Lakeshore Boulevard (NG-Ditch), was sampled twice. Also, various Red Bay Branch (RB-1, RB-2, RB-3) and tributary ditches (R1-SW, GO-1) were sampled in the Eggleston Heights area. Several 10-21 ft. deep SJRWMD monitoring wells (MW1-4) were sampled in the Julington Hills (4) and Eggleston Heights (4) areas, also. These results will be discussed later in this report.

PROJECT ORGANIZATION

With the exception of the DEP and AEL, Inc. lab analyses, all work was performed by the four (4) person Florida Tech Research Team consisting of:

T. V. Belanger, Ph.D. Prof. of Env. Science, Florida Tech., P.I., Project Supervisor
H. H. Heck, Ph.D., P.E., Prof. of Civil Eng., Florida Tech
T. L. Price Jr., Ph.D Student in Env. Science, Florida Tech
D. I. McGinnis, M.S. Student in Env. Science, Florida Tech

Dr. Belanger and the Florida Tech team worked closely with Richard Hicks, the DEP Project Manager. The Project Organization Chart is shown in Figure. 3.

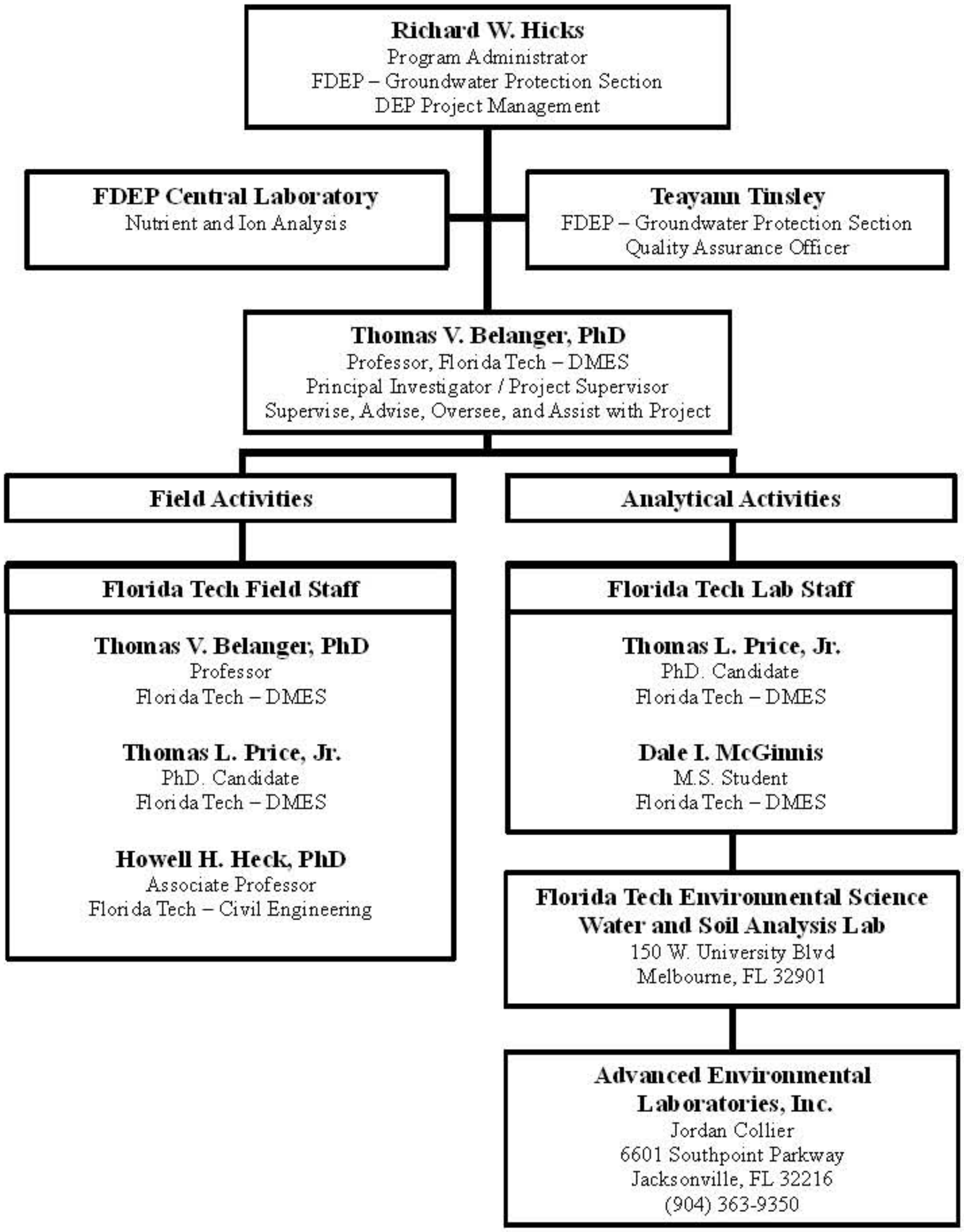


Figure 3. Project Organizational Chart

METHODS

Lab and Field Analyses and Procedures

Quality objectives and criteria in the SAP detail procedures for collection and analysis of water samples to ensure that data are acceptable and useable. Data were acceptable if the following objectives were met: (1) water and soil samples were collected in accordance with FDEP approved sampling procedures, and (2) samples were analyzed as described in standard and non-standard laboratory procedures. These objectives were met in this study. Specific DEP QA requirements are outlined in DEP Contract No. WM952. Sampling trips usually took three days for completion, and beginning dates for the three events were 12/29/09, 6/1/09 and 9/27/010. Summaries of parameter procedures follow, but for more detail on lab and field methods refer to the Sampling and Analysis Plan, FDEP Contract WM953.

Water Level--Field water level measurements were made in the piezometers with a Herron "Little Dipper" water level measurement pressure transducer and used for horizontal and vertical gradient calculations. Standard differential leveling procedures were used to determine relative elevations at top of casing heights for wells and piezometers. A bench mark was constructed at each location and assigned an assumed elevation of 10.00 ft. All other elevations were measured relative to this elevation (Ghilani and Wolf, 2008). Surveyed SJRWMD well bench marks were used when they are located in the immediate vicinity of the test areas.

Specific Conductance, Temperature, pH and Dissolved Oxygen (D.O.)--Specific conductance, temperature and pH of ground water and surface water were measured in the field with a Myron Ultrameter and D.O. was measured with a YSI Model 57 meter. Specific conductance measurements were calibrated with a potassium chloride standard at the beginning and end of each daily field trip. Dissolved oxygen meters were routinely checked with air calibration. Meters used to measure pH were calibrated against two buffer solutions prior to and after each daily field use. All calibrations were documented in the field notebook.

Fecal Coliform Bacteria --Fecal coliform bacteria were analyzed by AEL. Inc. Samples were collected in sterile plastic jars provided by AEL, Inc., kept on ice and delivered to the AEL, Inc. for fecal coliform analysis with six hours of sampling. At AEL, Inc. the samples were immediately analyzed using the EPA approved filtration technique (APHA, 1989) following DEP established protocol

Nutrients, Other Major Ions, and Isotopes—Florida Tech collected, filtered, preserved and delivered samples to the DEP Central Laboratory per the DEP Standard Operating Procedures. DEP procedures for Surface Water and Ground Water Sampling were followed and can be reviewed at the following site: (http://www.dep.state.fl.us/labs/qa/sops.htm).

Organic Wastewater Contaminants---Organic wastewater contaminants (OWC's) consist of substances such as pharmaceuticals, hormones, and stimulants, and are increasing in our nations water bodies. Recently, as detection techniques have improved, scientists are finding that pharmaceuticals and over the counter medications are common in estuaries, rivers, streams, groundwater and sediments. The primary way medications and personal care products (PCP's) make their way from the bottle into the environment seems to come from people flushing drugs and PCP's into wastewater treatment and septic tank systems where the treatment may not be adequate to remove all drug residues.

The OWC's measured in this study and evaluated as indicators of human fecal contamination are Triclosan® (an antimicrobial disinfectant) and caffeine (a stimulant). Screening for the presence of caffeine in environmental waters has been shown to be a promising predictor of human contamination (Peeler et al, 2006; Buerge et al, 2003; Ferreira et al, 2005; Seiler et al, 1999). In fact, when caffeine occurs in groundwater coincident with pharmaceuticals and elevated nitrate concentrations, it is regarded as "clear unambiguous evidence" of domestic wastewater contamination (Seiler et al, 1999. Like caffeine, Triclosan is one of the most commonly detected organic wastewater contaminants (Kolpin et al, 2002). It has been found in environmental waters with a frequency of 57.6% and median concentrations calculated at 0.14 *u*g/L (~4.8 x 10^{-10} M) and maximum reported concentrations of 2.3 *u*g/L (~7.9 x 10^{-9} M) (Kolpin et al, 2002.

Although accurate and cost effective analytical techniques have been a problem, the newly developed ELISA (enzyme linked immunosorbent assay) technique for the analysis of Triclosan and caffeine is very accurate, precise and cost effective and was uses in this study. The exact laboratory procedures for Triclosan and caffeine are presented in the SAP for this study. Screening for chemical indicators of human fecal contamination (Triclosan, caffeine) was conducted on selected surface water and selected ground water samples by Florida Tech. Duplicates were run on 10% of all samples.

Stable Nitrogen and Oxygen Isotope Ratios--- Samples were also collected for stable isotopes in the groundwater and surface water. Measurements of nitrogen and oxygen isotope ratios, $^{15}N/^{14}N$ and $^{18}O/^{16}O_{NO3}$, have been used for several years to help differentiate between sources of nitrate in ground water and to evaluate whether nitrogen concentration changes are due to the mixing of nitrate sources or to denitrification (Roadcap et al., 2002). These ratios for nitrogen and oxygen isotopes are represented in the delta notation, $\delta^{15}N$ and $\delta^{18}O$, respectively and are reported as parts per thousand (‰) deviations from recognized standards.

Over the years, researchers have associated isotopic ratios in ground water with a variety of sources and from that data general $\delta^{15}N$ ranges have been assigned for the types of sources. The three main nitrogen source categories are inorganic (from fertilizer), organic (from animal waste or domestic wastewater), and soil (which includes nitrogen from any source that is assimilated by the soil and accumulated in soil organic matter). Soil nitrogen can be a significant factor at sites where there is a significant amount of organic matter in the soil but it is not a factor where soils have very low organic content and nitrogen holding capacity.

Inorganic nitrogen sources like fertilizers and mineralized fertilizer residues have $\delta^{15}N$ values in the range of -2 to approximately 4‰. Organic sources of nitrogen like septic tank effluent and animal manure have $\delta^{15}N$ values in the range of 7 to approximately 20‰. Soil nitrogen, which includes the nitrogen that has been assimilated by the soil from a variety of sources, may be represented by $\delta^{15}N$ values ranging from -1 to 11‰. Soil nitrogen may be less of a factor where soils have low organic carbon content, such as the sandy soils in this area, because these types of soils do not retain much nitrogen. One factor that complicates the interpretation of data when using $\delta^{15}N$ data to attribute nitrate to types of source is fractionation of the nitrogen isotopes. Fractionation, through either chemical or biological processes, usually results in the product becoming enriched in the lighter isotopes and the residual, which is what we measure, being enriched in the heavier isotope. The common fractionation mechanism for stable isotopes in NO_3 is denitrification. In it, the lighter ^{14}N isotope is consumed by bacteria which leave a residual $^{15}N/^{14}N$ product that is enriched in the heavier ^{15}N isotope. The variability and range of the delta ^{15} N values should be different for different reservoirs or common materials, but different researchers quote different values for these materials. For example, according to Kendall (1998), organic fertilizers range from +6 to +30 %, and are related to processes occurring in animal wastes. The delta ^{15}N values of animals are related to their diet and the value of any animal is generally greater than the food it eats, and increases 3-4 % for each successive trophic level. A review of the literature indicates the high variability of delta N^{15} indicator data, however. For example, a 2008 groundwater sample taken within an OSTDS residential drainfield plume in Stuart, Florida showed high enrichment (29.3 delta ^{15}N), indicating the wastewater influence (Belanger et al., 2008). Mean nutrient values for this same site were >3.0 mg/L NOx-N and > 8.0 mg/L $P0_4$. NH_3-N levels were negligible. Constanzo et al., (2001) found groundwater mean delta ^{15}N levels in Davis and Salinas, California of 1.64 and 4.37 %, respectively, for a fertilizer source, and 10.21 and 7.31 %, respectively for an OSTDS source. This shows the variability of delta ^{15}N data and the difficulty in interpretation.

In recent years, researchers began to employ a "dual isotope method" to help evaluate the denitrification that is occurring in ground water. The second isotope in this dual approach is $\delta^{18}O_{NO3}$, which is the ratio of the heavier ^{18}O in NO_3 to the lighter ^{16}O. Denitrification results in the preferential fractionation of the lighter ^{16}O and enrichment of the heavier ^{18}O in the residue. Research has shown that when plotted against one another, the enriched $\delta^{18}O$ can indicate that the corresponding $\delta^{15}N$ value is influenced by denitrification. When samples from multiple points at the same site are plotted, the enrichment of the two isotopes due to denitrification generally results in a slope of roughly 2 to 1 (Roadcap et al, 2002).

Groundwater Seepage Measurement--Water fluxes through the sediment interface were measured directly using seepage meters positioned near the shore. Two adjacent shoreline seepage meters were used at each appropriate site in order to estimate precision, however several sites could not be equipped with seepage meters for various reasons (rocks, soupy muck sediments, etc.). The seepage meter technique has been cited by EPA as one of the best methods for measuring groundwater seepage (USEPA, 1988). Seepage meters followed the design of Lee (1977), with slight modifications (Fig. 4**).** Each meter consists of a 55 gallon steel drum cut to produce a hollow cylinder, open at one end, with a surface area of 0.29 m^2. A hole in the top of the meter is connected to a plastic collection (reservoir) bag by a polyethylene tube fitted through a rubber stopper.

Meters were installed without a reservoir bag and left undisturbed for a minimum of one day prior to measurement, allowing time for the initial flow disturbance to subside and the meter to settle into a fixed position. When the meter was ready, a reservoir bag with one L of water will be attached and the change in volume in the bag was determined over a defined time period. The seepage inflow or outflow was measured in change in volume per square meter per hour (mL/m^2-hr). These units are dimensionally equivalent to units of millimeters per hour (m/hr). Correction factors were applied to the data to correct for flow field disturbance and friction losses within the meter (Erickson, 1981; Cherkauer and McBride, 1988; Belanger and Montgomery, 1992).

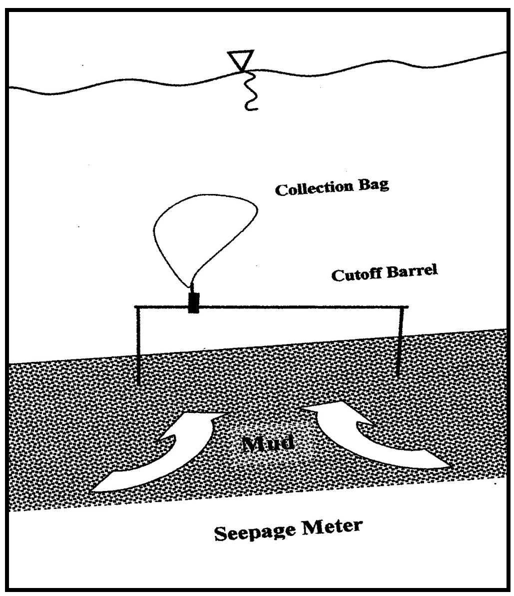


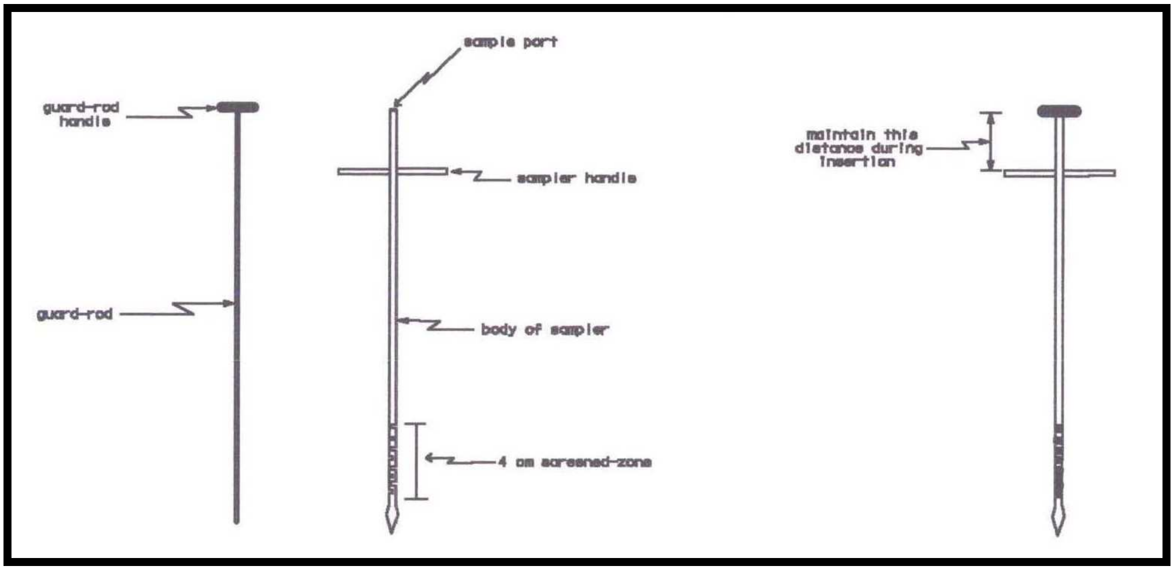
Figure 4. Diagram of a Seepage Meter.

Groundwater Gradients –Shallow (4-5 ft) ¾ in PVC piezometers were installed in the benthic sediment at nearshore sites (one per site). The piezometers had one ft. screened intervals with 0.010 slot screen. The in situ river piezometers were installed by jetting in a 1 ¼ inch temporary casing outside the piezometer pipe with a 1½ h.p. centrifugal Honda water pump connected to a 1 ¼ inch hose line. After the piezometers were allowed to settle and equilibrate for several days, the head difference between the surface water level (outside piezometer water level) and the groundwater (inside piezometer water level) was routinely measured (ΔH). The vertical hydraulic gradient was obtained by dividing the ΔH by the depth of the screen below the sediment surface. Terrestrial up-gradient and down-gradient 2 in piezometers were installed, similar to the ¾ in PVC installations described above (see site diagrams), with at least 2 ft. of screen below the water table at the time of installation. The horizontal gradients for the sites were calculated by dividing the vertical difference in water level between two points (up gradient and down gradient piezometer) by the horizontal distance between the two piezometers or between a piezometer and the river water level.

Groundwater Sampling---The M.H.E. PushPoint sampling tool allowed us to rapidly and accurately locate and sample groundwater: in essence to map and track contaminated groundwater movement in the area down gradient from OSTDS. The PushPoint device is a very simple, precisely machined tool consisting of a tubular body fashioned with a screened zone at one end and a sampling port at the other (Fig. 5**).** The bore of the PushPoint body is fitted with a guard rod that gives structural support to the PushPoint and prevents plugging and deformation of the screened zone during insertion into sediments. The screened-zone consists of a series of interlaced machined slots which form a short screened-zone with approximately 20% open area .The PushPoint is made of 316 stainless steel and comes in various lengths. In this study we primarily used 48 and 72 inch length and ¼ inch diameter PushPoints. The device is held in a manner that squeezes the two handles towards each other to maintain the guard-rod fully inserted in the PushPoint body during the insertion process. With the device held in this manner, the PushPoint was pushed into the sediment to the desired depth using a gentle twisting motion. When the desired depth was reached the guard-rod from the PushPoint body was removed without disturbing the position of the deployed sampler.

A GeoPump peristaltic pump was attached to the PushPoint sample port via Tygon tubing and water was withdrawn at a low-flow sampling rate (50-200 ml/min.). The first 20-50 ml of groundwater was generally turbid and this "development" water is discarded. Once non-turbid aliquots have been withdrawn, representative samples were collected for on-site and off-site analysis. Since the monitoring wells allowed for an easy determination of the distance to the water table, groundwater samples were obtained by sinking the appropriate length (either 36”, 48”, or 72” long) ¼” inside diameter PushPoint samplers in order to extract water from the top one foot of the water table. Samples were then extracted with a GeoPump peristaltic pump. Several depths from the same location were occasionally sampled by pulling the PushPoint up to a successively shallower sediment depth. For the September 2010 sampling event, ¾ in piezometers were installed at the sampling locations, with a 4 ft. screen interval occurring below the water table. Prior to sampling, the piezometers were developed by pumping (GeoPump) and discarding 3-4 well volumes. The appropriated length PushPoint rods were then placed inside the piezometers and pumped. This technique was assumed to be more representative because it was not as depth specific as PushPoint sampling, and it integrated water quality data from a 4 ft. groundwater depth interval. The September, 2010 site diagrams showing the sampling locations at each residence where this sampling method was used are shown in Appendix A. These diagrams are A4 (LP), A15 (JB), A21 (CST), A28 (DE), A32 (MR), A36 (MM), and A40 (DH).

A.



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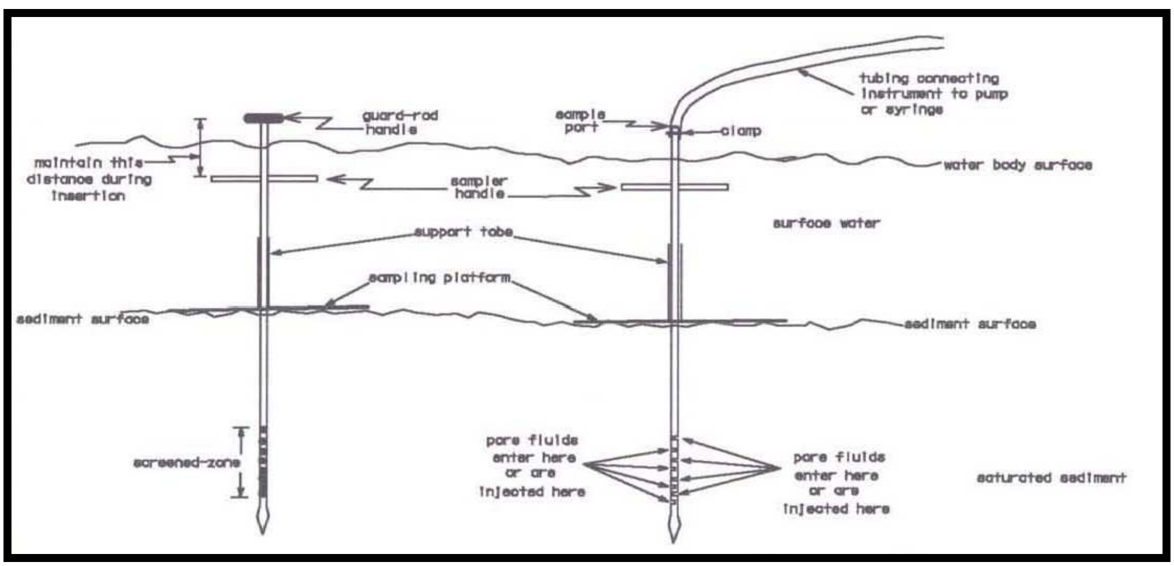

Figure 5. PushPoint Sampler Design (A) and Sampling Configuration (B).

Soil Sampling and Analysis--Percent soil particle size analyses were conducted on soil samples collected at two foot intervals from the land surface to water table at up gradient (near the drainfield) and down gradient (near the river or tributary) locations. Analyses were conducted by Florida Tech using standard sieving techniques (ASTM, 2008), and silt/clay, very fine sand, fine sand, medium sand, coarse sand and granule or larger fractions were determined. The sieve analysis data were also used to estimate hydraulic conductivity (Alyamani and Sen,1993). The method is based on the assumption that hydraulic conductivity increases with an increase in effective grain size. In addition, percent organic matter (O.M.) was determined on the soil samples by combusting the sample at 550 degrees C in a muffle furnace. Procedures for determining percent organic matter are outlined in Standard Methods (APHA, 1989) and Dean (1974). Ten percent of the sediment samples were run in duplicate for precision estimates. All sediment samples were saved for possible re-analysis at a later date.

Florida Tech Field and Lab Sample Analysis Parameters (Collection and analysis details are presented in the Sampling and Analysis Plan, FDEP Contract WM952).

Surface Water: turbidity, pH, conductivity, temp, D.O., fecal coliform bacteria, caffeine, Triclosan®

Ground Water: caffeine, Triclosan® turbidity, pH, conductivity, temp, D.O., fecal coliform bacteria, hydraulic gradients (vertical and horizontal), groundwater seepage

Note: Florida Tech sampled for fecal coliform bacteria in ground water and surface water and delivered samples to AEL, Inc. within the six (6) hr holding time constraint. Frequent delivery trips were needed during sampling.

Soil: particle size, % org. matter, hydraulic conductivity

DEP Lab Analysis Parameters. (Note: Florida Tech collected and shipped samples to the DEP laboratory according to the DEP SAP)

Surface Water: NH_3, TKN, NOx, TP, B, Fe, K, TOC, Cl, analyzed at the FDEP Central Laboratory

Ground Water: NH_3, TKN, NOx, TP, B, Fe. K, TOC, Cl, analyzed at the FDEP Central Laboratory

isotopes (δ^{15}N and δ^{18}O in nitrate), delivered to Colorado Plateau Stable Isotope Laboratory for analysis.

RESULTS

Sediment Particle Size (%), Organic Matter (%) and Hydraulic Conductivity (cm/s)

Sediment particle size, organic matter and hydraulic conductivity data from this study are presented in Table 1. Unless otherwise designated, all sediment samples were taken from up-gradient and down gradient 2 in piezometers at each residential site. The samples repesented a composite of sediment augered from one foot above and below the water table. Percent organic matter ranged from 0.25 at MR2 to 6.01 at RT2. Highest percentages of organic matter (LOI 550^{o} C) were found at RT2 (6.01%), JB1 (3.55%), CS1 (2.82%) and BQ (mean=1.66%). A mixed clay layer at DH, one foot thick and occurring at approximately four ft. below land surface, exhibited an organic matter content of approximately 4% and a silt/clay percentage of 16.9%. Another similar clay layer at MM had a silt/clay percentage of 21.3, indicating the layer is probably continuous along the north side of Cormorant Creek.

Lower coefficients of uniformity (C_u) yield higher hydraulic conductivities (K). The calculated C_u's in this study indicate the sediment at virtually all sites were well sorted in the medium to fine grain sand intervals. Using a Hazen coefficient of 80, the lower range for medium sand, yields the most representative hydraulic conductivity values (K_{80}) . K_{80}'s ranged from 0.31 cm/s at BQ1 and MM2 to 1.34 cm/s at CST9A. The CST site was characterized by high K values (>1.25 cm/s at all locations). RT1, RT2 and WH1 also exhibited high K_{80} values, with levels of 1.09 cm/s, 1.02 cm/s and 1.19 cm/s, respectively (Table 1). No significant statistical relationship was found between particle size, hydraulic conductivity or hydraulic gradients (vertical and horizontal) and plume migration distances, as other factors came into play.

Additional detailed soil information for the Jacksonville sampling sites is presented by Watts (1998). Basically, a large percentage of the study sites are well drained class A soils, with low runoff potential and low organic matter. This is particularly true for the Eggleston Heights and Julington Creek areas, which are almost entirely comprised of well drained entisols. Although the depth to the seasonal high water table ranges from 0.5 to > 6.0 ft., at most sites it is between 1.5 and 6.0 ft.

Table 1. Percent Particle Size, Percent Organic Matter and Estimated Hydraulic Conductivity (cm/s).

	Gravel	V Coarse	Coarse	Medium	Fine	V Fine	Silt/Clay	LOI 550°	C_u	K_{80}	K_{60}
BQ1	0.93%	0.46%	0.99%	2.06%	50.48%	43.43%	1.65%	1.14%	2.14	0.41	0.31
BQ2	0.83%	1.16%	2.11%	4.88%	71.24%	16.25%	3.53%	2.17%	1.87	0.82	0.58
CS2	0.33%	0.76%	1.83%	5.96%	79.91%	9.07%	2.15%	2.82%	1.52	1.25	0.94
CST1	0.00%	0.19%	1.77%	10.31%	80.43%	6.47%	0.83%	0.54%	1.52	1.44	1.00
DE1	0.03%	0.11%	1.44%	6.75%	55.25%	36.30%	0.12%	0.96%	2.14	0.47	0.36
DH1	0.12%	0.93%	1.15%	1.29%	73.33%	21.44%	1.74%	0.59%	1.87	0.72	0.50
JB1	0.51%	0.45%	0.74%	5.13%	76.03%	16.99%	0.14%	3.55%	1.68	0.95	0.71
MG1	0.00%	0.30%	1.94%	1.83%	55.74%	34.50%	5.70%	2.00%	2.30	0.38	0.29
MG3	0.00%	0.47%	1.20%	1.37%	53.98%	37.11%	5.88%	0.72%	2.22	0.38	0.27
MM1	0.04%	0.09%	0.10%	0.38%	72.69%	26.40%	0.30%	0.43%	1.93	0.63	0.44
MR1	0.34%	0.16%	0.52%	4.04%	84.96%	8.83%	1.14%	1.60%	1.52	1.25	0.94
RT1	0.20%	0.64%	6.18%	18.37%	60.43%	11.41%	2.78%	0.54%	1.80	1.09	0.82
RT2	0.67%	0.73%	2.86%	15.78%	64.92%	11.33%	3.70%	6.01%	1.80	1.02	0.71
WH1	0.02%	0.03%	0.25%	1.93%	85.63%	11.29%	0.86%	0.79%	1.52	1.17	0.87
CST9A	0.02%	0.26%	1.68%	11.09%	78.49%	6.71%	1.76%	0.88%	1.52	1.34	1.00
CST10	0.12%	0.27%	2.56%	9.81%	76.84%	8.82%	1.57%	0.96%	1.52	1.25	0.94
DE2	0.00%	0.04%	0.72%	4.99%	63.52%	26.43%	4.30%	0.66%	2.22	0.47	0.33
DE5	0.00%	0.08%	1.59%	8.42%	60.57%	24.96%	4.38%	1.49%	2.30	0.47	0.36
DH1A	0.03%	0.32%	1.20%	1.63%	71.26%	21.71%	3.84%	1.27%	2.14	0.54	0.41
DH7	0.00%	0.03%	0.25%	0.99%	71.77%	24.05%	2.91%	0.45%	2.07	0.54	0.36
DH7 clay	0.00%	1.68%	5.79%	6.88%	33.61%	35.15%	16.90%	4.00%	2.64	0.24	0.18
LP3	0.00%	0.07%	0.97%	10.43%	73.49%	13.57%	1.47%	0.34%	1.62	1.09	0.76
MM1A	0.00%	0.01%	0.05%	0.35%	73.88%	23.51%	2.20%	0.35%	1.93	0.63	0.44
MM2	0.00%	0.00%	0.15%	0.55%	63.95%	31.64%	3.71%	0.47%	2.14	0.47	0.31
MM clay	0.00%	0.03%	0.40%	2.60%	41.57%	34.10%	21.30%	n/a	2.83	0.18	0.13
MR2	0.02%	0.03%	0.26%	2.38%	75.77%	20.80%	0.74%	0.25%	1.74	0.82	0.58
MR8	0.02%	0.02%	0.17%	2.23%	85.52%	11.80%	0.24%	0.32%	1.46	1.25	0.87

Cu: Coefficient of Uniformity

K_{60}: Hydraulic conductivity calculated using Hazen Coefficient C=60

K_{80}: Hydraulic conductivity calculated using Hazen Coefficient C=80

Vertical Hydraulic Gradients, Horizontal Hydraulic Gradients and Groundwater Seepage

Gradient and groundwater seepage data are presented in Table 2**.** Vertical hydraulic gradients varied from 0.01 at MM on 6/1/10 and 9/28/10 to 0.37 at CS on 12/28/09. Horizontal hydraulic gradients were low at all sites, ranging from 0.01 at CST on 6/1/10 and 9/28/10 to 0.05 at RT on 12/28/09. Groundwater seepage ranged from a mean (two meters) of -178 mL/m^2-hr on 6/1/10 (High Tide) to a high of 4427 mL/m^2-hr at DH on 12/28/09 (Low Tide) (Table 2). Many gaps occurred in the hydraulic gradient and groundwater seepage data, as destroyed, lost and clogged piezometers and seepage meters were a constant problem. Seepage meters could not be installed at MG, CST, CS, JB, BQ, MR and WH due to unsuitable substrate or water level conditions (e.g. deep mucky sediment, rocky substrate, water level too low). No significant correlation was found between hydraulic gradient (vertical or horizontal) and groundwater seepage, as sediment and tidal effects dominated.

Water Quality Data

All field and lab groundwater and surface water quality data , including statistical mean and range data, are presented in Tables 3**,** 4, 5, and 6. A comparison of possible fecal contamination indicator data is shown in Table 7. All residential sites sampling diagrams (39) are shown in Appendix A, and although the sampling locations were usually the same at each site, some variability did occur between different sampling events and therefore the applicable site diagram should be referred to when interpreting groundwater quality data. Each residential site was labeled with the initials of the homeowner, and is referred to as such on the data tables.

Table 2. Hydraulic Gradient and Calculated Seepage Rate

LP	7/20/2009	12/28/2009	6/1/2010	9/28/2010
VHG	NS	0.07	0.08	0.06
HHG	0.003	0.003	0.002	0.003
GWS	LWL	1710 (LT)	LWL	LWL
MG				
VHG		0.07	NS	NS
HHG		0.02	NS	NS
GWS				
MM				
VHG		0.02	0.01	0.01
HHG		0.02	0.02	PD
GWS		2324 (LT)	442, 663 (HT)	BL
DH				
VHG		0.15	0.27	0.21
HHG		0.01	0.02	0.002
GWS		4427 (LT)	158 (HT)	1819 (RT)
CST				
VHG		0.2	0.34	0.07
HHG		0.02	0.01	0.01
GWS				
RT				
VHG		0.01	0.2	NS
HHG		0.05	0.003	NS
GWS		803 (LT)	-291, -65 (HT	NS

DE	7/20/2009	12/28/2009	6/1/2010	9/28/2010
VHG		0.04	0.02	0
HHG		0.04	LP	LP
GWS		50 (HT)	BL	280 (RT)
JB				
VHG		0.15	0.12	0.12
HHG		0.03	0.03	NS
GWS				
BQ				
VHG		PD	NS	NS
HHG		0.04	NS	NS
GWS				
MR				
VHG		NS	NS	NS
HHG		0.04	0.03	0.03
GWS		NS	NS	NS
WH				
VHG		0.4	NS	NS
HHG		0.016	NS	NS
GWS		LWL	NS	NS
CS				
VHG		0.37	NS	NS
HHG		0.02	NS	NS
GWS		LWL	NS	NS

VHG - Vertical Hydraulic Gradient
HHG - Horizontal Hydraulic Gradient
GWS - Ground Water Seepage
NS - Not Sampled

PD - Piezometer Destroyed
LP - Lost Piezometer
LWL - Low Water Level
BL - Bag Leak

LT - Low Tide
HT - High Tide
RT - Rising Tide

Table 3. Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
BQ-GW1	7/22/2009		19		0.41	0.86	0.42	1.280	0.073		
BQ-SW1	7/22/2009		11		0.076	0.78	0.32	1.100	0.11		
BQ-1	12/29/2009	2 U	11		0.42	2.3	0.004 UJ	2.304	0.26		
BQ-2	12/29/2009	2 U	10		0.49	1	0.008 U	1.008	0.92		
BQ-3	12/29/2009	2 U	6.7		0.054	0.67	0.008 U	0.678	0.72		
BQ-4	12/29/2009	2 U	6.8		0.016 I	0.5	0.008 U	0.508	0.34		
BQ-5	12/29/2009	2 U	9.9		0.39	1.1	0.009 I	1.109	1		
BQ-6	12/29/2009	2 U	11		0.31	1.3	0.011 IJ	1.311	0.17		
BQ-SW	12/29/2009	3600	20		0.17	0.96	0.54	1.500	0.085		
GW Mean		2	9		0.28	1.15	0.008	1.153	0.57		
GW Min Max		2, 2	6.7, 11		0.016, 0.49	0.5, 2.3	0.004, 0.011	0.508, 2.304	0.17, 1		
SW Mean		na	na	na	na	na	na	na	na		
SW Min Max		na	na	na	na	na	na	na	na		

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
BQ-GW1	7/22/2009	77 I			2.2 I	297	25.26	0.38	
BQ-SW1	7/22/2009	45 I			10	320	26.97	4.70	
BQ-1	12/29/2009	48 I				274	16		6.04
BQ-2	12/29/2009	49 I				268	16.1		5.99
BQ-3	12/29/2009	32 I				245	14.9		6.01
BQ-4	12/29/2009	31 I				366	14.9		6.42
BQ-5	12/29/2009	47 I				311	14.1		6.30
BQ-6	12/29/2009	50 I				270	14.3		6.22
BQ-SW	12/29/2009	64				402	12		6.79
GW Mean		43				289	15.1		6.13
GW Min Max		31, 50				245, 366	14.1, 16.1		5.99, 6.42
SW Mean		na	na	na	na	na	na	na	na
SW Min Max		na	na	na	na	na	na	na	na

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
A = Value reported is the mean of two measurements.
B =Result based on colony counts outside of acceptable range.
I = Value reported between laboratory MDL and PQL.
J = Estimated value.
U = Analyzed but not detected.
Y = Improperly preserved.
Z = Colonies too numerous to count.

Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
CS-GW1	7/21/2009		41		46	47	0.04 U	47.040	15		
CS-SW1	7/21/2009		37		0.054	1.5	0.49	1.990	0.14		
CS-1	12/30/2009	2 U	36		0.083	0.5	0.007 I	0.507	0.22		
CS-2	12/30/2009	4 B	48		0.01 U	0.14 I	2.5	2.640	0.004 U	15.570	9.750
CS-3	12/30/2009	6 B	55		0.071	0.26	0.005 I	0.265	0.037		
CS-SW	12/30/2009	160	45 A		0.052	0.23	1.1	1.330	0.009 I	11.430	6.470
CS-2	6/3/2010	2 U	67	73 Y	0.072 Y	0.17 IY	0.004 UY	0.174	0.018 Y		
CS-3	6/3/2010	2 U	79	100 Y	0.13 Y	0.49 Y	0.12 Y	0.610	0.18 Y		
CS-PZ1	6/3/2010	2 U	32	43 Y	0.01 Y	0.77 Y	2.8 Y	3.570	1.3 Y		
GW Mean		3	53	72	0.06	0.39	0.906	1.294	0.29	na	na
GW Min Max		2, 6	32, 79	43, 100	0.01, 0.13	0.14, 0.77	0.004, 2.8	0.174, 3.57	0.004, 1.3	na	na
SW Mean		na	na	na	na	na	na	na	na	na	na
SW Min Max		na	na	na	na	na	na	na	na	na	na

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
CS-GW1	7/21/2009	988			15	1165	26.43	0.74	
CS-SW1	7/21/2009	34 I			17	272	25.82	2.37	
CS-1	12/30/2009	32 I				255.6	17.5		6.26
CS-2	12/30/2009	44 I				302.9	17.5		5.88
CS-3	12/30/2009	97				514.6	17.3		6.82
CS-SW	12/30/2009	52 I				292.3	19		6.03
CS-2	6/3/2010	148	390	3.6		458.3	26.9		5.32
CS-3	6/3/2010	188	550	3.8		605.6	25		5.65
CS-PZ1	6/3/2010	41 I	2470	1.8		232	24	2.1/4.8	5.46
GW Mean		92	1137	3.07		395	21.4		5.77
GW Min Max		32, 188	390, 2470	1.8, 3.8		232, 605.6	17.3, 26.9		5.32, 6.82
SW Mean		na	na	na	na	na	na	na	na
SW Min Max		na	na	na	na	na	na	na	na

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
A = Value reported is the mean of two measurements.
B =Result based on colony counts outside of acceptable range.
I = Value reported between laboratory MDL and PQL.
J = Estimated value.
U = Analyzed but not detected.
Y = Improperly preserved.
Z = Colonies too numerous to count.

Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
CST-1	12/31/2009	2 U	12		0.01 U	0.32	0.29	0.610	0.16	24.310	15.040
CST-2	12/31/2009	2 U	58		56	63	0.008 I	63.008	4.6		
CST-3	12/31/2009	2 U	42		41	41	0.02	41.020	4.8		
CST-4	12/31/2009	2 U	38		65	62	1.7	63.700	0.21 A		
CST-5	12/31/2009	2 U	14		0.01 U	0.91	10	10.910	1	6.650	1.770
CST-6	12/31/2009	2 U	19		0.01 U	0.54	0.73	1.270	0.88		
CST-7	12/31/2009	2 U	9.8		0.01 U	0.57	3.3	3.870	0.53		
CST-8	12/31/2009	2 U	8.3		0.01 U	0.57	0.66	1.230	1.1		
CST-9	12/31/2009	2 U	34		3.1	3.5	30	33.500	1.4		
CST-SW	12/31/2009	270	34 A		0.041	0.6	0.79	1.390	0.049 A		
CST-1	6/1/2010	2 U	13	200	0.01 U	0.3	0.034	0.334	0.1		
CST-2	6/1/2010	2 U	34	120	13	13	36	49.000	0.49	6.860	1.920
CST-3	6/1/2010	2 U	66	140	55	51	0.008 I	51.008	4.5		
CST-4	6/1/2010	2 U	66	340	59	55	0.2 U	55.200	0.91		
CST-8	6/1/2010	2 U	17	65	0.01 U	0.31	0.13	0.440	0.17		
CST-9	6/1/2010	2 U	62	250	6.5	7.1	9.9	17.000	0.85 A	11.390	5.550
CST-10	6/1/2010	2 U	25	130	0.033	0.67	4.6	5.270	0.025	5.440	2.970
CST-11	6/1/2010	2 U	40	79	0.01 U	0.49	1.9	2.390	0.045		
CST-SW	6/1/2010	48	39 A	47 A	0.016 I	0.8	0.17	0.970	0.086		
CST-1	9/27/2010	16 U	72	150	0.011 I	0.22	3.4	3.620	0.015	3.410	5.660
CST-2	9/27/2010	16 B	51	100	12	13	3.7	16.700	0.43 A	20.340	10.790
CST-4	9/27/2010	16 U	56	280	60	60	0.067	60.067	4.6		
CST-9	9/27/2010	16 U	45	220	4.9	5.4	25	30.400	0.46		
CST-9A	9/27/2010	16 U	52	210	45	45	0.042	45.042	4.6		
CST-10	9/27/2010	16 U	14	94	0.46	1.6	3.9	5.500	0.71		
CST-11	9/27/2010	16 U	43	230	11	11	21	32.000	0.66	16.890	8.140
CST-11A	9/27/2010	16 U	26	210	5.6	5.8	4.4	10.200	1.1 A	17.300	11.330
CST-SW	9/27/2010	620	590	120	0.055	0.86	0.12	0.980	0.06		
GW Mean		6	37	176	17.51	17.69	6.440	24.132	1.37	12.510	6.016
GW Min Max		2, 16	8.3, 72	65, 340	0.01, 65	0.22, 63	0.008, 36	0.334, 63.7	0.015, 4.8	3.41, 24.31	1.77, 10.79
SW Mean		313	221	84	0.04	0.75	0.360	1.113	0.065		
SW Min Max		48, 620	34, 590	47, 120	0.016, 0.055	0.6, 0.86	0.12, 0.79	0.97, 1.39	0.049, 0.086		

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
A = Value reported is the mean of two measurements.
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U = Analyzed but not detected.
Y = Improperly preserved.
Z = Colonies too numerous to count.

Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
CST-1	12/31/2009	51 I				41.2	17.9		5.53
CST-2	12/31/2009	1000				1248	18.8		6.92
CST-3	12/31/2009	847				1205	17.8		6.24
CST-4	12/31/2009	872				2032	18.0		6.64
CST-5	12/31/2009	82				354.2	17.2		5.98
CST-6	12/31/2009	97				600.8	17.4		5.93
CST-7	12/31/2009	114				218.2	17.3		6.00
CST-8	12/31/2009	165				262.9	17.1		6.04
CST-9	12/31/2009	822				100.8	17.1		5.79
CST-SW	12/31/2009	33 I				276.4	13.5		6.75
CST-1	6/1/2010	47 I	3440	4.6		491.6	25.5		5.50
CST-2	6/1/2010	1140	1110	15.5		845.1	26.1		6.03
CST-3	6/1/2010	1720	1180	18		1536	26.0		6.84
CST-4	6/1/2010	1050	26900	18.3		1560	26.0		6.39
CST-8	6/1/2010	85	1360	3.2		331.3	27.1		5.74
CST-9	6/1/2010	697	650	10.4		1043	25.7		5.90
CST-10	6/1/2010	123	130	4.4		408	26.0		5.00
CST-11	6/1/2010	26 I	98 I	6		347.5	23.9		5.42
CST-SW	6/1/2010	47 I	130	2.2		337.4	30.7		6.70
CST-1	9/27/2010	50 I	190	4.4		649	26.4	0.9	5.34
CST-2	9/27/2010	1510	200	28.2		935	26.5	0.5	6.17
CST-4	9/27/2010	995	5250	22.4		1630	26.2	0.6	6.50
CST-9	9/27/2010	526	120 I	9.3		965	25.7	0.3	5.74
CST-9A	9/27/2010	1090	7780	18.6		1213	25.6	0.7	6.39
CST-10	9/27/2010	157	6030	8		373	25.8	0.4	5.77
CST-11	9/27/2010	927	130	15.3		992	26.0	0.3	5.35
CST-11A	9/27/2010	542	330	9.8		753	26.3	0.6	6.06
CST-SW	9/27/2010	166	130	12.2		1997	29.2	2.9	6.38
GW Mean		589	3431	12.3		805	29.7	0.5	5.98
GW Min Max		26, 1720	98, 26900	3.2, 28.2		41.2, 2032	17.1, 188	0.3, 0.9	5, 6.92
SW Mean		82	130	7.2		870	24.5	2.9	6.70
SW Min Max		33, 166	130, 130	2.2, 12.2		276.4, 1997	13.5, 30.7	2.9, 2.9	6.38, 6.75

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
A = Value reported is the mean of two measurements.

B =Result based on colony counts outside of acceptable range.
I = Value reported between laboratory MDL and PQL.
J = Estimated value.

U = Analyzed but not detected.
Y = Improperly preserved.
Z = Colonies too numerous to count.

Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
DE-GW	7/22/2009		27		0.7	1.2	0.01 I	1.210	0.79 A		
DE-SW	7/22/2009		17		0.079	0.67	0.19	0.860	0.093		
DE-1	12/29/2009	2 U	42		3.6	4.1	0.008 U	4.108	1.3		
DE-2	12/29/2009	2 U	32		0.043	0.54	0.008 U	0.548	0.43		
DE-3	12/29/2009	2 U	26		1.4	2.1	0.015 I	2.115	0.29		
DE-4	12/29/2009	2 U	18		0.34	0.75 J	0.008 U	0.758	0.64 A		
DE-5	12/29/2009	2 U	~		1.5	2.2	0.008 U	2.208	0.92		
DE-6	12/29/2009	2 U	31		0.68	1.5	0.008 U	1.508	0.64		
DE-7	12/29/2009	2 U	26		0.83	1.4	0.01 I	1.410	0.61		
DE-SW	12/29/2009	520	1200		0.14	0.68	0.31	0.990	0.1		
DE-1	6/2/2010	2 U	50	19	12	13	0.004 U	13.004	1.9		
DE-2	6/2/2010	2 U	29	2.2	1.9	2.6	0.004 U	2.604	0.81		
DE-3	6/2/2010	2 U	43	0.36 I	1.6	2.5	0.02 U	2.520	1.1		
DE-4	6/2/2010	2 U	20	3.1	0.67	1.4	0.004 U	1.404	0.41		
DE-5	6/2/2010	2 U	21	0.38 I	1	1.9	0.04 U	1.940	0.97		
DE-6	6/2/2010	2 U	18	0.78	0.017 I	0.6	0.004 U	0.604	0.71		
DE-PZ1	6/2/2010		31	38	0.6	0.98	0.006 I	0.986	1 A		
DE-SW	6/2/2010	46	620	100	0.01 I	0.62	0.026	0.646	0.089		
DE-1A	9/28/2010	6900 Q,A									
DE-1	9/28/2010	16 U,Q	31	120	0.39	1.3	1.3	2.600	1.2		
DE-2	9/28/2010	16 U,Q	49	5.9	3.4	4.6	0.009 I	4.609	3.5		
DE-3	9/28/2010	16 Q,B	34	21	0.31	1.4	0.095	1.495	0.57		
DE-4	9/28/2010	180 Q,B	68	35	13	15	0.004 U	15.004	3.4		
DE-5	9/28/2010	140 Q,B	120	34	0.83	2.6	0.034	2.634	1		
DE-6	9/28/2010	5500 Q	37	10 A	0.92	2.8	0.004 U	2.804	0.67		
DE-7	9/28/2010	210 B	90	20	0.74	2.6	0.004 U	2.604	0.89		
DE-8	9/28/2010	910 B	36	18	0.5	1.5	0.004 U	1.504	0.64		
DE-SW	9/28/2010	400	450	78	0.087	0.64	0.095	0.735	0.098 A		
GW Mean		632	41	22	2.10	3.06	0.073	3.135	1.07		
GW Min Max		2, 6900	18, 120	0.36, 120	0.017, 13	0.54, 15	0.004, 1.3	0.548, 15.004	0.29, 3.5		
SW Mean		322	757	89	0.08	0.65	0.144	0.790	0.10		
SW Min Max		46, 520	450, 1200	78, 100	0.01, 0.14	0.62, 0.68	0.026, 0.31	0.646, 0.99	0.089, 0.1		

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
A = Value reported is the mean of two measurements.
B =Result based on colony counts outside of acceptable range.
I = Value reported between laboratory MDL and PQL.
J = Estimated value.
U = Analyzed but not detected.
Y = Improperly preserved.
Z = Colonies too numerous to count.

Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
DE-GW	7/22/2009	84			6.7	487	27.86	0.19	
DE-SW	7/22/2009	47 I			8.4	276	27.22	2.29	
DE-1	12/29/2009	70				589.5	15.9		6.42
DE-2	12/29/2009	84				490.1	16.3		6.31
DE-3	12/29/2009	72				501.3	16.1		6.41
DE-4	12/29/2009	49 I				448.6	16.5		6.67
DE-5	12/29/2009	76				695.2	16.5		6.70
DE-6	12/29/2009	65				610.3	17		6.61
DE-7	12/29/2009	57 I				644.8	17		6.60
DE-SW	12/29/2009	282				3404	13.7		7.11
DE-1	6/2/2010	62	410	6		743	26.7		6.89
DE-2	6/2/2010	82	800	3.6		440	27.6		6.85
DE-3	6/2/2010	107	1990	3.7		459	28		6.68
DE-4	6/2/2010	87	3140	3.5		426.9	27.8		7.02
DE-5	6/2/2010	99	3630	3		609.3	28.1		6.99
DE-6	6/2/2010	103	440	2.6		642.6	27		6.86
DE-PZ1	6/2/2010	117	30 U	3.4		462.7	24.6	0.8	6.68
DE-SW	6/2/2010	188	360	13.9		1973	30.5	5.9	7.64
DE-1A	9/28/2010								
DE-1	9/28/2010	60	8260	10.9		562	26	1.4	6.18
DE-2	9/28/2010	226	1540	4.3		695	26.6	1	6.36
DE-3	9/28/2010	389	2440	5.3		683	26.7	1.1	6.49
DE-4	9/28/2010	241	3240	8.8		888	26.6	0.6	6.49
DE-5	9/28/2010	103	4380	5		1082	26.6	0.7	6.57
DE-6	9/28/2010	103	3580	3.3		617	26.8	0.4	6.36
DE-7	9/28/2010	97	4860	6.6		1006	27.2	0.5	6.50
DE-8	9/28/2010	89	480	3.6					
DE-SW	9/28/2010	154	270	10.8		1685	26.2	3.5	7.25
GW Mean		111	2615	4.9		633	23.4	0.8	6.60
GW Min Max		49, 389	30, 8260	2.6, 10.9		426.9, 1082	15.9, 28.1	0.4, 1.4	6.18, 7.02
SW Mean		208	315	12.35		2354	23.5	4.7	7.25
SW Min Max		154, 282	270, 360	10.8, 13.9		1685, 3404	13.7, 30.5	3.5, 5.9	7.11, 7.64

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
A = Value reported is the mean of two measurements.
B =Result based on colony counts outside of acceptable range.
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U = Analyzed but not detected.
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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
DH-GW1	7/21/2009		230		0.69	5.9	8.3	14.200	1.4 A		
DH-GW2	7/21/2009		40		0.01 I	1.5	17	18.500	1.8		
DH-SW1	7/21/2009		33		0.03	1.2	0.11	1.310	0.1		
DH-1	12/28/2009	2 U	56		0.25	0.64	0.004 U	0.644	0.15		
DH-2	12/28/2009	2 U	110		1.2	2.1	38	40.100	0.94	8.130	1.320
DH-3	12/28/2009	2 U	83		0.12	1.1	0.016	1.116	1		
DH-4	12/28/2009	2 U	40		0.045	0.32	3.9	4.220	0.4		
DH-5	12/28/2009	2 U	94		0.1	1.6 I	74	75.600	1.1	5.560	-0.650
DH-SW	12/28/2009	490	30		0.043	0.51	0.2	0.710	0.051		
DH-1	6/1/2010	2 U	37	170	0.016 I	0.21	0.62	0.830	0.56		
DH-2	6/1/2010	2 U	88	170	0.036	0.4 U	22	22.400	0.55 A	12.490	2.820
DH-7	6/1/2010	2 U	77	140	0.01 U	0.31	2.1	2.410	0.1		
DH-8	6/1/2010	2 U	96	100	0.01 U	0.44	6.8	7.240	0.22	17.990	9.140
DH-SW	6/1/2010	99 B	150	55	0.01 U	0.79	0.022	0.812	0.06		
DH-1	9/27/2010	16 U	200	120	0.36	0.68	0.69	1.370	0.047	8.510	4.080
DH-1A	9/27/2010	16 U	52	160	0.75	1.5	1.1	2.600	0.39	11.940	-0.350
DH-2	9/27/2010	16 U	59	170	0.27	0.76	0.28	1.040	0.19	15.690	4.960
DH-3	9/27/2010	16 U	40	98	0.18	0.99	0.01 I	1.000	0.21		
DH-7	9/27/2010	16 B	75	150	0.32	1.2	0.04 U	1.240	0.71		
DH-8	9/27/2010	16 U	69	160	0.14	0.42	0.49	0.910	0.15		
DH-9	9/27/2010	16 U	67	140	0.17	1.2	0.052	1.252	0.83		
DH-SW	9/27/2010	980	1200	180	0.035	0.88	0.067	0.947	0.084		
GW Mean		8	78	143	0.25	0.87	9.381	10.248	0.47	11.473	3.046
GW Min Max		2, 16	37, 200	98, 170	0.01, 1.2	0.21, 2.1	0.004, 74	0.644, 75.6	0.047, 1.1	5.56, 17.99	-0.65, 9.14
SW Mean		523	460	118	0.03	0.73	0.096	0.823	0.07		
SW Min Max		99, 980	30, 1200	55, 180	0.01, 0.043	0.51, 0.88	0.022, 0.2	0.71, 0.947	0.051, 0.084		

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
A = Value reported is the mean of two measurements.
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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
DH-GW1	7/21/2009	268			11	1404	26.77	0.38	
DH-GW2	7/21/2009	115			13	785	25.03	4.59	
DH-SW1	7/21/2009	30 I			20	272	26.78	2.42	
DH-1	12/28/2009	52 I				602.3	19		7.07
DH-2	12/28/2009	371				1118	19.5		6.43
DH-3	12/28/2009	68				722.4	19.8		6.95
DH-4	12/28/2009	37 I				680.9	18.1		6.89
DH-5	12/28/2009	564				1183	17		6.84
DH-SW	12/28/2009	31 I				254.9	18.6		6.98
DH-1	6/1/2010	53 I	50 I	2.9		613.6	25.7		6.41
DH-2	6/1/2010	166	56 I	4.5		806.2	25.3		6.80
DH-7	6/1/2010	76	330	3.3		704.3	25		6.53
DH-8	6/1/2010	132	64 I	4.6		743.5	24.9		6.59
DH-SW	6/1/2010	64	280	4		591	35.3	7.5	5.02
DH-1	9/27/2010	104	11300	3.9		1041	28.6		6.88
DH-1A	9/27/2010	260	7240	3.8		669	32		7.01
DH-2	9/27/2010	267	49500	3.5		569	29.2		6.30
DH-3	9/27/2010	96	27700	1.6		369	29.6		5.38
DH-7	9/27/2010	196	6730	8.8		859	26.3	1	6.49
DH-8	9/27/2010	204	20000	5.2		688	27.1		6.30
DH-9	9/27/2010	91	39800	3.4		511	26.7		5.96
DH-SW	9/27/2010	294	360	24.2		4204	27.9	4.4	6.76
GW Mean		171	14797	4.1		743	24.6	1.0	6.55
GW Min Max		37, 564	50, 49500	1.6, 8.8		369, 1183	17, 32	1, 1	5.38, 7.07
SW Mean		130	320	14.1		1683	27.3	5.95	6.76
SW Min Max		31, 294	280, 360	4, 24.2		254.9, 4204	18.6, 35.3	4.4, 7.5	5.02, 6.98

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.

Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.

A = Value reported is the mean of two measurements.

B =Result based on colony counts outside of acceptable range.

I = Value reported between laboratory MDL and PQL.

J = Estimated value.

U = Analyzed but not detected.

Y = Improperly preserved.

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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
JB-GW1	7/22/2009		18		0.079	0.31 I	14	14.310	0.004 U		
JB-SW1	7/22/2009		27		0.06	0.49	0.36	0.850	0.12		
JB-1	12/29/2009	2 B	11		0.01 U	0.41	15	15.410	0.008 I		
JB-2	12/29/2009	2 U	16		0.026	0.55	16	16.550	0.16	8.190	8.630
JB-3	12/29/2009	2 U	16 A		0.91	1.9	2	3.900	0.22		
JB-4	12/29/2009	2 U	14		0.5 Y	~ O	~ O	0.000	0.52 Y		
JB-SW	12/29/2009	3500	36		0.094	0.49	0.37	0.860	0.088 A		
JB-1	6/3/2010		13	69 Y	0.01 IY	0.37 IY	18 Y	18.370	0.042 Y		
JB-2	6/3/2010		16	87 Y	0.027 Y	0.32 IY	11 Y	11.320	0.069 Y		
JB-3	6/3/2010		19	84 Y	0.94 Y	2.2 Y	3.1 Y	5.300	0.18 Y		
JB-4	6/3/2010		18	63 Y	2.4 Y	3.2 Y	0.012 Y	3.212	0.65 Y		
JB-SW	6/3/2010		17	24 Y	0.041 Y	0.65 Y	0.14 Y	0.790	0.2 Y		
JB-1	9/28/2010	16 U	14	74	0.011 I	0.4	10	10.400	0.022		
JB-2	9/28/2010	16 U	0.021	0.38 I	12	0.087	12	12.087	0.087	29.680	20.500
JB-3	9/28/2010	16 U	18	86	0.83	1.2	1.3	2.500	0.064	19.040	11.590
JB-4	9/28/2010	16 U	15	47	1.3	2.5	0.4	2.900	0.63		
JB-SW	9/28/2010	3200	16	31	0.043	1	0.28	1.280	0.17		
GW Mean		9	14	64	1.58	1.19	8.074	8.496	0.22	18.970	13.573
GW Min Max		2, 16	0.021, 19	0.38, 87	0.01, 12	0.087, 3.2	0.012, 18	0, 18.37	0.008, 0.65	8.19, 29.68	8.63, 20.5
SW Mean		3350	23	28	0.06	0.71	0.263	0.977	0.15		
SW Min Max		3200, 3500	16, 36	24, 31	0.041, 0.094	0.49, 1	0.14, 0.37	0.79, 1.28	0.088, 0.2		

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
JB-GW1	7/22/2009	102			2 I	386	22.06	0.90	
JB-SW1	7/22/2009	72 I			6.2	580	26.20	4.54	
JB-1	12/29/2009	98				329.2	20.3		3.69
JB-2	12/29/2009	115				364.7	19.6		3.93
JB-3	12/29/2009	117				254.6	16.4		5.63
JB-4	12/29/2009	70				309.7	16.5		6.26
JB-SW	12/29/2009	66				595.1	12.3		6.88
JB-1	6/3/2010	99	440	8.6		346.5	25.5		4.01
JB-2	6/3/2010	90	930	3.6		356.7	24.6		3.90
JB-3	6/3/2010	99	500	5.4		299.6	24.4		4.01
JB-4	6/3/2010	172	7400	4		356	25.1		6.24
JB-SW	6/3/2010	53 I	540	2.6		355.7	26.4		6.78
JB-1	9/28/2010	100	2820	8.5		338	25	3.7	4.68
JB-2	9/28/2010	124	1000	5.2		372	23.5	1.4	4.29
JB-3	9/28/2010	113	1250	4.6		242	24		4.93
JB-4	9/28/2010	184	8250	5		415	24.7		6.62
JB-SW	9/28/2010	59 I	720	2.4		419	23.9	3	6.70
GW Mean		115	2824	5.6		332	22.5	2.6	4.49
GW Min Max		70, 184	440, 8250	3.6, 8.6		242, 415	16.4, 25.5	1.4, 3.7	3.69, 6.62
SW Mean		59	630	2.5		457	20.9	na	6.79
SW Min Max		53, 66	540, 720	2.4, 2.6		355.7, 595.1	12.3, 26.4	na	6.7, 6.88

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
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J = Estimated value.

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Z = Colonies too numerous to count.

Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
LP-GW1	7/20/2009		20		0.079	0.89	0.098 I	0.988	0.031		
LP-SW1	7/20/2009		29		0.024	1.1	0.48	1.580	0.087		
LP-1	12/28/2009	2 U	15		0.01 U	0.24	5.9	6.140	0.12	7.370	4.190
LP-2	12/28/2009	14	14		0.01 U	0.19 I	0.5	0.690	0.065 A	9.420	5.550
LP-3	12/28/2009	2 U	19		0.01 U	0.4 U	21	21.400	0.018		
LP-4	12/28/2009	2 U	41		0.01 U	0.37 I	14	14.370	0.061	8.070	2.580
LP-SW	12/28/2009	160	28		0.024	0.63	0.4	1.030	0.056		
LP-1	6/1/2010	2 U	31	110	0.01 U	0.24 I	13	13.240	0.006 I	8.270	2.410
LP-2A	6/1/2010	2 U	54	250	0.01 U	3	3.9	6.900	0.07	0.910	-0.300
LP-3	6/1/2010	2 U	30	160	0.01 U	0.37 I	15	15.370	0.06	3.070	0.310
LP-4	6/1/2010	2 U	40	320	0.01 U	0.51	5.5	6.010	2.4		
LP-5	6/1/2010	2 U	6.6	160	0.023	1.4	3.8	5.200	0.059		
LP-6D	6/1/2010		38	200	0.01 I	0.66 I	22	22.660	0.59		
LP-6S	6/1/2010	2 U	29	120	0.086	0.62	0.02 U	0.640	0.093		
LP-SW	6/1/2010	34 B	37	37	0.019 I	0.66	0.24	0.900	0.099		
LP-WELL	6/1/2010		17	190	0.15	0.2 I	0.004 U	0.204	0.004 U		
LP-3	9/27/2010	16 B	40	150	0.01 U	0.44 I	26	26.440	0.024	5.000	0.410
LP-4	9/27/2010	400	24	96	0.01 U	0.31	8	8.310	2.1	3.500	2.010
LP-5	9/27/2010	16 B	35	96	0.01 U	0.4	9.8	10.200	0.063 A		
LP-6	9/27/2010	32 U	52	200	0.014 I	0.76 I	39	39.760	0.42	8.920	1.540
LP-1	9/27/2010	16 U	17	76	0.01 U	0.29	4.2	4.490	0.11	6.270	3.230
LP-2A	9/27/2010	16 U	18	170	0.01 U	0.23 J	0.27	0.500	0.08		
LP-SW	9/27/2010	130 B	250	53 A	0.014 I	1.2	0.097	1.297	0.1		
GW Mean		33	30	162	0.02	0.61	11.288	11.901	0.37	6.080	2.193
GW Min Max		2, 400	6.6, 54	76, 320	0.01, 0.086	0.19, 3	0.02, 39	0.5, 39.76	0.006, 2.4	0.91, 9.42	-0.3, 5.55
SW Mean		108	105	45	0.02	0.83	0.246	1.076	0.09		
SW Min Max		34, 160	28, 250	37, 53	0.014, 0.024	0.63, 1.2	0.097, 0.4	0.9, 1.297	0.056, 0.1		

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
A = Value reported is the mean of two measurements.
B =Result based on colony counts outside of acceptable range.
I = Value reported between laboratory MDL and PQL.
J = Estimated value.
U = Analyzed but not detected.
Y = Improperly preserved.
Z = Colonies too numerous to count.

Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
LP-GW1	7/20/2009	120			12	379	25.47	5.95	
LP-SW1	7/20/2009	33 I			16	285	26.97	4.91	
LP-1	12/28/2009	72				196.7	21.3		6.15
LP-2	12/28/2009	35 I				500.1	20.3		6.59
LP-3	12/28/2009	26 I				510.3	19.5		6.66
LP-4	12/28/2009	59 I				738.9	18.9		7.03
LP-SW	12/28/2009	26 I				276.2	16.8		6.66
LP-1	6/1/2010	52 I	30 U	3.6		481.3	22.4	2.3	5.51
LP-2A	6/1/2010	48 I	370	4.7		757.8	23.4		6.20
LP-3	6/1/2010	44 I	2020	7		640.3	24.2		6.75
LP-4	6/1/2010	96	870	7		881.3	23.7		6.57
LP-5	6/1/2010	16 I	590	2		491.2	24.5		6.53
LP-6D	6/1/2010	84	1090	9.9		845.2	22.9		6.42
LP-6S	6/1/2010	118	1290	4.5		457.2	24.6		6.25
LP-SW	6/1/2010	42 I	170	1.9		343.8	25.2	2.2	6.80
LP-WELL	6/1/2010	39 I	30 U	2.9 A		643.7	24.1	1.7	7.61
LP-3	9/27/2010	38 I	51 I	5.8		835	25	4.6	6.53
LP-4	9/27/2010	148	580	5		503	24.9	4.9	6.81
LP-5	9/27/2010	116	1690	5.1		500	24.8	2.8	6.43
LP-6	9/27/2010	92	6430	9.2		1080	25.6	2.3	6.60
LP-1	9/27/2010	63 A	570 A	2.5 A		312	24	7.7	6.19
LP-2A	9/27/2010	43 I	400	2		595	24.5	0.9	5.65
LP-SW	9/27/2010	82	180	5.6		1142	26	1.5	6.69
GW Mean		68	1229	5.3		607	23.2	3.6	6.53
GW Min Max		16, 148	30, 6430	2, 9.9		196.7, 1080	18.9, 25.6	0.9, 7.7	5.51, 7.03
SW Mean		50	175	3.8		587	22.7	1.85	6.69
SW Min Max		26, 82	170, 180	1.9, 5.6		276.2, 1142	16.8, 26	1.5, 2.2	6.66, 6.8

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I = Value reported between laboratory MDL and PQL.
J = Estimated value.
U = Analyzed but not detected.
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Z = Colonies too numerous to count.

Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
MG-GW3	7/20/2009		52		1.2	2.5	0.43	2.930	0.2		
MG-SW1	7/20/2009		28		0.02 I	2.2	0.044	2.244	0.36		
MG-1	12/28/2009	2 U	24		0.83	1.3	0.004 U	1.304	0.062		
MG-1-B	12/28/2009	2 U	35		2.8	3.2	0.007 I	3.207	0.16		
MG-2	12/28/2009	2 U	50		0.17	0.52	0.74	1.260	0.004 I		
MG-3	12/28/2009	2 U	60		0.21	0.59	0.18	0.770	0.046		
MG-SW	12/28/2009	120	180		0.12	0.74	0.18	0.920	0.12		
GW Mean		2	42		1.00	1.40	0.233	1.635	0.07		
GW Min Max		2, 2	24, 60		0.17, 2.8	0.52, 3.2	0.004, 0.74	0.77, 3.207	0.004, 0.16		
SW Mean		na	na		na	na	na	na	na		
SW Min Max		na	na		na	na	na	na	na		

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
MG-GW3	7/20/2009	70 I			6.2	752	25.60	0.31	
MG-SW1	7/20/2009	58 I			11	402	28.27	7.60	
MG-1	12/28/2009	164				287.8	17		6.50
MG-1-B	12/28/2009	120				341.5	17.3		6.55
MG-2	12/28/2009	91				649.5	14.1		6.52
MG-3	12/28/2009	141				673	15.5		6.63
MG-SW	12/28/2009	91				886.5	12.9		7.13
GW Mean		129				488	16.0		6.54
GW Min Max		91, 164				287.8, 673	14.1, 17.3		6.5, 6.63
SW Mean		na				na	na		na
SW Min Max		na				na	na		na

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
A = Value reported is the mean of two measurements.

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I = Value reported between laboratory MDL and PQL.
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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
MM-GW1	7/21/2009		30		0.038	0.87	0.04 U	0.910	0.075		
MM-SW1	7/21/2009		26		0.064	1.1	0.24	1.340	0.12		
MM-1	12/28/2009	20	61		0.17	2.5	0.021	2.521	2		
MM-2	12/28/2009	2	49		0.16	0.59 I	25	25.590	0.004 U	9.390	3.900
MM-3	12/28/2009	20	19 A		0.081	0.58	0.008 U	0.588	0.098		
MM-4	12/28/2009	20	16		0.1	1.4	3.1	4.500	0.49 AJ	12.940	10.580
MM-SW	12/28/2009	620 B	29		0.042	0.55	0.23	0.780	0.049		
MM-1	6/2/2010	2 U	53	42	0.058 I	1.6	0.12	1.720	0.48		
MM-2	6/2/2010	2 U	37	31	0.12	0.35	0.43	0.780	0.059		
MM-4	6/2/2010		39	71	0.024	0.41	0.91	1.320	0.008 I		
MM-5	6/2/2010	2 B	26	41	0.2	0.97	0.08 J	1.050	0.036		
MM-6	6/2/2010		27	30	0.092	0.47	0.86	1.330	0.012		
MM-7	6/2/2010	2 B	23 A	0.95 A	0.55	1	0.1 U	1.100	0.048		
MM-PZ1	6/2/2010		35	33	0.01 U	0.37	6.4	6.770	2	5.530	2.920
MM-PZ2	6/2/2010		18	20	0.17	0.38	0.1 U	0.480	0.024		
MM-PZ3	6/2/2010	5 B	36	34	0.13	0.61	0.088	0.698	0.17		
MM-SW	6/2/2010	380 B	100	39	0.027	0.62	0.28	0.900	0.08	9.570	5.890
MM-WELL	6/2/2010	2 U	28	26	0.096	0.12 I	4.6	4.720	0.084	6.370	3.310
MM-1	9/27/2010	16 U	62	97	0.044	0.24	4	4.240	0.016	14.320	8.280
MM-1A	9/27/2010	16 U	43	85	0.54	1.3	3.2	4.500	0.32	16.770	9.920
MM-2	9/27/2010	16 U	53	59	0.12	1.1	0.008 I	1.108	0.52		
MM-4	9/27/2010	16 U	46	72	0.037	0.32 J	6.4	6.720	0.023	11.770	7.070
MM-5	9/27/2010	16 U	17	29	0.15	0.77	0.006 I	0.776	0.11		
MM-SW	9/27/2010	350 B	910	150	0.082	0.84	0.14	0.980	0.11		
GW Mean		10	36	45	0.15	0.79	2.917	3.711	0.34	11.013	6.569
GW Min Max		2, 20	16, 62	0.95, 97	0.01, 0.55	0.12, 2.5	0.006, 25	0.48, 25.59	0.004, 2	5.53, 16.77	2.92, 10.58
SW Mean		450	346	95	0.05	0.67	0.217	0.887	0.08	na	na
SW Min Max		350, 620	29, 910	39, 150	0.027, 0.082	0.55, 0.84	0.14, 0.28	0.78, 0.98	0.049, 0.11	na	na

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J = Estimated value.

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Z = Colonies too numerous to count.

Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
MM-GW1	7/21/2009	33 I			15	297	25.97	5.36	
MM-SW1	7/21/2009	29 I			10	256	26.07	2.95	
MM-1	12/28/2009	83				509.6	14.3		6.56
MM-2	12/28/2009	176				5635	15.1		5.55
MM-3	12/28/2009	31 I				79.17	16		6.84
MM-4	12/28/2009	29 I				52.46	15		6.47
MM-SW	12/28/2009	32 I				210.3	12.5		6.88
MM-1	6/2/2010	89	36500	3.7		331.1	24		6.07
MM-2	6/2/2010	53 I	12700	0.87 I		220.1	27.1		6.00
MM-4	6/2/2010	124	120 I	3.1		353.1	23.5		6.14
MM-5	6/2/2010	130	660	2.7		252.1	23.7		6.54
MM-6	6/2/2010	53 I	130	1.4		201.6	24.6		6.09
MM-7	6/2/2010	25 I	6060	2.6		170	29		6.29
MM-PZ1	6/2/2010	74	1000	6.2		321.3	23.5		6.90
MM-PZ2	6/2/2010	26 I	12600	1.4		226.6	24.3		6.69
MM-PZ3	6/2/2010	65	28700	1.3		222.8	26.4		6.05
MM-SW	6/2/2010	52 I	440	3.1		561.5	26.1	3.6	6.34
MM-WELL	6/2/2010	35 I	4070	1.4		265.5	23.6		6.44
MM-1	9/27/2010	62	4580	4.6		493			4.38
MM-1A	9/27/2010	97	9760	5.2		460	22.9		6.62
MM-2	9/27/2010	54 I	6410	1.8					
MM-4	9/27/2010	83	610	5.1					
MM-5	9/27/2010	43 I	6390	1.4		187	25.1	0.8	5.65
MM-SW	9/27/2010	233	630	18.4		3352		4.7	5.93
GW Mean		70	8686	2.9		587	22.4	na	6.29
GW Min Max		25, 176	120, 36500	0.87, 6.2		52.46, 5635	14.3, 29	na	4.38, 6.9
SW Mean		106	535	10.8		1375	19.3	4.15	6.34
SW Min Max		32, 233	440, 630	3.1, 18.4		210.3, 3352	12.5, 26.1	3.6, 4.7	5.93, 6.88

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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
MR-GW1	7/23/2009		53		0.01 U	0.15 I	2.8	2.950	0.14		
MR-SW1	7/23/2009		49		0.095	0.46	2.3	2.760	0.026		
MR-1	12/30/2009	4 B	110		0.034	0.2 I	0.059	0.259	2.3		
MR-2	12/30/2009	2 U	140		0.01 U	0.43	1.9	2.330	0.62	5.670	0.400
MR-3	12/30/2009	2 U	170		0.01 UY	0.45 Y	2.9 Y	3.350	0.24 Y		
MR-4	12/30/2009	2 U	99		2.6	3.1	0.004 U	3.104	3.7		
MR-5	12/30/2009	2 U	100		4.7	5.1	0.004 U	5.104	1.8		
MR-6	12/30/2009	2 U	170		3.7	4	0.02 U	4.020	1		
MR-7	12/30/2009	2 U	140		10	12	0.02 U	12.020	2.5		
MR-8	12/30/2009	2 U	160		18	20	0.02 U	20.020	1.4		
MR-9	12/30/2009	2 U	170		0.86	1.2	0.024 I	1.224	0.038 A		
MR-10	12/30/2009	2 U	34		0.17	0.61	0.004 U	0.614	0.29		
MR-SW	12/30/2009	630 B	53		0.1	0.31	2.2	2.510	0.017 A		
MR-1	6/3/2010	120 B	48	92	0.05	0.24	0.008 U	0.248	2.1		
MR-2	6/3/2010	2 B	48	60	0.01 U	0.1 I	0.01 I	0.110	0.48		
MR-3	6/3/2010	2 B	44	60	0.094	0.24	0.008 U	0.248	0.072		
MR-4	6/3/2010	2 U	48	63	1.3 Y	1.6 Y	0.008 IY	1.608	0.56 Y		
MR-5	6/3/2010	2 U	95	100	6.1	6.3	0.008 U	6.308	0.31		
MR-6	6/3/2010	2 U	69	38	4.6 Y	4.7 Y	0.008 IY	4.708	0.091 Y		
MR-7	6/3/2010	2 U	46	50	0.25	0.68	0.02 U	0.700	0.32		
MR-SW	6/3/2010	3700	44	50 Y	0.029 Y	0.32 Y	1.4 Y	1.720	0.023 Y		
MR-1	9/28/2010	16 U	140	120	0.01 U	0.68 I	29	29.680	1.9		
MR-2	9/28/2010	96 B	63	76	0.086	0.56	0.52	1.080	0.98	6.470	0.290
MR-3	9/28/2010	16 U	44	61	0.087	0.19 I	0.28	0.470	0.013	34.830	20.270
MR-7	9/28/2010	16 U	65	59	0.22	0.5	0.017	0.517	0.097	19.030	14.270
MR-8	9/28/2010	16 U	51	57	0.28	0.61	0.005 I	0.615	0.061		
MR-9	9/28/2010	16 U	45	54	0.32	0.57	0.004 I	0.574	0.068		
MR-10	9/28/2010	16 B	43	40	0.32	0.44	0.004 U	0.444	0.041		
MR-SW	9/28/2010	2400	52	59	0.091	0.33	1.9	2.230	0.03 A		
GW Mean		14	91	70	2.15	2.60	2.474	5.073	0.90	16.500	8.808
GW Min Max		2, 120	34, 170	38, 120	0.01, 18	0.1, 20	0.004, 29	0.11, 29.68	0.013, 3.7	5.67, 34.83	0.29, 20.27
SW Mean		2243	50	55	0.07	0.32	1.833	2.153	0.02		
SW Min Max		630, 3700	44, 53	50, 59	0.029, 0.1	0.31, 0.33	1.4, 2.2	1.72, 2.51	0.017, 0.03		

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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
MR-GW1	7/23/2009	62 I			1.1 I				
MR-SW1	7/23/2009	88			3.2 I				
MR-1	12/30/2009	31 I				794	17.8		6.48
MR-2	12/30/2009	40 I				1288	18.3		6.21
MR-3	12/30/2009	51 IY				827	18.2		5.34
MR-4	12/30/2009	31 I				831.6	17.7		6.78
MR-5	12/30/2009	38 I				828.5	17.9		6.86
MR-6	12/30/2009	45 I				837.7	18.5		5.83
MR-7	12/30/2009	191				880	18.6		6.55
MR-8	12/30/2009	68				890.2	17.6		6.45
MR-9	12/30/2009	71				783.3	17.7		6.19
MR-10	12/30/2009	34 I				331	18.7		6.21
MR-SW	12/30/2009	89 A				401.9	17.2		6.99
MR-1	6/3/2010	75	170	2.7		534.4	23.2		6.09
MR-2	6/3/2010	72	120	2.6		381	23.3		5.67
MR-3	6/3/2010	71	190	0.84 I		407.8	22.9		5.65
MR-4	6/3/2010	85 Y	170	1.4		494	23.7		6.45
MR-5	6/3/2010	62	2410	3.8		687	23.2		5.71
MR-6	6/3/2010	56 I	390	3.4		496.5	23.7		5.98
MR-7	6/3/2010	54 I	2370	2		348.6	27.5		5.73
MR-SW	6/3/2010	110 I	180 I	3.7		385.7	24.7		6.48
MR-1	9/28/2010	378	2720	10.8		1245	26.2	1.3	5.91
MR-2	9/28/2010	78	400	2.4		446	25.6	1	5.85
MR-3	9/28/2010	80	500	1.2		413	25.3	0.6	5.98
MR-7	9/28/2010	81	240	1.3		458	24.4	1	5.79
MR-8	9/28/2010	85	460	0.95 I		439	24	0.6	5.94
MR-9	9/28/2010	98	2000	1.1 I		433	24.4	0.7	6.13
MR-10	9/28/2010	103	260	0.99 I		453	25	0.7	6.38
MR-SW	9/28/2010	92	280	3.1		460	24.9	5	5.68
GW Mean		93	833	3.0		647	21.8	0.8	6.04
GW Min Max		31, 378	100, 2720	0.84, 10.8		331, 1288	17.6, 27.5	0.6, 1.3	5.34, 6.86
SW Mean		97	230	3.4		416	22.3	na	6.48
SW Min Max		89, 110	180, 280	3.1, 3.7		385.7, 460	17.2, 24.9	na	5.68, 6.99

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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
MW-1	6/3/2010	22 B	47	23 Y	1.1 Y	1.4 Y	0.004 UY	1.404	0.048 Y		
MW-2	6/3/2010	2 U	39	50 Y	0.01 UY	0.27 IY	12 Y	12.270	0.004 UY	13.990	6.630
MW-3	6/3/2010	2 U	33	42 Y	0.01 UY	0.16 UY	11 Y	11.160	0.008 IY	7.000	4.640
MW-4	6/3/2010	2 B	38 A	54 AY	0.01 UY	0.23 Y	7.8 Y	8.030	0.018 Y	7.490	3.290
JF-MW2	6/1/2010		21	96	0.01 U	0.11 I	1.1	1.210	0.004 I	4.300	0.490
MDR-MW5	6/1/2010		21	44	0.01 U	0.08 U	1.4	1.480	0.005 I	3.500	2.330
MDR-MW7	6/1/2010		26	48	0.01 U	0.13 I	4.8	4.930	0.008 I	3.890	0.520
GW Mean		7	32	51	0.17	0.34	5.443	5.783	0.01	6.695	2.983
GW Min Max		2, 22	21, 47	23, 96	0.01, 1.1	0.08, 1.4	0.004, 12	1.21, 12.27	0.004, 0.048	3.5, 13.99	0.49, 6.63

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
MW-1	6/3/2010	45 I	840	1.1 I		497.1	24.3	0.4	6.07
MW-2	6/3/2010	87 A	62 I	5.1 A		367.2	24.4	0.8	5.58
MW-3	6/3/2010	36 I	90 I	5.1		310.1	23.3	4.8	4.62
MW-4	6/3/2010	127	340	2.5		308.5	27.3	5.2	5.06
JF-MW2	6/1/2010	40 I	86 I	3.6		367.2	24.4	0.8	5.58
MDR-MW5	6/1/2010	39 I	30 U	2.2					
MDR-MW7	6/1/2010	36 I	32 I	3.7 A					
GW Mean		59	211	3.3		370	24.7	2.4	5.58
GW Min Max		36, 127	30, 840	1.1, 5.1		308.5, 497.1	23.3, 27.3	0.4, 5.2	4.62, 6.07

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Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
NJ-1	6/2/2010	2 U	27	75	0.19	0.63	0.005 I	0.635	0.76		
NJ-2	6/2/2010	2 U	19	37	3.9	4.4	0.004 U	4.404	3.6		
NJ-3	6/2/2010	2 U	34	69	0.55	0.91	0.004 UJ	0.914	0.36		
NJ-4	6/2/2010	2 U	34	80	0.35	0.75	0.004 U	0.754	1		
NJ-5	6/2/2010	2 U	30	59	0.75	1.3	0.004 U	1.304	0.84		
NJ-6	6/2/2010	2 U	79	17	3	3.7	0.004 U	3.704	0.7		
NJ-7	6/2/2010	2 U	200	21	2	2.5	0.004 U	2.504	1.5		
GW Mean		2	60	51	1.53	2.03	0.004	2.031	1.25		
GW Min Max		2, 2	19, 200	17, 80	0.19, 3.9	0.63, 4.4	0.004, 0.005	0.635, 4.404	0.36, 3.6		

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
NJ-1	6/2/2010	91	760	5.2		447.8	30.6		6.83
NJ-2	6/2/2010	79	810	3.9		344.3	28		6.82
NJ-3	6/2/2010	77	1380	3.8		446.6	25.7		6.80
NJ-4	6/2/2010	77	1890	4.9		473.5	25.4		6.72
NJ-5	6/2/2010	93	500	4.1		437.1	25.9		6.15
NJ-6	6/2/2010	89	1450	25.5		651	29.9		6.73
NJ-7	6/2/2010	99	120	139		1039	27.3		6.68
GW Mean		86	987	26.6		548	27.5		6.73
GW Min Max		77, 99	120, 1890	3.8, 139		344.3, 1039	25.4, 30.6		6.15, 6.83

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
NJ-1	6/2/2010	2 U	27	75	0.19	0.63	0.005 I	0.635	0.76		
NJ-2	6/2/2010	2 U	19	37	3.9	4.4	0.004 U	4.404	3.6		
NJ-3	6/2/2010	2 U	34	69	0.55	0.91	0.004 UJ	0.914	0.36		
NJ-4	6/2/2010	2 U	34	80	0.35	0.75	0.004 U	0.754	1		
NJ-5	6/2/2010	2 U	30	59	0.75	1.3	0.004 U	1.304	0.84		
NJ-6	6/2/2010	2 U	79	17	3	3.7	0.004 U	3.704	0.7		
NJ-7	6/2/2010	2 U	200	21	2	2.5	0.004 U	2.504	1.5		
GW Mean		2	60	51	1.53	2.03	0.004	2.031	1.25		
GW Min Max		2, 2	19, 200	17, 80	0.19, 3.9	0.63, 4.4	0.004, 0.005	0.635, 4.404	0.36, 3.6		

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
NJ-1	6/2/2010	91	760	5.2		447.8	30.6		6.83
NJ-2	6/2/2010	79	810	3.9		344.3	28		6.82
NJ-3	6/2/2010	77	1380	3.8		446.6	25.7		6.80
NJ-4	6/2/2010	77	1890	4.9		473.5	25.4		6.72
NJ-5	6/2/2010	93	500	4.1		437.1	25.9		6.15
NJ-6	6/2/2010	89	1450	25.5		651	29.9		6.73
NJ-7	6/2/2010	99	120	139		1039	27.3		6.68
GW Mean		86	987	26.6		548	27.5		6.73
GW Min Max		77, 99	120, 1890	3.8, 139		344.3, 1039	25.4, 30.6		6.15, 6.83

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
A = Value reported is the mean of two measurements.

B =Result based on colony counts outside of acceptable range.
I = Value reported between laboratory MDL and PQL.
J = Estimated value.

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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
NG-Ditch	7/22/2009		17		0.2	0.64	1.1	1.740	0.57 A		
NG-SW	12/29/2009	500	20		0.15	0.78	1.2	1.980	0.39		
R1-SW	6/3/2010	400	59	76	0.057	0.34	0.94	1.280	0.022 A	16.89	8.88
R1-SW	9/28/2010	660	46	52	0.034	0.24	1.5	1.740	0.036	19.92	10.46
GO-1	6/3/2010	2200	25	28	0.058	0.78	0.34	1.120	0.12		
RB-1	12/30/2009	860 B	55		0.14	0.49	2.5	2.990	0.021		
RB-2	12/30/2009	6400 B	46		0.061	0.36	4.6	4.960	0.044 A	13.24	7.41
RB-3	12/30/2009	1100 B	52		0.077	0.31 J	2.1	2.410	0.017		
RB-2	6/3/2010	2200	68	54	0.14	0.93	2.9	3.830	0.062	13.99	6.63
RB-3	6/3/2010	4600	52	63	0.034	0.3	1.2	1.500	0.016	14.7	7.71
RB-1	9/28/2010	110	60	58	0.18	0.46	3.1	3.560	0.041	14.79	7.76
RB-2	9/28/2010	2800	47	51	0.073	0.35	2.8	3.150	0.063	13.24	8.32
RB-3	9/28/2010	3000	51	60	0.082	0.3	1.7	2.000	0.024	13.45	5.79
SW Mean		2069	48	55	0.09	0.47	2.073	2.543	0.07	15.028	7.870
SW Min Max		110, 6400	20, 68	28, 76	0.034, 0.18	0.24, 0.93	0.34, 4.6	1.12, 4.96	0.016, 0.39	13.24, 19.92	5.79, 10.46

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.

Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.

A = Value reported is the mean of two measurements.

B =Result based on colony counts outside of acceptable range.

I = Value reported between laboratory MDL and PQL.

J = Estimated value.

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Z = Colonies too numerous to count.

Table 3. (cont.) Water Quality Data by Site.

Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
NG-Ditch	7/22/2009	83 A			6.3	383	26.69	3.54	
NG-SW	12/29/2009	85 A				352.7	16.9		6.88
R1-SW	6/3/2010	70	540	2.9		462.5	28.6		6.07
R1-SW	9/28/2010	73	270	2.9					
GO-1	6/3/2010	58 I	460	2.2		242.5	34.5		6.46
RB-1	12/30/2009	91				506.9	19.8		7.06
RB-2	12/30/2009	87				352	18.4		6.85
RB-3	12/30/2009	87				369.7	18.3		7.08
RB-2	6/3/2010	101	190	3.2		593.6	28.4		7.00
RB-3	6/3/2010	89 A	370 A	2.9 A		383.3	29.4		6.49
RB-1	9/28/2010	98	180	3.2					
RB-2	9/28/2010	73	350	3.4					
RB-3	9/28/2010	90 A	340 A	3.1 A					
SW Mean		84	338	3.0		408	24.3		6.87
SW Min Max		58, 101	180, 540	2.2, 3.4		242.5, 593.6	16.9, 34.5		6.07, 7.08

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.

Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.

A = Value reported is the mean of two measurements.

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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
RT-GW1	7/22/2009		9.5		0.15	0.52	0.011	0.531	1.4		
RT-GW2	7/22/2009		13		0.13	0.5	0.004 U	0.504	2.1		
RT-SW1	7/22/2009		17		0.11	0.87	0.16	1.030	0.13		
RT-1	12/29/2009	2 U	110		2.8	4.2	0.004 U	4.204	2.1		
RT-2	12/29/2009	2 U	14		0.93	1.7	0.004 U	1.704	1.2		
RT-3	12/29/2009	2 U	22		2.2	3	0.004 U	3.004	2.3		
RT-3-B	12/29/2009		15		1.9	2.7	0.006 I	2.706	2.2		
RT-4 (P7S	12/29/2009	28 B	20		0.68	2.4	0.004 U	2.404	1.7		
RT-5	12/29/2009	2 U	17		1.8	2.9	0.004 U	2.904	1.5		
RT-SW	12/29/2009	170 B	1200		0.15	0.78	0.27	1.050	0.079	7.16	4.56
RT-1	6/2/2010	2 U	98	3.9	2.8	4	0.004 U	4.004	2		
RT-1A	6/2/2010	2 U	79	27	0.25	0.64	0.02 U	0.660	2.1		
RT-3	6/2/2010	2 U	19	1.5	2.2	3.6	0.004 U	3.604	1.5		
RT-3A	6/2/2010	2 U	10	11	0.21	0.73	0.004 U	0.734	2		
RT-3B	6/2/2010	2 U	16	1	3.4	3.8	0.04 U	3.840	2.3		
RT-5	6/2/2010	15 B	23	2.6	2	3	0.004 U	3.004	0.98		
RT-PZ1	6/2/2010	2 U	17	37	1	1.9	0.02 U	1.920	0.99		
RT-PZ2	6/2/2010	6000 Z	29	72	0.47	1.4	0.004 U	1.404	0.92		
RT-SW	6/2/2010	100 B	520	91	0.031	0.58	0.084	0.664	0.083 A		
GW Mean		5	35	20	1.62	2.57	0.009	2.578	1.70	na	na
GW Min Max		2, 28	10, 110	1, 72	0.21, 3.4	0.64, 4.2	0.004, 0.04	0.66, 4.204	0.92, 2.3	na	na
SW Mean		135	860	91	0.09	0.68	0.177	0.857	0.08		
SW Min Max		100, 170	520, 1200	91, 91	0.031, 0.15	0.58, 0.78	0.084, 0.27	0.664, 1.05	0.079, 0.083		

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
Caffiene Detection, Below (BD) = 0.175 ppb, Above (AD) = 50 ppb.
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Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
RT-GW1	7/22/2009	94			7.1	269	25.71	0.72	
RT-GW2	7/22/2009	110			6.3	324	27.00	1.08	
RT-SW1	7/22/2009	51 I			8.5	240	27.42	2.35	
RT-1	12/29/2009	165				813.3	6.3		7.27
RT-2	12/29/2009	46 I				280.2	12.9		6.42
RT-3	12/29/2009	47 I				366	13.7		6.36
RT-3-B	12/29/2009	46 I				331.2	14.7		6.27
RT-4 (P7S	12/29/2009	54 I				338.6	15.7		6.19
RT-5	12/29/2009	46 I				320.3	15		6.25
RT-SW	12/29/2009	310				3947	11.7		7.00
RT-1	6/2/2010	140	260	169		748	27.1		6.86
RT-1A	6/2/2010	88	820	12.5		497.5	28.9		6.81
RT-3	6/2/2010	77	3960	30.3		314.6	25.2		6.61
RT-3A	6/2/2010	86	440	2.6		202.4	25.8		6.85
RT-3B	6/2/2010	75	1520	7.7		355.5	25.6		6.70
RT-5	6/2/2010	58 I	1860	31.3		331	26.9		6.76
RT-PZ1	6/2/2010	66	2000	4.9		312.2	24.6	0.5	6.85
RT-PZ2	6/2/2010	81	1090	38.1		468	24.9	0.5	6.39
RT-SW	6/2/2010	160 A	390 A	12.4 A		1973	31.5	3.5	7.42
GW Mean		77	1494	37.1		406	20.5	0.5	6.66
GW Min Max		46, 165	260, 3960	2.6, 169		202.4, 813.3	6.3, 28.9	0.5, 0.5	6.19, 7.27
SW Mean		235	390	12.4		2960	21.6	3.5	7.21
SW Min Max		160, 310	390, 390	12.4, 12.4		1973, 3947	11.7, 31.5	3.5, 3.5	7, 7.42

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Z = Colonies too numerous to count.

Table 3. (cont.) Water Quality Data by Site.

Sample ID	Date	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
WH-GW1	7/23/2009		20		0.056	0.19 I	0.04 U	0.230	0.024		
WH-SW1	7/23/2009		51		0.087	0.75 AJ	1.6	2.350	0.09		
WH-1	12/30/2009	2 U	13		0.2	0.38	0.008 I	0.388	0.02		
WH-2	12/30/2009	2 U	12		0.028	0.29	3.5	3.790	0.039	16.400	12.810
WH-3	12/30/2009	2 U	6.3		0.042	0.42	0.005 I	0.425	0.062		
WH-4	12/30/2009	2 U	35		0.14	1.2	0.004 U	1.204	0.26		
WH-4-B	12/30/2009	2 U	9		0.051	0.65	0.004 U	0.654	0.054		
WH-5	12/30/2009	2 U	9.2 A		0.28	1.3	0.01 I	1.310	0.12		
WH-SW	12/30/2009	540	54		0.046	0.38	1.9	2.280	0.018 A	12.710	6.470
GW Mean		2	14		0.12	0.71	0.589	1.295	0.09	na	na
GW Min Max		2, 2	6.3, 35		0.028, 0.28	0.29, 1.3	0.004, 3.5	0.388, 3.79	0.02, 0.26	na	na
SW Mean		na	na		na	na	na	na	na	na	na
SW Min Max		na	na		na	na	na	na	na	na	na

Sample ID	Date	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
WH-GW1	7/23/2009	23 I			1.8 I	183	26.72	0.90	
WH-SW1	7/23/2009	82			4 I	444	26.70	4.79	
WH-1	12/30/2009	18 I				148.5	15.9		6.28
WH-2	12/30/2009	15 U				91.9	16.2		6.18
WH-3	12/30/2009	17 I				126.7	16.7		6.29
WH-4	12/30/2009	15 U				204.9	15.5		6.21
WH-4-B	12/30/2009	15 U				118.1	15.6		6.12
WH-5	12/30/2009	21 I				123.5	16.9		5.82
WH-SW	12/30/2009	78 A				417.9	14.2		6.59
GW Mean		17				136	16.1		6.20
GW Min Max		15, 21				91.9, 204.9	15.5, 16.9		5.82, 6.29
SW Mean		na				na	na		na
SW Min Max		na				na	na		na

Triclosan Detection, Below (BD) = 0.020 ppb, Above (AD) = 2.5 ppb.
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J = Estimated value.

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Table 4. Surface water parameter mean and range values by site.

Surface Water		JB		LP		MG		MM		MR	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Coliform	**col/100ml**	3350	3200, 3500	108	34, 160	na	na	450	350, 620	2243	630, 3700
Cl	**mg/L**	23	16, 36	105	28, 250	na	na	346	29, 910	50	44, 53
SO_4	**mg/L**	28	24, 31	45	37, 53			95	39, 150	55	50, 59
NH_3	**mg/L**	0.06	0.041, 0.094	0.02	0.014, 0.024	na	na	0.05	0.027, 0.082	0.07	0.029, 0.1
TKN	**mg/L**	0.71	0.49, 1	0.83	0.63, 1.2	na	na	0.67	0.55, 0.84	0.32	0.31, 0.33
NO_X	**mg/L**	0.263	0.14, 0.37	0.246	0.097, 0.4	na	na	0.217	0.14, 0.28	1.833	1.4, 2.2
TN	**mg/L**	0.977	0.79, 1.28	1.076	0.9, 1.297	na	na	0.887	0.78, 0.98	2.153	1.72, 2.51
TP	**mg/L**	0.15	0.088, 0.2	0.09	0.056, 0.1	na	na	0.08	0.049, 0.11	0.02	0.017, 0.03
B	**mg/L**	59	53, 66	50	26, 82	na	na	106	32, 233	97	89, 110
Fe	**ug/L**	630	540, 720	175	170, 180			535	440, 630	230	180, 280
K	**mg/L**	2.5	2.4, 2.6	3.8	1.9, 5.6			10.8	3.1, 18.4	3.4	3.1, 3.7
TOC	**mg/L**										
Spec Cond	**uS**	457	355.7, 595.1	587	276.2, 1142	na	na	1375	210.3, 3352	416	385.7, 460
Temp	**C**	20.9	12.3, 26.4	22.7	16.8, 26	na	na	19.3	12.5, 26.1	22.3	17.2, 24.9
DO	**mg/L**	na	na	1.85	1.5, 2.2			4.15	3.6, 4.7	na	na
pH	**SU**	6.79	6.7, 6.88	6.69	6.66, 6.8	na	na	6.34	5.93, 6.88	6.48	5.68, 6.99

Table 4 (cont). Surface water parameter mean and range values by site.

Surface Water		BQ		CS		CST		DE		DH	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Coliform	**col/100ml**	na	na	na	na	6	2, 16	322	46, 520	523	99, 980
Cl	**mg/L**	na	na	na	na	37	8.3, 72	757	450, 1200	460	30, 1200
SO_4	**mg/L**	na	na	na	na	176	65, 340	89	78, 100	118	55, 180
NH_3	**mg/L**	na	na	na	na	17.51	0.01, 65	0.08	0.01, 0.14	0.03	0.01, 0.043
TKN	**mg/L**	na	na	na	na	17.69	0.22, 63	0.65	0.62, 0.68	0.73	0.51, 0.88
NO_X	**mg/L**	na	na	na	na	6.440	0.008, 36	0.144	0.026, 0.31	0.096	0.022, 0.2
TN	**mg/L**	na	na	na	na	24.132	0.334, 63.7	0.790	0.646, 0.99	0.823	0.71, 0.947
TP	**mg/L**	na	na	na	na	1.37	0.015, 4.8	0.10	0.089, 0.1	0.07	0.051, 0.084
B	**mg/L**	na	na	na	na	82	33, 166	208	154, 282	130	31, 294
Fe	**ug/L**	na	na	na	na	130	130, 130	315	270, 360	320	280, 360
K	**mg/L**	na	na	na	na	7.2	2.2, 12.2	12.35	10.8, 13.9	14.1	4, 24.2
TOC	**mg/L**	na	na	na	na						
Spec Cond	**uS**	na	na	na	na	870	276.4, 1997	2354	1685, 3404	1683	254.9, 4204
Temp	**C**	na	na	na	na	24.5	13.5, 30.7	23.5	13.7, 30.5	27.3	18.6, 35.3
DO	**mg/L**	na	na	na	na	2.9	2.9, 2.9	4.7	3.5, 5.9	5.95	4.4, 7.5
pH	**SU**	na	na	na	na	6.70	6.38, 6.75	7.25	7.11, 7.64	6.76	5.02, 6.98

Table 4 (cont). Surface water parameter mean and range values by site.

Surface Water		**MW**		**NJ**		**SW**		**RT**		**WH**	
		Mean	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
Coliform	**col/100ml**					2069	110, 6400	135	100, 170	na	na
Cl	**mg/L**					48	20, 68	860	520, 1200	na	na
SO_4	**mg/L**					55	28, 76	91	91, 91	na	na
NH_3	**mg/L**					0.09	0.034, 0.18	0.09	0.031, 0.15	na	na
TKN	**mg/L**					0.47	0.24, 0.93	0.68	0.58, 0.78	na	na
NO_X	**mg/L**					2.073	0.34, 4.6	0.177	0.084, 0.27	na	na
TN	**mg/L**					2.543	1.12, 4.96	0.857	0.664, 1.05	na	na
TP	**mg/L**					0.07	0.016, 0.39	0.08	0.079, 0.083	na	na
B	**mg/L**					84	58, 101	235	160, 310	na	na
Fe	**ug/L**					338	180, 540	390	390, 390		
K	**mg/L**					3.0	2.2, 3.4	12.4	12.4, 12.4		
TOC	**mg/L**										
Spec Cond	**uS**					408	242.5, 593.6	2960	1973, 3947	na	na
Temp	**C**					24.3	16.9, 34.5	21.6	11.7, 31.5	na	na
DO	**mg/L**							3.5	3.5, 3.5		
pH	**SU**					6.87	6.07, 7.08	7.21	7, 7.42	na	na

Table 5. Groundwater parameter mean and range values by site.

Groundwater		BQ		CS		CST		DE		DH	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Coliform	**col/100ml**	2	2, 2	3	2, 6	6	2, 16	632	2, 6900	8	2, 16
Cl	**mg/L**	9	6.7, 11	53	32, 79	37	8.3, 72	41	18, 120	78	37, 200
SO_4	**mg/L**			72	43, 100	176	65, 340	22	0.36, 120	143	98, 170
NH_3	**mg/L**	0.28	0.016, 0.49	0.06	0.01, 0.13	17.51	0.01, 65	2.10	0.017, 13	0.25	0.01, 1.2
TKN	**mg/L**	1.15	0.5, 2.3	0.39	0.14, 0.77	17.69	0.22, 63	3.06	0.54, 15	0.87	0.21, 2.1
NO_X	**mg/L**	0.008	0.004, 0.011	0.906	0.004, 2.8	6.440	0.008, 36	0.073	0.004, 1.3	9.381	0.004, 74
TN	**mg/L**	1.153	0.508, 2.304	1.294	0.174, 3.57	24.132	0.334, 63.7	3.135	0.548, 15.0	10.248	0.644, 75.6
TP	**mg/L**	0.57	0.17, 1	0.29	0.004, 1.3	1.37	0.015, 4.8	1.07	0.29, 3.5	0.47	0.047, 1.1
B	**mg/L**	43	31, 50	92	32, 188	589	26, 1720	111	49, 389	171	37, 564
Fe	**ug/L**			1137	390, 2470	3431	98, 26900	2615	30, 8260	14797	50, 49500
K	**mg/L**			3.07	1.8, 3.8	12.3	3.2, 28.2	4.9	2.6, 10.9	4.1	1.6, 8.8
TOC	**mg/L**										
Spec Cond	**uS**	289	245, 366	395	232, 605.6	805	41.2, 2032	633	426.9, 1082	743	369, 1183
Temp	**C**	15.1	14.1, 16.1	21.4	17.3, 26.9	29.7	17.1, 188	23.4	15.9, 28.1	24.6	17, 32
DO	**mg/L**					0.5	0.3, 0.9	0.8	0.4, 1.4	1.0	1, 1
pH	**SU**	6.13	5.99, 6.42	5.77	5.32, 6.82	5.98	5, 6.92	6.60	6.18, 7.02	6.55	5.38, 7.07

Table 5 (cont). Groundwater parameter mean and range values by site.

Groundwater		JB		LP		MG		MM		MR	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Coliform	**col/100ml**	9	2, 16	33	2, 400	2	2, 2	10	2, 20	14	2, 120
Cl	**mg/L**	14	0.021, 19	30	6.6, 54	42	24, 60	36	16, 62	91	34, 170
SO_4	**mg/L**	63.80	0.38, 87	162	76, 320			45	0.95, 97	70	38, 120
NH_3	**mg/L**	1.58	0.01, 12	0.02	0.01, 0.086	1.00	0.17, 2.8	0.15	0.01, 0.55	2.15	0.01, 18
TKN	**mg/L**	1.19	0.087, 3.2	0.61	0.19, 3	1.40	0.52, 3.2	0.79	0.12, 2.5	2.60	0.1, 20
NO_X	**mg/L**	8.074	0.012, 18	11.288	0.02, 39	0.233	0.004, 0.74	2.917	0.006, 25	2.474	0.004, 29
TN	**mg/L**	8.496	0, 18.37	11.901	0.5, 39.76	1.635	0.77, 3.207	3.711	0.48, 25.59	5.073	0.11, 29.68
TP	**mg/L**	0.22	0.008, 0.65	0.37	0.006, 2.4	0.07	0.004, 0.16	0.34	0.004, 2	0.90	0.013, 3.7
B	**mg/L**	115	70, 184	68	16, 148	129	91, 164	70	25, 176	93	31, 378
Fe	**ug/L**	2824	440, 8250	1229	30, 6430			8686	120, 36500	833	100, 2720
K	**mg/L**	5.6	3.6, 8.6	5.3	2, 9.9			2.9	0.87, 6.2	3.0	0.84, 10.8
TOC	**mg/L**										
Spec Cond	**uS**	332	242, 415	607	196.7, 1080	488	287.8, 673	587	52.46, 5635	647	331, 1288
Temp	**C**	22.5	16.4, 25.5	23.2	18.9, 25.6	16.0	14.1, 17.3	22.4	14.3, 29	21.8	17.6, 27.5
DO	**mg/L**	2.6	1.4, 3.7	3.6	0.9, 7.7			na	na	0.8	0.6, 1.3
pH	**SU**	4.49	3.69, 6.62	6.53	5.51, 7.03	6.54	6.5, 6.63	6.29	4.38, 6.9	6.04	5.34, 6.86

Table 5 (cont). Groundwater parameter mean and range values by site.

Groundwater		MW		NJ		SW		RT		WH	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Coliform	**col/100ml**	7	2, 22	2	2, 2			5	2, 28	2	2, 2
Cl	**mg/L**	32	21, 47	60	19, 200			35	10, 110	14	6.3, 35
SO_4	**mg/L**	51	23, 96	51	17, 80			20	1, 72		
NH_3	**mg/L**	0.17	0.01, 1.1	1.53	0.19, 3.9			1.62	0.21, 3.4	0.12	0.028, 0.28
TKN	**mg/L**	0.34	0.08, 1.4	2.03	0.63, 4.4			2.57	0.64, 4.2	0.71	0.29, 1.3
NO_X	**mg/L**	5.443	0.004, 12	0.004	0.004, 0.005			0.009	0.004, 0.04	0.589	0.004, 3.5
TN	**mg/L**	5.783	1.21, 12.27	2.031	0.635, 4.404			2.578	0.66, 4.204	1.295	0.388, 3.79
TP	**mg/L**	0.01	0.004, 0.048	1.25	0.36, 3.6			1.70	0.92, 2.3	0.09	0.02, 0.26
B	**mg/L**	59	36, 127	86	77, 99			77	46, 165	17	15, 21
Fe	**ug/L**	211	30, 840	987	120, 1890			1494	260, 3960		
K	**mg/L**	3.3	1.1, 5.1	26.6	3.8, 139			37.1	2.6, 169		
TOC	**mg/L**										
Spec Cond	**uS**	370	308.5, 497.1	548	344.3, 1039			406	202.4, 813.3	136	91.9, 204.9
Temp	**C**	24.7	23.3, 27.3	27.5	25.4, 30.6			20.5	6.3, 28.9	16.1	15.5, 16.9
DO	**mg/L**	2.4	0.4, 5.2					0.5	0.5, 0.5		
pH	**SU**	5.58	4.62, 6.07	6.73	6.15, 6.83			6.66	6.19, 7.27	6.20	5.82, 6.29

Table 6. Entire Study, Mean and Range Data for Surface Water and Groundwater parameters.

Sample ID	Coliform col/100ml	Cl mg/L	SO_4 mg/L	NH_3 mg/L	TKN mg/L	NO_X mg/L	TN mg/L	TP mg/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
Grand GW Mean	96	50	87	3.19	3.71	4.019	7.687	0.75	10.955	5.600
Grand GW Min Max	2, 6900	0.021, 910	0.36, 340	0.01, 65	0.08, 63	0.004, 74	0, 75.6	0.004, 4.8	0.91, 34.83	-0.65, 20.5
Grand SW Mean	1266	218	68	0.07	0.60	0.985	1.583	0.08	13.994	7.435
Grans SW Min Max	34, 6400	16, 1200	24, 180	0.01, 0.18	0.23, 1.2	0.022, 4.6	0.646, 4.96	0.009, 0.39	9.57, 19.92	5.79, 10.46

Sample ID	B mg/L	Fe ug/L	K mg/L	TOC mg/L	Spec Cond uS	Temp C	DO mg/L	pH SU
Grand GW Mean	158	3827	8.7		588	23.2	1.6	6.30
Grand GW Min Max	15, 1720	30, 49500	0.84, 169		41.2, 5635	6.3, 188	0.3, 7.7	3.69, 7.61
Grand SW Mean	101	337	6.3		983	22.3	3.975	6.78
Grans SW Min Max	26, 310	130, 720	1.9, 24.2		210.3, 4204	11.7, 35.3	1.5, 7.5	5.02, 7.64

Table 7. Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	**Date**	**Coliform col/100ml**	**Cl mg/L**	**NH_3 mg/L**	**NO_X mg/L**	**TP mg/L**	**B mg/L**	**Triclosan ug/L**	**Caffeine ug/L**	**$\delta^{15}N$ ‰**	**$\delta^{18}O$ ‰**
BQ-GW1	7/22/2009		19	0.41	0.42	0.073	77 I				
BQ-SW1	7/22/2009		11	0.076	0.32	0.11	45 I				
BQ-1	12/29/2009	2 U	11	0.42	0.004 UJ	0.26	48 I	BD	BD		
BQ-2	12/29/2009	2 U	10	0.49	0.008 U	0.92	49 I	BD	BD		
BQ-3	12/29/2009	2 U	6.7	0.054	0.008 U	0.72	32 I	0.03	BD		
BQ-4	12/29/2009	2 U	6.8	0.016 I	0.008 U	0.34	31 I	BD	BD		
BQ-5	12/29/2009	2 U	9.9	0.39	0.009 I	1	47 I	BD	BD		
BQ-6	12/29/2009	2 U	11	0.31	0.011 IJ	0.17	50 I	BD	BD		
BQ-SW	12/29/2009	3600	20	0.17	0.54	0.085	64	BD	BD		

Sample ID	**Date**	**Coliform col/100ml**	**Cl mg/L**	**NH_3 mg/L**	**NO_X mg/L**	**TP mg/L**	**B mg/L**	**Triclosan ug/L**	**Caffeine ug/L**	**$\delta^{15}N$ ‰**	**$\delta^{18}O$ ‰**
CS-GW1	7/21/2009		41	46	0.04 U	15	988				
CS-SW1	7/21/2009		37	0.054	0.49	0.14	34 I				
CS-1	12/30/2009	2 U	36	0.083	0.007 I	0.22	32 I				
CS-2	12/30/2009	4 B	48	0.01 U	2.5	0.004 U	44 I			15.57	9.75
CS-3	12/30/2009	6 B	55	0.071	0.005 I	0.037	97				
CS-SW	12/30/2009	160	45 A	0.052	1.1	0.009 I	52 I			11.43	6.47
CS-2	6/3/2010	2 U	67	0.072 Y	0.004 UY	0.018 Y	148	BD	AD		
CS-3	6/3/2010	2 U	79	0.13 Y	0.12 Y	0.18 Y	188	0.03	0.22		
CS-PZ1	6/3/2010	2 U	32	0.01 Y	2.8 Y	1.3 Y	41 I	BD	2.66		

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_X mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
CST-1	12/31/2009	2 U	12	0.01 U	0.29	0.16	51 I	BD	BD	24.31	15.04
CST-2	12/31/2009	2 U	58	56	0.008 I	4.6	1000		BD		
CST-3	12/31/2009	2 U	42	41	0.02	4.8	847	BD	0.3		
CST-4	12/31/2009	2 U	38	65	1.7	0.21 A	872	BD	BD		
CST-5	12/31/2009	2 U	14	0.01 U	10	1	82	BD	BD	6.65	1.77
CST-6	12/31/2009	2 U	19	0.01 U	0.73	0.88	97	BD	BD		
CST-7	12/31/2009	2 U	9.8	0.01 U	3.3	0.53	114	BD	BD		
CST-8	12/31/2009	2 U	8.3	0.01 U	0.66	1.1	165	BD	BD		
CST-9	12/31/2009	2 U	34	3.1	30	1.4	822	BD	BD		
CST-SW	12/31/2009	270	34 A	0.041	0.79	0.049 A	33 I	BD	1.22		
CST-1	6/1/2010	2 U	13	0.01 U	0.034	0.1	47 I	BD	0.37		
CST-2	6/1/2010	2 U	34	13	36	0.49	1140	0.23	0.7	6.86	1.92
CST-3	6/1/2010	2 U	66	55	0.008 I	4.5	1720	0.42	0.37		
CST-4	6/1/2010	2 U	66	59	0.2 U	0.91	1050	0.06	4.2		
CST-8	6/1/2010	2 U	17	0.01 U	0.13	0.17	85	BD	0.65		
CST-9	6/1/2010	2 U	62	6.5	9.9	0.85 A	697	BD	0.22	11.39	5.55
CST-10	6/1/2010	2 U	25	0.033	4.6	0.025	123	BD	0.32	5.44	2.97
CST-11	6/1/2010	2 U	40	0.01 U	1.9	0.045	26 I	BD	0.41		
CST-SW	6/1/2010	48	39 A	0.016 I	0.17	0.086	47 I	0.03	0.56		
CST-1	9/27/2010	16 U	72	0.011 I	3.4	0.015	50 I	0.03	0.88	3.41	5.66
CST-2	9/27/2010	16 B	51	12	3.7	0.43 A	1510	0.03	0.67	20.34	10.79
CST-4	9/27/2010	16 U	56	60	0.067	4.6	995	0.04	0.5		
CST-9	9/27/2010	16 U	45	4.9	25	0.46	526	0.02	0.88		
CST-9A	9/27/2010	16 U	52	45	0.042	4.6	1090	0.02	0.76		
CST-10	9/27/2010	16 U	14	0.46	3.9	0.71	157	0.02	0.94		
CST-11	9/27/2010	16 U	43	11	21	0.66	927	0.03	0.77	16.89	8.14
CST-11A	9/27/2010	16 U	26	5.6	4.4	1.1 A	542		0.96	17.3	11.33
CST-SW	9/27/2010	620	590	0.055	0.12	0.06	166	0.46	0.54		

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_X mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
DE-GW	7/22/2009		27	0.7	0.01 I	0.79 A	84				
DE-SW	7/22/2009		17	0.079	0.19	0.093	47 I				
DE-1	12/29/2009	2 U	42	3.6	0.008 U	1.3	70	BD	BD		
DE-2	12/29/2009	2 U	32	0.043	0.008 U	0.43	84	0.03	BD		
DE-3	12/29/2009	2 U	26	1.4	0.015 I	0.29	72	0.14	BD		
DE-4	12/29/2009	2 U	18	0.34	0.008 U	0.64 A	49 I	0.13	BD		
DE-5	12/29/2009	2 U	~	1.5	0.008 U	0.92	76	0.04	BD		
DE-6	12/29/2009	2 U	31	0.68	0.008 U	0.64	65	BD	BD		
DE-7	12/29/2009	2 U	26	0.83	0.01 I	0.61	57 I	0.05	BD		
DE-SW	12/29/2009	520	1200	0.14	0.31	0.1	282	0.11	BD		
DE-1	6/2/2010	2 U	50	12	0.004 U	1.9	62	0.05	0.57		
DE-2	6/2/2010	2 U	29	1.9	0.004 U	0.81	82	0.25	0.42		
DE-3	6/2/2010	2 U	43	1.6	0.02 U	1.1	107		0.27		
DE-4	6/2/2010	2 U	20	0.67	0.004 U	0.41	87	0.12	0.34		
DE-5	6/2/2010	2 U	21	1	0.04 U	0.97	99	BD	0.73		
DE-6	6/2/2010	2 U	18	0.017 I	0.004 U	0.71	103	0.05	0.33		
DE-PZ1	6/2/2010		31	0.6	0.006 I	1 A	117				
DE-SW	6/2/2010	46	620	0.01 I	0.026	0.089	188	BD	0.45		
DE-1A	9/28/2010	6900 Q,A									
DE-1	9/28/2010	16 U,Q	31	0.39	1.3	1.2	60	0.06	0.58		
DE-2	9/28/2010	16 U,Q	49	3.4	0.009 I	3.5	226	BD	0.25		
DE-3	9/28/2010	16 Q,B	34	0.31	0.095	0.57	389	BD	0.37		
DE-4	9/28/2010	180 Q,B	68	13	0.004 U	3.4	241	0.03	0.41		
DE-5	9/28/2010	140 Q,B	120	0.83	0.034	1	103	0.33	BD		
DE-6	9/28/2010	5500 Q	37	0.92	0.004 U	0.67	103		0.38		
DE-7	9/28/2010	210 B	90	0.74	0.004 U	0.89	97	0.05	0.59		
DE-8	9/28/2010	910 B	36	0.5	0.004 U	0.64	89	0.25	0.58		
DE-SW	9/28/2010	400	450	0.087	0.095	0.098 A	154	0.12	0.41		

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_X mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
DH-GW1	7/21/2009		230	0.69	8.3	1.4 A	268				
DH-GW2	7/21/2009		40	0.01 I	17	1.8	115				
DH-SW1	7/21/2009		33	0.03	0.11	0.1	30 I				
DH-1	12/28/2009	2 U	56	0.25	0.004 U	0.15	52 I	BD	BD		
DH-2	12/28/2009	2 U	110	1.2	38	0.94	371	BD	0.28	8.13	1.32
DH-3	12/28/2009	2 U	83	0.12	0.016	1	68	BD	BD		
DH-4	12/28/2009	2 U	40	0.045	3.9	0.4	37 I	BD	BD		
DH-5	12/28/2009	2 U	94	0.1	74	1.1	564	BD	BD	5.56	-0.65
DH-SW	12/28/2009	490	30	0.043	0.2	0.051	31 I	0.05	BD		
DH-1	6/1/2010	2 U	37	0.016 I	0.62	0.56	53 I	BD	5.23		
DH-2	6/1/2010	2 U	88	0.036	22	0.55 A	166	BD	7.5	12.49	2.82
DH-7	6/1/2010	2 U	77	0.01 U	2.1	0.1	76	BD	AD		
DH-8	6/1/2010	2 U	96	0.01 U	6.8	0.22	132	BD	0.32	17.99	9.14
DH-SW	6/1/2010	99 B	150	0.01 U	0.022	0.06	64	BD	0.3		
DH-1	9/27/2010	16 U	200	0.36	0.69	0.047	104	0.04	0.54	8.51	4.08
DH-1A	9/27/2010	16 U	52	0.75	1.1	0.39	260	0.04	0.74	11.94	-0.35
DH-2	9/27/2010	16 U	59	0.27	0.28	0.19	267	0.03	0.41	15.69	4.96
DH-3	9/27/2010	16 U	40	0.18	0.01 I	0.21	96	0.03	0.55		
DH-7	9/27/2010	16 B	75	0.32	0.04 U	0.71	196	0.02	0.64		
DH-8	9/27/2010	16 U	69	0.14	0.49	0.15	204	0.02	1.22		
DH-9	9/27/2010	16 U	67	0.17	0.052	0.83	91	0.08	0.71		
DH-SW	9/27/2010	980	1200	0.035	0.067	0.084	294	0.02	1.25		

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_x mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
JB-GW1	7/22/2009		18	0.079	14	0.004 U	102				
JB-SW1	7/22/2009		27	0.06	0.36	0.12	72 I				
JB-1	12/29/2009	2 B	11	0.01 U	15	0.008 I	98	0.02	BD		
JB-2	12/29/2009	2 U	16	0.026	16	0.16	115	0.12	BD	8.190	8.630
JB-3	12/29/2009	2 U	16 A	0.91	2	0.22	117	BD	BD		
JB-4	12/29/2009	2 U	14	0.5 Y	~ O	0.52 Y	70	0.04	BD		
JB-SW	12/29/2009	3500	36	0.094	0.37	0.088 A	66		BD		
JB-1	6/3/2010		13	0.01 IY	18 Y	0.042 Y	99	BD	0.67		
JB-2	6/3/2010		16	0.027 Y	11 Y	0.069 Y	90	0.02	0.55		
JB-3	6/3/2010		19	0.94 Y	3.1 Y	0.18 Y	99	0.02	0.72		
JB-4	6/3/2010		18	2.4 Y	0.012 Y	0.65 Y	172	0.08	0.61		
JB-SW	6/3/2010		17	0.041 Y	0.14 Y	0.2 Y	53 I	0.02	0.54		
JB-1	9/28/2010	16 U	14	0.011 I	10	0.022	100	0.03	0.41		
JB-2	9/28/2010	16 U	0.021	12	12	0.087	124	0.05	0.48	29.680	20.500
JB-3	9/28/2010	16 U	18	0.83	1.3	0.064	113	0.03	0.41	19.040	11.590
JB-4	9/28/2010	16 U	15	1.3	0.4	0.63	184	0.03	0.49		
JB-SW	9/28/2010	3200	16	0.043	0.28	0.17	59 I	0.03	0.5		

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_X mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
LP-GW1	7/20/2009		20	0.079	0.098 I	0.031	120				
LP-SW1	7/20/2009		29	0.024	0.48	0.087	33 I				
LP-1	12/28/2009	2 U	15	0.01 U	5.9	0.12	72	BD	BD	7.370	4.190
LP-2	12/28/2009	14	14	0.01 U	0.5	0.065 A	35 I	BD	BD	9.420	5.550
LP-3	12/28/2009	2 U	19	0.01 U	21	0.018	26 I	BD	BD		
LP-4	12/28/2009	2 U	41	0.01 U	14	0.061	59 I	BD	BD	8.070	2.580
LP-SW	12/28/2009	160	28	0.024	0.4	0.056	26 I	BD	BD		
LP-1	6/1/2010	2 U	31	0.01 U	13	0.006 I	52 I	BD	1.67	8.270	2.410
LP-2A	6/1/2010	2 U	54	0.01 U	3.9	0.07	48 I	BD	BD	0.910	-0.300
LP-3	6/1/2010	2 U	30	0.01 U	15	0.06	44 I	BD	0.46	3.070	0.310
LP-4	6/1/2010	2 U	40	0.01 U	5.5	2.4	96	BD	BD		
LP-5	6/1/2010	2 U	6.6	0.023	3.8	0.059	16 I	BD	BD		
LP-6D	6/1/2010		38	0.01 I	22	0.59	84				
LP-6S	6/1/2010	2 U	29	0.086	0.02 U	0.093	118	0.46			
LP-SW	6/1/2010	34 B	37	0.019 I	0.24	0.099	42 I	BD	0.31		
LP-WELL	6/1/2010		17	0.15	0.004 U	0.004 U	39 I	BD	0.52		
LP-3	9/27/2010	16 B	40	0.01 U	26	0.024	38 I	0.57	AD	5.000	0.410
LP-4	9/27/2010	400	24	0.01 U	8	2.1	148	0.02	0.65	3.500	2.010
LP-5	9/27/2010	16 B	35	0.01 U	9.8	0.063 A	116	0.29			
LP-6	9/27/2010	32 U	52	0.014 I	39	0.42	92	0.04		8.920	1.540
LP-1	9/27/2010	16 U	17	0.01 U	4.2	0.11	63 A	0.03	0.58	6.270	3.230
LP-2A	9/27/2010	16 U	18	0.01 U	0.27	0.08	43 I	0.03	1.05		
LP-SW	9/27/2010	130 B	250	0.014 I	0.097	0.1	82	0.27	0.92		

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_X mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
MG-GW3	7/20/2009		52	1.2	0.43	0.2	70 I				
MG-SW1	7/20/2009		28	0.02 I	0.044	0.36	58 I				
MG-1	12/28/2009	2 U	24	0.83	0.004 U	0.062	164	0.29	BD		
MG-1-B	12/28/2009	2 U	35	2.8	0.007 I	0.16	120	0.38	BD		
MG-2	12/28/2009	2 U	50	0.17	0.74	0.004 I	91	0.24	BD		
MG-3	12/28/2009	2 U	60	0.21	0.18	0.046	141	0.03	BD		
MG-SW	12/28/2009	120	180	0.12	0.18	0.12	91	0.06	BD		

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_x mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
MM-GW1	7/21/2009		30	0.038	0.04 U	0.075	33 I				
MM-SW1	7/21/2009		26	0.064	0.24	0.12	29 I				
MM-1	12/28/2009	20	61	0.17	0.021	2	83	BD	BD		
MM-2	12/28/2009	2	49	0.16	25	0.004 U	176	BD	BD	9.390	3.900
MM-3	12/28/2009	20	19 A	0.081	0.008 U	0.098	31 I	0.21	BD		
MM-4	12/28/2009	20	16	0.1	3.1	0.49 AJ	29 I	BD	BD	12.940	10.580
MM-SW	12/28/2009	620 B	29	0.042	0.23	0.049	32 I	BD	BD		
MM-1	6/2/2010	2 U	53	0.058 I	0.12	0.48	89		0.88		
MM-2	6/2/2010	2 U	37	0.12	0.43	0.059	53 I	BD	0.23		
MM-4	6/2/2010		39	0.024	0.91	0.008 I	124	BD	0.21		
MM-5	6/2/2010	2 B	26	0.2	0.08 J	0.036	130	BD	1.32		
MM-6	6/2/2010		27	0.092	0.86	0.012	53 I	0.04	2.89		
MM-7	6/2/2010	2 B	23 A	0.55	0.1 U	0.048	25 I	BD	0.33		
MM-PZ1	6/2/2010		35	0.01 U	6.4	2	74	0.36		5.530	2.920
MM-PZ2	6/2/2010		18	0.17	0.1 U	0.024	26 I	BD	AD		
MM-PZ3	6/2/2010	5 B	36	0.13	0.088	0.17	65	BD	0.71		
MM-SW	6/2/2010	380 B	100	0.027	0.28	0.08	52 I		0.58	9.570	5.890
MM-WELL	6/2/2010	2 U	28	0.096	4.6	0.084	35 I	BD	0.79	6.370	3.310
MM-1	9/27/2010	16 U	62	0.044	4	0.016	62	0.36	AD	14.320	8.280
MM-1A	9/27/2010	16 U	43	0.54	3.2	0.32	97	0.35	0.71	16.770	9.920
MM-2	9/27/2010	16 U	53	0.12	0.008 I	0.52	54 I	0.35	0.79		
MM-4	9/27/2010	16 U	46	0.037	6.4	0.023	83	0.43	0.71	11.770	7.070
MM-5	9/27/2010	16 U	17	0.15	0.006 I	0.11	43 I	0.31	0.85		
MM-SW	9/27/2010	350 B	910	0.082	0.14	0.11	233	0.44	AD		

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_X mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
MR-GW1	7/23/2009		53	0.01 U	2.8	0.14	62 I				
MR-SW1	7/23/2009		49	0.095	2.3	0.026	88				
MR-1	12/30/2009	4 B	110	0.034	0.059	2.3	31 I	BD	BD		
MR-2	12/30/2009	2 U	140	0.01 U	1.9	0.62	40 I	BD	BD	5.670	0.400
MR-3	12/30/2009	2 U	170	0.01 UY	2.9 Y	0.24 Y	51 IY	BD	BD		
MR-4	12/30/2009	2 U	99	2.6	0.004 U	3.7	31 I	BD	BD		
MR-5	12/30/2009	2 U	100	4.7	0.004 U	1.8	38 I	BD	BD		
MR-6	12/30/2009	2 U	170	3.7	0.02 U	1	45 I	BD	BD		
MR-7	12/30/2009	2 U	140	10	0.02 U	2.5	191	BD	BD		
MR-8	12/30/2009	2 U	160	18	0.02 U	1.4	68	BD	BD		
MR-9	12/30/2009	2 U	170	0.86	0.024 I	0.038 A	71	BD	BD		
MR-10	12/30/2009	2 U	34	0.17	0.004 U	0.29	34 I	BD	BD		
MR-SW	12/30/2009	630 B	53	0.1	2.2	0.017 A	89 A	BD	BD		
MR-1	6/3/2010	120 B	48	0.05	0.008 U	2.1	75		0.26		
MR-2	6/3/2010	2 B	48	0.01 U	0.01 I	0.48	72	0.03	0.25		
MR-3	6/3/2010	2 B	44	0.094	0.008 U	0.072	71		0.37		
MR-4	6/3/2010	2 U	48	1.3 Y	0.008 IY	0.56 Y	85 Y		0.41		
MR-5	6/3/2010	2 U	95	6.1	0.008 U	0.31	62	0.29	0.55		
MR-6	6/3/2010	2 U	69	4.6 Y	0.008 IY	0.091 Y	56 I	0.04	0.38		
MR-7	6/3/2010	2 U	46	0.25	0.02 U	0.32	54 I	0.27	0.59		
MR-SW	6/3/2010	3700	44	0.029 Y	1.4 Y	0.023 Y	110 I		0.58		
MR-1	9/28/2010	16 U	140	0.01 U	29	1.9	378	0.7	0.32		
MR-2	9/28/2010	96 B	63	0.086	0.52	0.98	78	0.68	BD	6.470	0.290
MR-3	9/28/2010	16 U	44	0.087	0.28	0.013	80	BD	BD	34.830	20.270
MR-7	9/28/2010	16 U	65	0.22	0.017	0.097	81		0.23	19.030	14.270
MR-8	9/28/2010	16 U	51	0.28	0.005 I	0.061	85	0.03	0.21		
MR-9	9/28/2010	16 U	45	0.32	0.004 I	0.068	98	0.03	BD		
MR-10	9/28/2010	16 B	43	0.32	0.004 U	0.041	103	0.23	BD		
MR-SW	9/28/2010	2400	52	0.091	1.9	0.03 A	92	0.43	BD		

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_X mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
MW-1	6/3/2010	22 B	47	1.1 Y	0.004 UY	0.048 Y	45 I	0.11	0.58		
MW-2	6/3/2010	2 U	39	0.01 UY	12 Y	0.004 UY	87 A	BD	0.41	13.99	6.63
MW-3	6/3/2010	2 U	33	0.01 UY	11 Y	0.008 IY	36 I	BD	0.41	7.00	4.64
MW-4	6/3/2010	2 B	38 A	0.01 UY	7.8 Y	0.018 Y	127	BD	0.48	7.49	3.29
JF-MW2	6/1/2010		21	0.01 U	1.1	0.004 I	40 I			4.3	0.49
MDR-MW5	6/1/2010		21	0.01 U	1.4	0.005 I	39 I			3.50	2.33
MDR-MW7	6/1/2010		26	0.01 U	4.8	0.008 I	36 I	BD	0.41	3.89	0.52

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_X mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
NJ-1	6/2/2010	2 U	27	0.19	0.005 I	0.76	91	BD	0.49		
NJ-2	6/2/2010	2 U	19	3.9	0.004 U	3.6	79	BD	0.5		
NJ-3	6/2/2010	2 U	34	0.55	0.004 UJ	0.36	77	BD	0.54		
NJ-4	6/2/2010	2 U	34	0.35	0.004 U	1	77	0.07	0.74		
NJ-5	6/2/2010	2 U	30	0.75	0.004 U	0.84	93	0.04	0.41		
NJ-6	6/2/2010	2 U	79	3	0.004 U	0.7	89	BD	0.55		
NJ-7	6/2/2010	2 U	200	2	0.004 U	1.5	99	BD	0.64		

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_X mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
NG-Ditch	7/22/2009		17	0.2	1.1	0.57 A	83 A				
NG-SW	12/29/2009	500	20	0.15	1.2	0.39	85 A				
R1-SW	6/3/2010	400	59	0.057	0.94	0.022 A	70	0.05	0.96	16.89	8.88
R1-SW	9/28/2010	660	46	0.034	1.5	0.036	73	0.48	AD	19.92	10.46
GO-1	6/3/2010	2200	25	0.058	0.34	0.12	58 I	0.02	0.31		
RB-1	12/30/2009	860 B	55	0.14	2.5	0.021	91	BD	BD		
RB-2	12/30/2009	6400 B	46	0.061	4.6	0.044 A	87	BD	BD	13.24	7.41
RB-3	12/30/2009	1100 B	52	0.077	2.1	0.017	87				
RB-2	6/3/2010	2200	68	0.14	2.9	0.062	101	0.13	1.22	13.99	6.63
RB-3	6/3/2010	4600	52	0.034	1.2	0.016	89 A	0.2	0.71	14.7	7.71
RB-1	9/28/2010	110	60	0.18	3.1	0.041	98		0.55	14.79	7.76
RB-2	9/28/2010	2800	47	0.073	2.8	0.063	73		0.69	13.24	8.32
RB-3	9/28/2010	3000	51	0.082	1.7	0.024	90 A		BD	13.45	5.79

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_X mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
RT-GW1	7/22/2009		9.5	0.15	0.011	1.4	94				
RT-GW2	7/22/2009		13	0.13	0.004 U	2.1	110				
RT-SW1	7/22/2009		17	0.11	0.16	0.13	51 I				
RT-1	12/29/2009	2 U	110	2.8	0.004 U	2.1	165	BD			
RT-2	12/29/2009	2 U	14	0.93	0.004 U	1.2	46 I	BD			
RT-3	12/29/2009	2 U	22	2.2	0.004 U	2.3	47 I	BD			
RT-3-B	12/29/2009		15	1.9	0.006 I	2.2	46 I	BD			
RT-4 (P7S)	12/29/2009	28 B	20	0.68	0.004 U	1.7	54 I	BD	0.77		
RT-5	12/29/2009	2 U	17	1.8	0.004 U	1.5	46 I	BD			
RT-SW	12/29/2009	170 B	1200	0.15	0.27	0.079	310	BD		7.16	4.56
RT-1	6/2/2010	2 U	98	2.8	0.004 U	2	140	0.06	0.67		
RT-1A	6/2/2010	2 U	79	0.25	0.02 U	2.1	88	BD	0.5		
RT-3	6/2/2010	2 U	19	2.2	0.004 U	1.5	77	BD	0.88		
RT-3A	6/2/2010	2 U	10	0.21	0.004 U	2	86	BD	0.76		
RT-3B	6/2/2010	2 U	16	3.4	0.04 U	2.3	75	0.02	0.94		
RT-5	6/2/2010	15 B	23	2	0.004 U	0.98	58 I	0.03	0.77		
RT-PZ1	6/2/2010	2 U	17	1	0.02 U	0.99	66		0.56		
RT-PZ2	6/2/2010	6000 Z	29	0.47	0.004 U	0.92	81	0.09	0.88		
RT-SW	6/2/2010	100 B	520	0.031	0.084	0.083 A	160 A	0.05	1.25		

Note: Residential Site Locations are shown in Appendix A.

Table 7 (cont.). Comparison of Possible Indicators of Fecal Contamination (Septic Tank Influence)

Sample ID	Date	Coliform col/100ml	Cl mg/L	NH_3 mg/L	NO_X mg/L	TP mg/L	B mg/L	Triclosan ug/L	Caffeine ug/L	$\delta^{15}N$ ‰	$\delta^{18}O$ ‰
WH-GW1	7/23/2009		20	0.056	0.04 U	0.024	23 I				
WH-SW1	7/23/2009		51	0.087	1.6	0.09	82				
WH-1	12/30/2009	2 U	13	0.2	0.008 I	0.02	18 I	BD	BD		
WH-2	12/30/2009	2 U	12	0.028	3.5	0.039	15 U	BD	BD	16.400	12.810
WH-3	12/30/2009	2 U	6.3	0.042	0.005 I	0.062	17 I	BD	BD		
WH-4	12/30/2009	2 U	35	0.14	0.004 U	0.26	15 U	BD	BD		
WH-4-B	12/30/2009	2 U	9	0.051	0.004 U	0.054	15 U	BD	0.27		
WH-5	12/30/2009	2 U	9.2 A	0.28	0.01 I	0.12	21 I	0.22	BD		
WH-SW	12/30/2009	540	54	0.046	1.9	0.018 A	78 A	BD	BD	12.710	6.470

Note: Residential Site Locations are shown in Appendix A.

DISCUSSION

Water Quality Concerns

The sometimes shallow water table depth, permeable sandy substrate and high numbers of OSTDS in the Jacksonville area represent a high-risk setting for groundwater contamination from domestic waste water disposal. Two of the major OSTDS concerns are fecal bacteria and nutrient loading. Fecal coliform bacteria can come from humans or wildlife and are important because they serve as indicators of pathogenic contamination, possibly affecting fish and other organisms and even causing waterborne disease outbreaks. Although the consequences of fecal contamination can be severe, OSTDS are generally not a significant source of bacteria to water bodies because the soil is an excellent removal mechanism when the waste is allowed to percolate through a sufficient depth of unsaturated soil (>2 ft.) before reaching the groundwater. Many other studies confirm the high and nearly complete removal of fecal coliform bacteria in properly functioning drainfields (Hagedorn et al. 1981; Reneau Jr. et al. 1989). The state of Florida fecal coliform bacteria standard for Class III surface waters is 800 colonies per 100 mL on any one day (FDEP, 2002). Sources of bacteria can be from municipal wastewater discharges, from septic tank discharges, runoff or ground water seepage from live stock producing area (pastures and feedlots), areas where manure is applied as fertilizer, or from wildlife populations, such as waterfowl and wadingbirds. One of the goals of this study was to determine if fecal coliform bacteria found in the surface and groundwater were derived from human fecal contamination (septic tanks) or other sources. Septic tanks are designed to reduce or eliminate most human health or environmental threats posed by pollutants in wastewater In the LSJR watershed, however, special concern exists because of the high number of OSTDS and the fact that the water table is often high, sometimes resulting in a very thin unsaturated zone (< 2 ft.). Generally, the water table in most of Duval County is within 5 ft. of land surface, and can be less than 2 ft. in areas adjacent to water bodies (Causey, 1975). The thin soil, coupled with the fact that the distances between OSTDS drainfields and the LSJR and tributaries are often short (<75 ft.), indicates bacterial contamination may be possible.

OSTDS nutrient loading is a concern because of the threat of eutrophication (nutrient loading and resultant biotic production). Nitrogen is an important plant nutrient in freshwater bodies and is usually assumed to be the limiting nutrient and major contributor to the eutrophication of coastal and estuarine waters. Nitrogen exists in the ammonia and organic forms in septic tanks, but is quickly nitrified under the aerobic soil conditions of most drainfields. Ammonium ions can be discharged into the subsurface environment or they can be generated within the upper layers of soil from ammonification process (conversion of organic nitrogen to ammonia nitrogen). The transport and fate of ammonium ions may involve adsorption, cation exchange, incorporation into microbial biomass or release to the atmosphere in the gaseous form (denitrification). Adsorption is probably the major mechanism of removal in the subsurface environment for all nutrients. Nitrate ions can also be discharged directly or generated within the upper layers of the soil. The transport and fate of nitrate ions may involve movement with the water phase, uptake by plants or denitrification. Nitrates can move readily with the groundwater with minimal transformation and are a concern. The occurrence of high nitrate concentrations in groundwater is particularly frequent below drainfields installed in sand. In tighter soils where oxygen diffusion is more difficult, the ammonium in the wastewater will not be nitrified by the soil, removing it from the waste stream (Sikora and Corey, 1976)

Phosphorus is also a key plant nutrient and, although it can move through soils and reach groundwater, it is usually not a major concern since it can be easily retained in underlying soils due to chemical changes and adsorption. It is retained primarily as a precipitate of calcium, aluminum and iron. Phosphorus contamination can occur, however, in sandy soils low in organic content, soils with high water tables, or from systems operated for many years (Sikora and Corey, 1976). Many of our sampling sites exhibited these conditions.

Past Studies on the Indian River Lagoon (IRL) That Are Relevant To This Study (By The Principal Investigators):

In view of the high numbers of OSTDS and the poor site conditions often existing in the IRL watershed, five Florida Tech studies (including this NPS study) were recently funded by three different agencies to directly determine the importance of OSTDS contamination to the IRL (NPS, SFWMD,NEP) and results would apply to the LSJR Basin, as well. (Belanger, Heck and Andrews, 1997; Belanger and Price, 2006; Belanger and Price, 2007; Belanger, 2009; Zarillo et al., 2010). These yearly studies were similar to this DEP LSJR study and involved the seasonal collection of water quality and hydrologic data. Groundwater samples were collected at each site from piezometers and PushPoint samplers at locations adjacent to and down-gradient from the septic tank drainfield to the edge of the surface water.

When the data from the previous completed IRL completed studies are combined, plume migration distances can be determined under the various environmental and OSTDS conditions. To date, our site-specific data indicate nutrient travel distances are generally in the 1-3 ft/yr range and that bacteria are removed within short distances of the drainfield, as the soil is generally an effective bacterial filter. Data from these studies indicate that residence age, depth to water table, sediment type and horizontal hydraulic gradient are very important site factors in determining nutrient plume migration distance. Also, the sandy soils that characterized most of our sites, were not very effective in adsorbing phosphate.

Questions To Be Addressed:

The following information was mentioned in the SAP as needed and pertinent to this study:

1. Estimates of nutrient and bacterial loading to surface waters from septic tanks in the neighborhoods evaluated in this study and information applicable to other neighborhoods under similar settings (general conclusions obtained from specific

site and regional well sampling, comparison of areas on septic tanks with those on sewer and other control areas, etc.);
2. Potential nutrient impacts from residential lawn fertilization and other onsite sources in comparison to septic tank (conclusions made from sampling sites and obtaining homeowner fertilization practice data);
3. Contaminant plume dimensions and migration rates at the chosen sites in each area;
4. Critical physical and chemical site factors influencing OSDS nutrient loading and plume migration, with worst case scenarios identified; and
5. Residual impacts of disconnected septic systems at converted sites (OSDS to sewer) as continuing sources of nutrients (Murray Hill B and Eggleston Heights

The above issues, to the extent possible, will be discussed in the following discussion:

Water Quality

Major ion concentrations can be used to compare surface water and groundwater characteristics, and some can be used as indicators of septic tank influence. Pitt and others (1975) classified certain constituents as naturally occurring in groundwater or associated with septic tank effluent, and summarized the chemical characteristics of shallow groundwater in areas influenced by septic tanks in Dade County, Florida. Phelps (1994) summarized chemical characteristics of water from the surficial aquifer system in Duval County. A comparison of data from this study and those summarized by Pitt and others (1975 and Phelps (1994) is given in Table 8.

Table 8. Summary of major ion constituents from groundwater samples from this study in Duval County 2009-2010, the surficial aquifer system in Duval Colunty 1970-1989, and selected surficial aquifer wells in areas serviced by septic tanks, Dade County 1970-1973.

Constituent	Jacksonville FL [a] 2009-2010		Duval County, FL [b] 1970-1989		Dade County, FL [c] 1970-1973	
	mean	range	mean	range	mean	range
Chloride (mg/L)	50	0.021, 910	16	3, 100	28	0, 50
Iron (ug/L)	3827	30, 49500	1510	10, 12000	1910	0.7, 36000
pH (SU) [d]	6.3	3.69, 7.61	5.8	3.8, 8.1	7.7	6.8, 8.5
Potassium (mg/L)	8.7	0.84, 169	0.8	0.4, 1.0	3.1	0.2, 5.7
Conductivity (uS/cm)	588	41.2, 5635	218	31, 960	541	182, 694
Sulfate (mg/L)	87	0.36, 340	12	0.2, 87	26	0, 42

[a] Samples collected for this study.

[b] Phelps, 1994.

[c] Pitt, 1975.

[d] Median pH value.

A range of ion concentrations was found in the groundwater and surface water at the various sampling sites. Some of this variation was undoubtedly caused by soil and geology differences, some were caused by variations in tidal influence, and some may have been caused by human influence (septic tanks and fertilizer). The much higher ranges for many parameters in this study generally reflect the proximity of certain sites to tidally influenced tributaries, and do not necessarily indicate septic tank influence. For example, with surface water, chloride concentrations largely reflected nearness to the ocean and tidal condition. In this study, surface water chloride levels varied from 11 mg/L at BQ SW on 7/22/09 to 1200 mg/L at RT-SW on 12/29/09, at DE-SW on 12/29/09 and at DH-SW on 9/27/10. Groundwater concentrations, unless sampling sites are in the hyporheic zone, are more likely to reflect geological and human impact differences. Groundwater chloride levels varied from 0.02 mg/L at JB-2 on 9/28/10 to 910 mg/L at DH GW-1 on 7/21/09. Specific conductance, an indirect measure of dissolved solids, and sulfate, a major constituent of seawater, are also influenced by geology and tidal conditions and varied similarly. The mean specific conductance is similar to Dade County surficial aquifer wells located in OSTDS areas. Iron exhibited a very large concentration range in the surface water (130 – 720 ug/L) and groundwater (30 – 49,500 ug/L) in this study and, although most of this varability is due to geological site differences, some of the higher groundwater levels may be due to septic tank impacts. The much higher iron found in this study versus Dade County surficial aquifer data from septic tank areas may be an indication of septic tank influence. Boron also varied widely in surface water (26 – 310 mg/L) and groundwater (15 – 1720 mg/L), and the high range of boron concentrations observed at some sites might be indicative of septic tank influence at some sites (Table 3). Boron is a constituent of household products and often can be seen in septic tank effluent.

The basic forms of nitrogen in water are nitrite, nitrate, ammonia and organic nitrogen. All forms except organic nitrogen were measured in this study. However, since Total Kjeldahl Nitrogen (TKN) was measured, and it represents organic plus ammonia, organic nitrogen can be estimated by subtracting ammonia from TKN. NO_X primarily represents nitrate, since nitrite is usually a very small fraction of the total.

The water quality standards for Class III surface waters are broad and state that nutrients (TN and TP) shall be limited as needed to prevent violations of other standards, that man-induced nutrient enrichment shall be considered degradation, and that nutrient concentrations of a water body shall not be altered so as to cause an imbalance in the natural populations of aquatic flora and fauna (FDEP, 2002). The Total Maximum Daily Load for nutrients in the Lower St. Johns River is therefore based on chlorophyll a values, which are directly related to nutrient concentrations in the water column (Magley and Joyner, 2008). In the past, the U.S. EPA (2000) provided guidance nutrient concentrations for rivers and streams in Ecoregion XII, which covers the Lower St. Johns Basin. Their proposed values, 0.90 mg/L for TN and 0.04 mg/L for TP, were exceeded in most of the surface water samples collected at our study sites.

<u>Indicators of Human Fecal Contamination</u>

The organic wastewater contaminants (OWC's) used as chemical indicators of human fecal contamination (caffeine, Triclosan) proved to be unreliable, and there was no statistically significant relationship found ($p<.10$) between levels of the OWC's and concentrations of other possible indicators of septic tank impact (Cl, NOx, NH_4, TP, B, FC bacteria). At some sites (CST, DH) where some septic tank impact was observed for short distances through elevated NH_4 and NOx in nutrient plumes, overall levels of OWC's (caffeine and Triclosan) were often higher but variations in the OWC's and other indicators at the individual sampling sites at these residences did not correlate. A valuable indicator of nitrate sources is the the nitrogen and oxygen isotope data (Table 7), although anomalies did occur. In many cases the isotope data agreed with conclusions reached by evaluating other water quality data, but in many cases it did not, as discussed in the following sections.

Site Water Quality Comparisons

Clear evidence of OSTDS nutrient and bacterial impact downgradient from septic tank drainfields was rare, and at no sites were nutrient and bacterial plumes documented in this study as reaching the adjacent surface water. In most cases bacteria were not elevated downgradient from the drainfield, as bacteria was greatly reduced within short distances of the drainfield (<10 ft.). In this study, no significant relationships were found between nutrient or bacterial plume migration distances and particle size, hydraulic conductivity or hydraulic gradients (vertical and horizontal).

Only five sites were equipped with seepage meters, due primarily to unsuitable bottom conditions, but rates varied widely from site to site and were highly tidal dependent (inverse relationship) (Table 2). Surface and groundwater showed great differences in nutrient and bacterial levels, reflecting different drainage basin characteristics (geology, fertilization practices, wildlife, septic tanks), but in many cases it is difficult to definitively pinpoint the exact cause of high levels. Ground water samples had total nitrogen (TN) values ranging from 0.0 to 75.6 mg/L, with NOx ranging from 0.004 to 74.0 mg/L, and total phosphorus (TP) concentrations ranging from 0.004 to 4.8 mg/L. Mean groundwater NOx concentrations varied from 0.004 mg/L at NJ to 11.29 mg/L at LP , and mean TP concentrations ranged from 0.01 mg/L at MG to 1.7 mg/L at RT. Mean surface water concentrations of NOx varied from 0.14 mg/L at DE to 6.40 mg/L at CST, while the corresponding mean TP variation was 0.07 mg/L at DH to 1.37 mg/L at CST.

Murray Hill B

An area consistently showing very high fecal coliform bacteria in the surface water was Murray Hill B, as levels at JB-SW and BQ-SW were consistently greater than 3000 col/100mL. This is consistent with USGS findings for their study that focused on Big Fishweir and Little Fishweir Creeks (Phelps, 1994). The two homes in Murray Hill B that were sampled (BQ and JB) exhibited different fertilization practices, as BQ did not fertilize and JB fertilized at least twice per year. Except for more silt/clay at BQ (mean= 2.59 %) than at JB (0.14 %), the particle size, hydraulic conductivity (K_{80}) and horizontal hydraulic gradient data are similar for the two sites and allow for a meaningful comparison (Tables 1 and 2). Only one of the sites, JB, had significant concentrations of NOx or NH_3. The mean groundwater concentration of NOx at BQ was 0.008 mg/L, while the mean groundwater concentration of NOx at JB was 8.07 mg/L The mean NH_3 levels were 1.58 and 0.28 mg/L, respectively, for JB and BQ. A comparison of the nutrient concentration data at the two sites shows the effect of fertilization and strongly suggests that the main source of NOx in the groundwater at JB was fertilizer (Table 3). The measurable caffeine levels in June and September, 2010, at JB groundwater and surface water sites is difficult to explain and does not fit with the other data and indicates the unreliable nature of the caffeine and Triclosan data. Again, data throughout this study indicate the chosen OWC's (caffeine and Triclosan) do not appear to be reliable indicators of human fecal contamination.

Although we believe fertilizer to be the main source of nutrients at JB, the isotope data contradict this conclusion and several other indicators implied OSTDS influence at JB1 and JB2 (Table 7). The isotope samples from the Murray Hill B sites indicate significant enrichment of ^{15}N and ^{18}O, and those values, in conjunction with the slightly elevated boron in the samples, indicate the nitrate source to be mixed (fertilizer and wastewater). BQ groundwater exhibited very low B, OWC's, and nutrient levels, suggesting no residual wastewater inputs from the disconnected septic tank system occurred at that site.

Waterside

The residential sites selected for isotope monitoring in the Waterside Drive neighborhood all had very low to non-detectable nitrate concentrations (Table 3). Only one sample from one of the Waterside Drive sites (RT) had sufficient nitrate in it for isotope analysis. Isotope analysis showed the plotted isotope values from the Waterside neighborhood sample is consistent with a septic tank effluent source of nitrate (Fig. 6). DE, on Waterside Drive, is another site where we expected to see nutrient loading to the surface water (Cedar Creek), as the septic tank was located only 90 ft from the water and there was a good slope (hydraulic gradient) to the water. Basically there was no downgradient impact, however, and some of the collected data are difficult to explain. Low nutrient concentrations were found throughout the site, except for high NH_3 at DE-1 on 6/2/10 and DE-2 and DE-4 on 9/28/10 (Table 3). These sites were located short distances from the drainfield. No fecal coliform bacteria were found downgradient from the drainfield, except for the September, 2010 sampling event, when high numbers (180-5500 col/100mL) were found at DE-4 through DE-8. We believe a fecal coliform source other than the septic tank is at play here, as DE-1 through DE-3, adjacent to the drainfield, was not impacted.

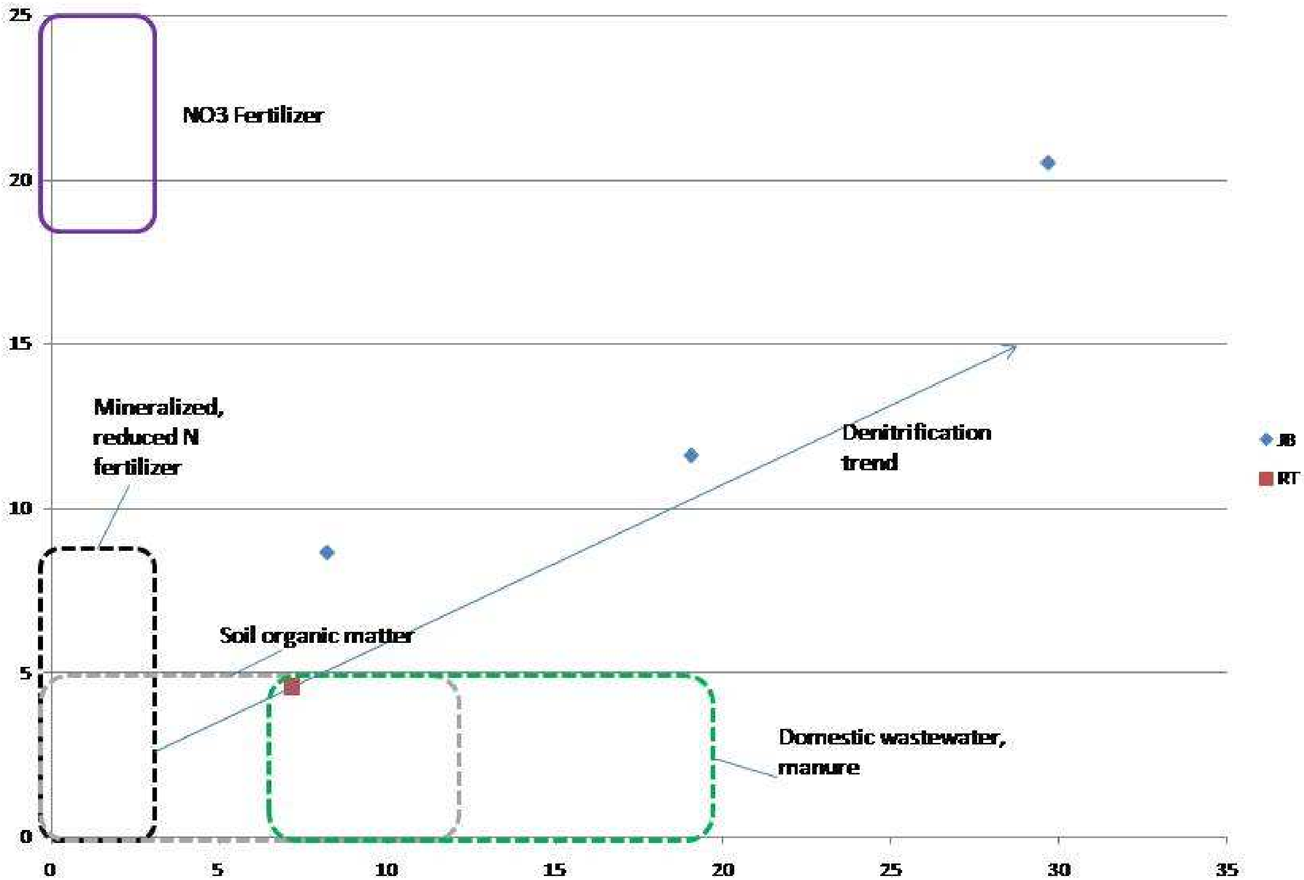

Figure 6. $\delta^{15}N$ versus $\delta^{18}O_{NO3}$ plot for stations in Waterside and Murray Hill B neighborhood sites

Eggleston Heights

In Eggleston Heights, Red Bay Branch (MR-SW) and several tributaries to Red Bay Branch (GO-1, RB-2, RB-3) consistently exhibited fecal coliform levels > 2000 col/100mL. Additional sampling of SJRWMD wells (MW-2 through MW-4) in the Eggleston Heights area showed moderate levels of bacteria (< 22 col/100mL), but these same wells exhibited high levels of NOx, ranging from 7.8 to 12 mg/L (Table 3). The

RB and R1 surface water tributaries generally were fairly high in NOx, also, with levels ranging between 1.0 and 4.0 mg/L (Table 3).

Samples were collected from several of the residential backyard sites as well as three of the SJRWMD monitoring wells in Eggleston Heights during the three sampling episodes. The backyard samples include two homes with active septic tanks (MR and WH) and one home where the septic tank has been decommissioned for several years (CS). Figure 7 shows the plot of these results for the two isotope ratios in all isotopes samples collected. In general, these data indicate significant enrichment of both ^{15}N and ^{18}O in some of the samples due to denitrification. The probable sources of the nitrate appear to be domestic wastewater from septic tanks and soil nitrogen. Elevated boron concentrations from these sites appear to support the septic tank influence on the samples. Although the groundwater isotope and boron data support septic tank influence at MR, WH and CS, the nutrient and bacterial data are very low to non-existent at downgradient locations and indicate minimal OSTDS influence. CS, the disconnected site in Eggleston Heights, exhibited very low groundwater concentrations and bacterial levels below detection. This supports our conclusion from Murray Hill B that the disconnected septic tanks and drainfields are not contributing significant nutrients to the groundwater and surface water. MR, in the Eggleston Heights subdivision, represents another site where, because of the layout and septic tank location, we expected to see high nutrient and bacterial impact downgradient from the drainfield, but that was not the case. Although elevated NOx concentrations existed eight ft. from the drainfield at MR-1(29 mg/L) and MR-1D (27 mg/L) in September, 2010, no other locations at MR were impacted by nutrients or bacteria (Table 3). However, a portion of the nutrient plume migrating from this drainfield could have been on an adjacent lot to which we did not have access.

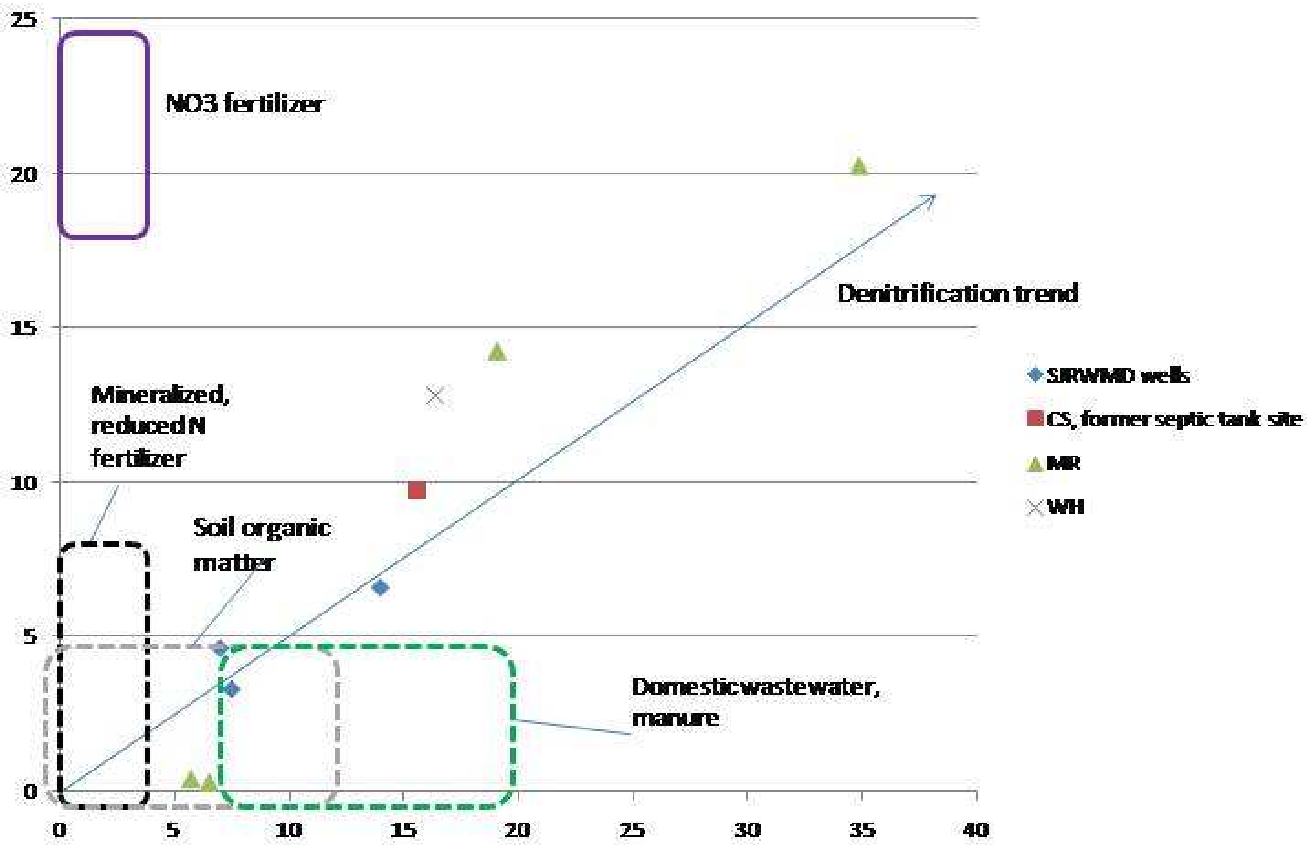

Figure 7. $\delta^{15}N$ versus $\delta^{18}O_{NO3}$ plot for stations in Eggleston Heights neighborhood

Julington Creek

This area includes two residential sites (LP and CST) and several SJRWMD monitoring wells. The $\delta^{15}N$ versus $\delta^{18}O_{NO3}$ plot (Figure 8) shows that several of these stations are influenced by inorganic fertilizer. Lawns at both the LP and CST sites are regularly fertilized according to the homeowners and it would seem from the SJRWMD well data that fertilizer use throughout the neighborhood is contributing to the nitrate in the ground water and that the sources are mixed. Enrichment of both ^{15}N and ^{18}O in samples from the CST site indicates that conditions at that site are more favorable for denitrification than at LP, perhaps due to soil characteristics and/or high water table, and this was supported by the low dissolved oxygen levels in the groundwater at this site (Table 3).

Additional sampling of SJRWMD wells adjacent to LP in Julington Hills, coupled with our PushPoint and piezometer well sampling, confirmed the very high NOx levels found in previous well sampling in this neighborhood by the SJRWMD. The source of this NOx in this area has been a mystery, and it appears that both septic tanks and fertilizers may be involved. The mean NOx concentration at LP was 11.29 mg/L and high levels were prevalent at nearly all sampled sites, except LP-2 and LP2A, but the other OSTDS indicators were low and the delta 15N data indicated inorganic fertilizer is the likely source. Measurable fecal coliform bacteria at LP-2 and LP-4 indicate possible septic tank influence, although in most cases bacteria were generally below detection. The owner (LP) does fertilize twice per year and therefore fertilizer, applied on site, appears to be a significant nutrient source. The high fecal coliform level found at LP-4 (400 col/100mL) and the above detection (AD) level of caffeine at LP-3 on 9/27/2010 is unexplainable at this time.

CST exhibited a high percentage of fine grained soil particles, and although the horizontal hydraulic gradient was low (< 0.02), the soil hydraulic conductivity (K_{80}) was higher than any other site (> 1.25 cm/s) and together with the high loading at this site helps explain the OSTDS impact seen at sampling sites more than 50 ft. from the drainfield. The mean NOx level at CST was 6.44 mg/L, and the mean NH_3 concentration was 17.51 mg/L, but these high means were due to high concentrations occurring at locations a short distance downgradient from the drainfield in a definite contaminant plume. Low NH_3 and NOx concentrations were found at CST-1 (control) in December 09 (0.01 and 0.29 mg/L, respectively) and June 010 (.01 and .03 mg/L, respectively), but NOx increased to 3.4 mg/L at CST-1 in September, 010, several weeks after fertilization. This increase at CST-1 shows the fertilization effect on the groundwater, and although this fertilizer effect is seen at most sites, the concentration is much lower than the septic tank contributions for sampling sites located directly downgradient from the drainfield (CST-2,3,4,5,9,10,11,11A). High NH_3 levels downgradient from the drainfield at some sites indicated little nitrification was occurring, and probable anaerobic conditions existed. Dissolved oxygen data from September, 2010 confirmed oxygen levels < 1.0 mg/L, and the low oxygen data support the isotope finding that conditions at CST are favorable for denitrification. High NH_3 (>11 mg/L) and NOx (21 mg/L) levels were found at CST 11 and 11A in September 2010, 50 ft. from the edge of the drainfield.

Given that the home is 25 years old, we know the NH_3/NOx plume migrated at least 50 ft in that time period, or about 2 ft/yr. The data at this site is somewhat complicated, however, as the original drainfield failed and was replaced between sampling episodes in 2010.

Although CST represents the most impacted site in this study, from a groundwater stand-point, Julington Creek was still approximately 50 yds from CST 11, our farthest site from the drainfield. Boron was elevated at the edge of the drainfield (CST-2,3,4) and indicated septic tank impact, also. Fecal coliform bacteria were not detected at any site, however, showing the effectiveness of the soil filter in removing bacteria.

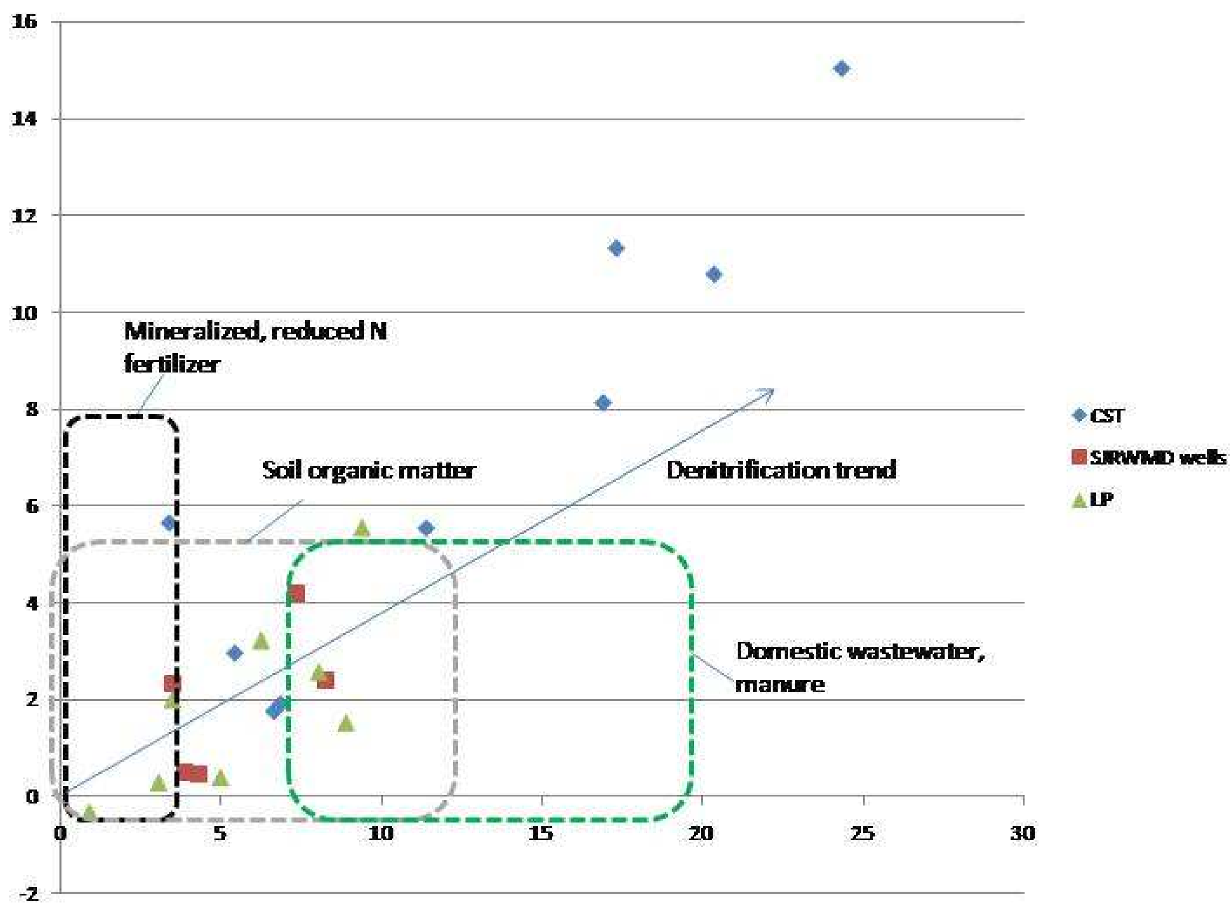

Figure 8. $\delta^{15}N$ versus $\delta^{18}O_{NO3}$ plot for stations in Julington Creek neighborhood

Julington Hills

This area includes two residential sites (DH and MM). The $\delta^{15}N$ versus $\delta^{18}O_{NO3}$ plot (Figure 9) indicates that domestic wastewater from septic tanks and possibly soil organic matter are the contributing sources of nitrate. Enrichment of ^{15}N and ^{18}O in many of the samples from the MM site indicate that they have been subjected to denitrification, which may be due to their distance from the drainfield, soil characteristics and/or depth to ground water. Neither the MM nor the DH properties receive much (if any) fertilizer and therefore septic tank influence should be easier to discern.

DH represents another site with high septic tank loading and a short distance from the drainfield to surface water (Cormorant Creek). Two septic tanks were present in the backyard, but fecal coliform bacteria were not detected downgradient and high NOx was only observed at a few sites. NOx was high at one site (DH-2 located ten ft. from the drainfield in December, 2009 (38 mg/L) and June, 2010 (22 mg/L). Another high NOx concentration was seen at DH-5 (74 mg/L) in December, 2009---but it is unclear if this isolated occurrence was the result of OSTDS or another source, such as pet waste. This site (DH) has been highly loaded for fifty years and therefore we expected to see more impact. DH exhibited a high mean NOx level (9.38 mg/L), but this high mean concentration is due primarily to several extremely high levels encountered several feet from the edge of the drainfield, and data did not indicate significant septic tank plume migration.

September 2010 data at MM indicate possible NOx septic tank impact at locations MM-1 (4.0 mg/L), MM-1A (3.2 mg/L) and MM-4 (6.4 mg/L) downgradient from the septic tank. If the above higher concentrations are due to the septic tank, it appears NOx has travelled approximately 100 ft. since 1967 (2.3 ft./yr), and is similar to the rate estimated for CST (2.0 ft./yr).

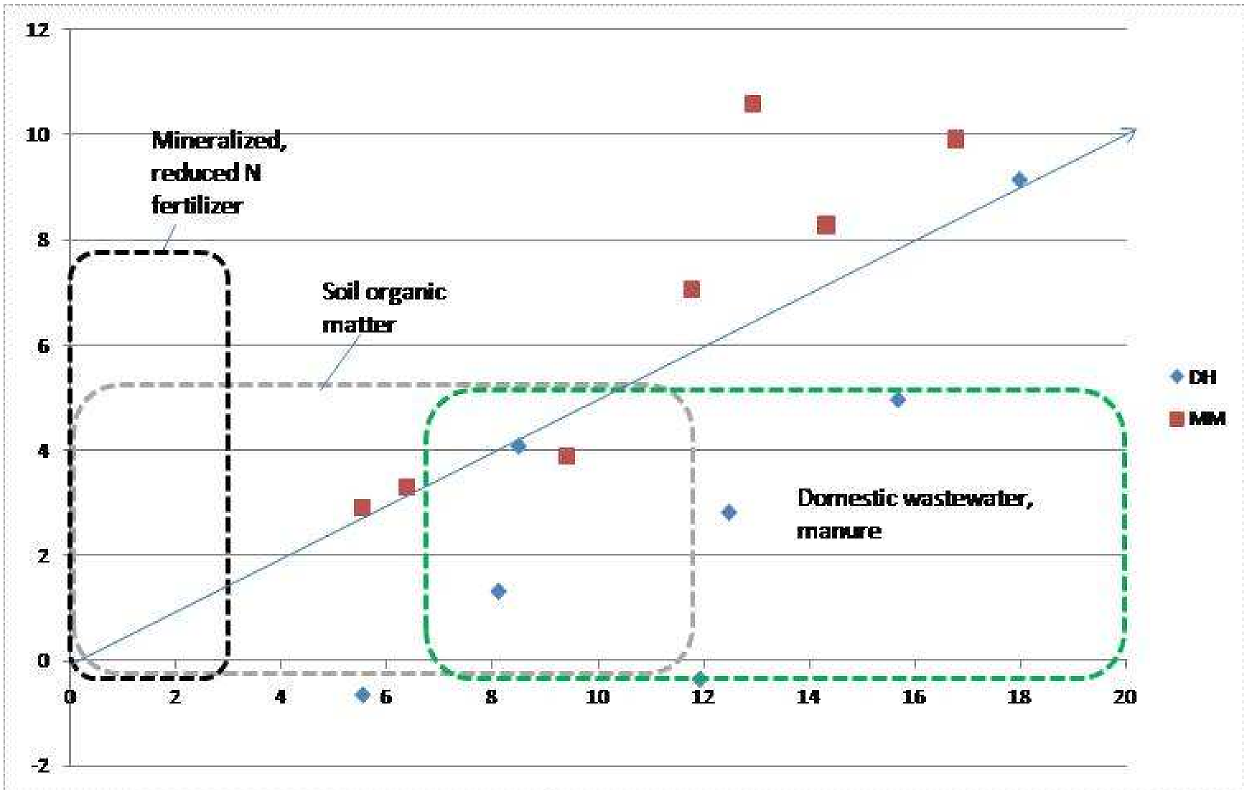

Figure 9. $\delta^{15}N$ versus $\delta^{18}O_{NO3}$ plot for stations in Julington Hills neighborhood.

Summary and Conclusions

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For our nitrogen contamination analyses, two key questions were asked that guided our evaluation. The first question (1) is: Is the dissolved inorganic nitrogen (DIN) high? High is a relative term, but this question can generally be answered. If the answer to this first question is yes, than we know the groundwater (and often the adjacent surface water) is probably highly impacted by man, but the source cannot be identified (generally fertilizer or OSTDS). If the answer to question 1 is no, the groundwater and surface water are not impacted. Now, if the answer to question 1 is yes, then question 2 is asked: Are delta ^{15}N levels high and what do the levels indicate? Again, because the various key questions and indicators in this study most often gave conflicting answers, the level of DIN (NOx-N, NH_3-N) was believed to be the most important metric and was given the highest priority in data interpretation, with the delta ^{15}N levels being of secondary importance. After this, levels of other indicators of OSTDS influence, such as boron and OWC's (caffeine, triclosan) were checked to see if they corroborated the DIN and delta ^{15}N data.

All OSTDS indicators (DIN, fecal coliform bacteria, B, delta ^{15}N, OWC's) are shown in Table 7, and rarely were all indicators analyzed at the same sampling location at the same time. In no case did all indicators of OSTDS impact agree. At several locations, however, many of the indicators showed impact. These included the groundwater sites CST (1,2,3,4,11,11A), DH (2), JB (1,2), MM (1,1A, 4), and surface water sites R1-SW and RB (1,2,3) (Table 7). At these locations we can say with a fair amount of certainty that there is OSTDS impact. Because of the high DIN found at several other locations, OSTDS impact may be occurring there also. Although OSTDS impact was found at several locations (above), continuous plumes indicating nutrient and bacterial loading from OSTDS to adjacent down-gradient surface water were not indicated by the monitoring from any of the individual sites in this study.

Sikora and Corey (1976) list the potential removal efficiency of conventional septic tank systems for TN and TP as 10 to 40 percent and 85 to 95 percent, respectively. Exact removal efficiencies depend on construction details and site characteristics and are based on observations of groundwater exiting the septic tank drainfield. Typical removal efficiencies result, on average, in about 20 to 57 mg/L of TN and 0.5 to 5.6 mg/L TP being discharged from the drainfield. Fecal coliform bacteria are less of a concern as the soil is generally an effective filter for bacteria. Properly functioning septic tanks also result in retention and die off of most fecal and pathogenic bacteria (U.S. EPA, 2002b). We found in this and previous studies that high nutrient and bacteria concentrations are usually rapidly reduced down-gradient of non-failing septic tank drainfields in most soil systems, and the data indicate that OSTDS at the majority of these study sites do not appear to have significant groundwater plumes containing nutrients or bacteria. This conclusion was indicated in this study by the low down-gradient nutrient and fecal coliform bacteria levels occurring under a range of hydrogeologic scenarios. However, data interpretation and source conclusions derived from chemical indicator and nitrogen isotope data were sometimes contradictory

According to our observations and conversations with the homeowners, the septic tanks (with the exception of CST) monitored in this study were functioning properly and not failing. Data from this study, coupled with collective data from other studies on the Indian River Lagoon (Belanger, Heck and Andrews, 1997; Belanger and Price, 2006; Belanger and Price, 2007; Belanger, 2009; Zarillo et al., 2010), indicate that while OSTDS can contribute nutrients to water bodies such as the LSJR and its tributaries under certain site condition scenarios, properly functioning (not failing) OSTDS may not be as significant a source of nutrients and bacteria as many have thought. This conclusion, however, is not a universal conclusion, as other studies in Florida and elsewhere have sometimes indicated more impact. Also, data evaluation at selected sites in this study identified lawn fertilizer as a potentially significant source of nutrients that warrants further assessment.

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