# GROUND WATER ASSESSMENT REPORT

# SITE 10

## Lake Jesup Watershed, Sanford Florida

***March 10, 2008***

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The FDEP Ground Water Protection Section, assisted by the FDEP Site Investigation Section, conducted an assessment during the week of December 10, 2007 to document shallow ground water conditions at the City of Sanford's Site 10 wastewater residuals and reclaimed wastewater application site. The assessment was conducted to ground truth existing nutrient concentrations and ground water flow conditions and provides current information for shallow ground water in hay field areas that drain to Lake Jesup. This information will be used to assist development of the Lake Jesup Basin Management Action Plan (BMAP).

### *Background*

The Site 10 wastewater facility is located on 1,868 acres of land bounded on the west by Lake Jesup, on the north and east by SR 46 and on the south by the Lake Jesup Conservation Area owned by the St. Johns River Water Management District (SJRWMD). A fringe of marsh and wetland vegetation separates the site from the open water of Lake Jesup. Land cover on the site consists of wooded wetland and drainage-modified pasture and citrus groves.

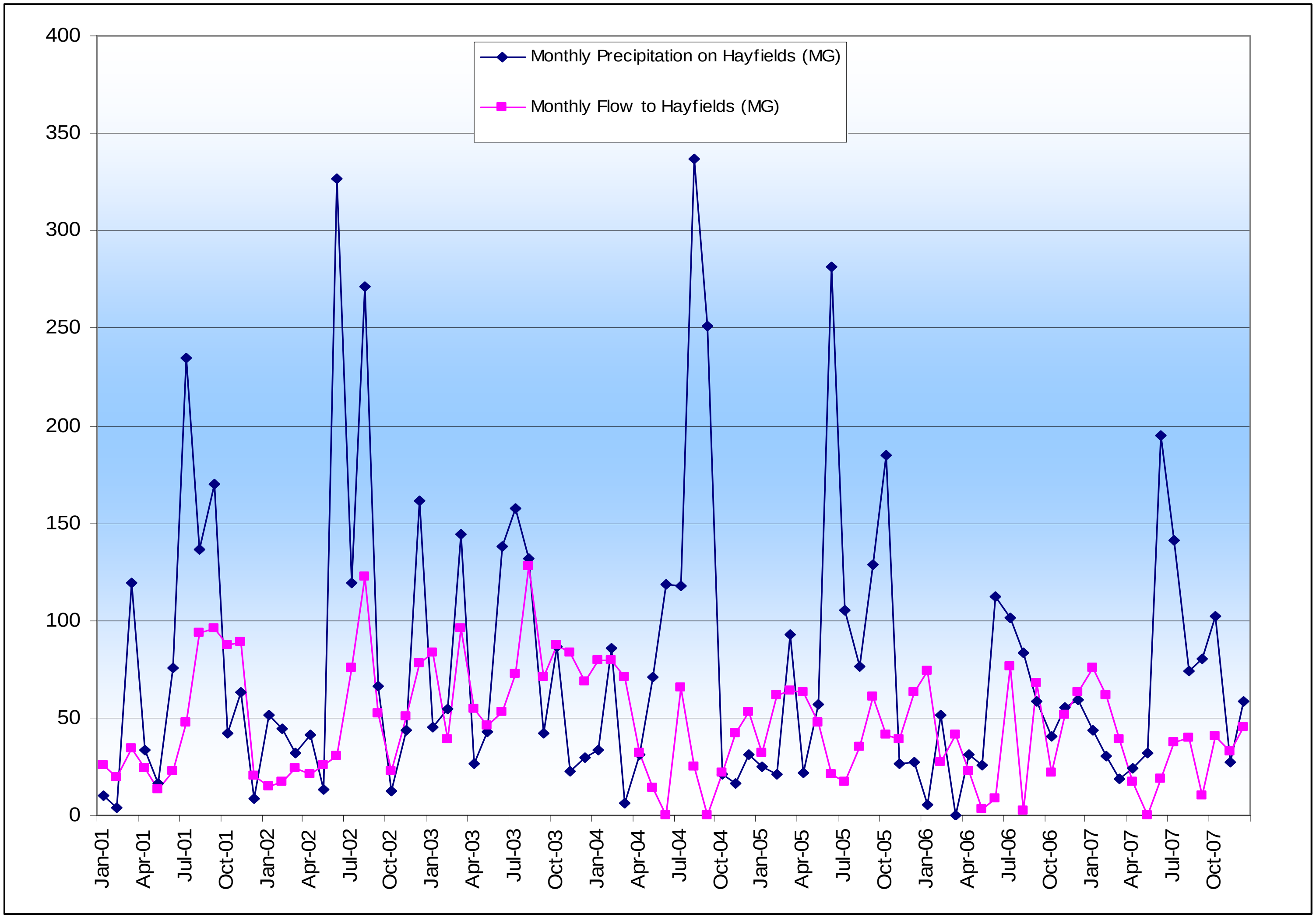
The City of Sanford holds a Domestic Wastewater Facility National Pollutant Discharge Elimination System (NPDES) permit to discharge 2.84 million gallons per day (MGD) of treated wastewater to a permitted capacity slow-rate public access reuse system at the Site 10 facility. The facility includes two storage ponds (37 million gallon capacity) and a pumping station that distributes the wastewater to 620 acres of improved pasture via flood irrigation and 270 acres of citrus groves via a micro-jet irrigation system.

In a recent report by Camp Dresser and McKee (Danielle Honour, P. E., February 27, 2007 memorandum to Paul Moore of the City of Sanford), Camp Dresser and McKee (CDM) provided a data evaluation and simple ground water transport model to obtain an estimate of the ground water loading of nitrate from the site to the lake. While the approach taken has merit and was a good effort based on available ground water quality data, the ground water monitoring wells available for the study were not properly located to provide ground water quality and elevation data representative of the residuals/reclaimed water application areas near the lake. These wells were installed for regulatory monitoring years before the recent CDM Site 10 analysis was conducted. Only 2 of the 13 monitoring wells available for the CDM evaluation appear to be located in areas that drain to the lake and these two wells provided results for only the northern edge of the site (per **Figures 9** and **16** in the CDM memo, which are in **Appendix A**). In addition, the CDM report did not evaluate the potential for phosphorus from the site to impact the lake via ground water discharge. Ground water quality and flow data from fields that drain to the lake were needed to refine the data set used in the CDM model.

## *Recent Usage of Site 10 for Reuse Water Application*

The City of Sanford Wastewater Utilities Department maintains records of reclaimed water application to the hay fields and citrus groves at Site 10. Prior to the assessment, the City provided FDEP with a tabular summary of reuse water received by Site 10 and distributed to the hay fields and citrus groves. **Figure 1** is a chart that shows monthly flows to the hay fields and monthly rainfall at the site. **Table 1** provides a summary of the distribution of reuse water to the hay fields and citrus groves and precipitation for the month of December, 2007. According to the City, application of water to the hay fields is balanced against the need for water to irrigate the citrus groves on the site, which received most of the water during the fall months of 2007. Most of the hay field area is in the Lake Jesup watershed, whereas most of the citrus groves are not.

Some of the hay fields received a significant amount of reuse water during the week prior to this assessment. Field 1 received water most recently based on moisture in the ditches and the elevated water table in comparison to the other fields at the time of the assessment. Reuse water is applied via flood irrigation to major longitudinal ditches in the fields. Transverse ditches perpendicular to the longitudinal ditches disperse the water across the field so that it can be assimilated. Excess water is routed to perimeter ditches and then to adjacent stormwater ponds. There was no evidence of recent application of residuals at any of the fields that were sampled as part of this assessment.




Source: Richard Casella, City of Sanford Utilities

**Figure 1 Summary of Reclaimed Water Application to Hay fields at Site 10**

**Table 1 Precipitation and Reclaimed Water Application Summary for Site 10 in December 2007**

| Date | Precipitation (in/dy)[1] | Reuse Water Flow to Site 10 Retention Pond (MGD)[2] | Flow to Citrus Grove on Property (MGD)[2] | Flow to Hay Fields, not differentiated (MGD)[2] |
|---|---|---|---|---|
| 1 Sat | 0 | 3.935 | 0 | 0 |
| 2 Sun | 0 | 2.014 | 0.216 | 0 |
| 3 Mon | 0 | 2.128 | 0.2 | 0 |
| 4 Tue | 0 | 1.128 | 0.487 | 0 |
| 5 Wed | 0 | 0 | 0 | 2.417 |
| 6 Thu | 0 | 1.081 | 0.138 | 3.918 |
| 7 Fri | 0 | 1.175 | 0 | 3.824 |
| 8 Sat | 1.4 | 0.971 | 0 | 1.314 |
| 9 Sun | 0 | 1.857 | 0.289 | 0 |
| 10 Mon | 0 | 1.39 | 0.683 | 0 |
| 11 Tue | 0 | 1.147 | 0.575 | 0 |
| 12 Wed | 0 | 0.602 | 0.615 | 0 |
| 13 Thu | 0 | 1.048 | 0.235 | 0 |
| 14 Fri | 0 | 0.343 | 0.134 | 0 |
| 15 Sat | 0 | 1.106 | 0.765 | 0 |
| 16 Sun | 1.15 | 2.709 | 0.247 | 0 |
| 17 Mon | 0.01 | 3.036 | 0.155 | 0 |
| 18 Tue | 0 | 2.253 | 0 | 1.444 |
| 19 Wed | 0 | 2.014 | 0 | 3.591 |
| 20 Thu | 0 | 1.799 | 0 | 3.535 |
| 21 Fri | 0 | 2.667 | 0 | 3.502 |
| 22 Sat | 0.5 | 1.822 | 0 | 3.446 |
| 23 Sun | 0 | 3.162 | 0 | 3.414 |
| 24 Mon | 0.02 | 1.602 | 0 | 3.4 |
| 25 Tue | 0.06 | 1.316 | 0 | 3.376 |
| 26 Wed | 0.16 | 1.341 | 0 | 3.347 |
| 27 Thu | 0.02 | 1.141 | 0.382 | 3.362 |
| 28 Fri | 0 | 1.548 | 0.479 | 1.119 |
| 29 Sat | 0 | 2.083 | 0.469 | 0 |
| 30 Sun | 0.15 | 1.992 | 0.482 | 0 |
| 31 Mon | 0.02 | 2.295 | 0.487 | 0 |
| Sum | 3.49 | 52.705 | 7.038 | 45.009 |
| Avg | 0.11258065 | 1.70016129 | 0.22703226 | 1.45190323 |
| Max | 1.4 | 3.935 | 0.765 | 3.918 |
| Min | 0 | 0 | 0 | 0 |

Note: Highlighted rows represent conditions when FDEP assessment was conducted.
[1] Inches per day
[2] Million gallons per day
Source: Richard Casella, City of Sanford Utilities

## *Field Activities*

This project included collection of ground water samples representative of hay fields in the western part of the site, which is in the Lake Jesup drainage basin. The fields where monitoring was performed are shown in **Figure 2**. These fields have been used for application of treated wastewater and some have received residuals. In addition, information on depth to ground water and flow gradient was obtained to estimate the ground water flow gradient across the portion of Site 10 that drains to the lake. The ground water quality and flow gradient data were collected to help better understand the potential for nutrients to migrate from the site toward the lake. The specific field activities included installation of temporary wells; ground water sampling; an elevation survey and water level measurements; and an assessment of the contribution of a potential spring or flowing well at the north end of the site. In addition to activities performed by

FDEP staff, representatives of Seminole County also collected two surface water samples from surface water streams draining from the site toward Lake Jesup. In addition to these activities, SJRWMD conducted a reconnaissance at Site 10 to search for evidence of a spring or flowing well that was postulated as a source of surface water flow in the northern part of the site.

### Temporary Well Installation

A total of 13 shallow temporary monitoring wells were installed to provide ground water quality data representative of the fields shown in **Figure 2**. These small-diameter "micro" wells were installed in the hay fields in such a manner as to provide east-west coverage of ground water quality as well as provide measuring points to establish a generalized ground water flow gradient. These were installed by the FDEP Site Investigation Section's direct-push rig. In addition to well installations, the direct-push rig was used to collect continuous core samples from four well locations (one at each field). Depths of the temporary wells ranged from 12 to 15 feet below land surface or 6 to 11 feet below the water table. Well completion depths are summarized in **Table 2**. The hay fields are numbered by the City and FDEP used the same naming convention in our assessment. Three wells each were installed in Fields 1, 3, 4 and 16. In addition, one well was installed in the eastern end of Field 2. Geologic descriptions and well completion information are provided in **Appendix B**.


**Figure 2- Site 10 Sampling Locations**

## Ground Water Sampling

Each of the temporary wells was sampled by certified staff in accordance with FDEP sampling standard operating procedures and analyzed at the FDEP Central Laboratory. Laboratory and field parameters included the following:

- Nitrate+nitrite (as nitrogen)
- Ammonia nitrogen
- Total phosphorus
- Chloride
- Specific Conductance
- pH

The results of laboratory analyses and field screening are discussed in a following section.

## Surface Water Sampling

The Seminole County Water Quality Section collected two surface water samples from Site 10 on December 13, 2007. These were collected from the outfall streams from two stormwater ponds that receive overflow from hay fields ("Jes E" and "Jes H" on **Figure 2**). The surface water sampling results are discussed in a following section.

## Elevation Survey and Water Level Measurement

This assessment included an elevation survey and water level measurements to estimate a ground water flow direction and gradient across each of the hay fields being monitored. The elevation survey was conducted using standard leveling techniques, tying-in the top-of-casing elevations of the wells in each field. Water levels were then measured and converted to elevations to establish the ground water flow gradient between wells in each field, giving a generalized gradient across the site that can be used for modeling purposes. Approximate well locations were established using global positioning system equipment.

## Investigation of Artesian Well/Spring Flow

The CDM Site 10 analysis identified the possibility of an artesian well or spring located on the site near Pond A-2. A representative of the St. Johns River Water Management District conducted an investigation on June 20, 2007 to look for the possibility of an uncapped artesian well or spring on the site (Curtis, 2007). At the time of the inspection, rainfall levels were very low and the site was atypically dry and there was no flow coming from the area suspected as being the source of the spring or flowing well. The standing water (and vicinity) did not exhibit obvious movement, sand boils or sulfur reducing (white) filamentous bacteria which is often associated with flow from the Floridan aquifer. No conclusive evidence of Floridan aquifer springs or flowing artesian wells was observed. The standing water exhibited some tannin discoloration consistent with surface water seepage and runoff.  If a point location of water discharge such as a trickling rivulet or sand boil is observed at some point in the future, SJRWMD will be available to return to the site for addition investigation.

## *Findings*

### Site Geology and Ground Water Flow

Most of Site 10 is a mosaic of drained pasture and wooded wetlands.  Natural soils in the area are mainly spodisols, which have a sandy surface horizon and a spodic or organic horizon at a depth of approximately 2 feet or less.  Two core samples from each of the fields that were collected in this assessment were reflective of native soil conditions in some areas, but cores at two other locations (F4-MW1 and F1MW1, **Figure 2**) contained highly organic material from ground surface to depths of up to several feet.  Based on their location and odor, these may be locations where residuals were applied and incorporated into the soil. Below the soil zone, cores representative of the four fields contained interbedded layers of sand, clayey sand and clay.  The clay content and depth of clay layers were observed to vary from site to site but in general, clay content appeared to increase with depth.  Monitoring wells in this assessment were set in the sandy material which represents the surficial aquifer.

According to the CDM report, the surficial aquifer extends up to 25 feet feet in thickness and the lithologies encountered in this assessment agree with CDM's findings.  CDM also reported that an intermediate confining unit, composed of clayey material, was encountered from 8 to 25 feet below land surface (BLS) in the southeastern part of the site.  For their conceptual model, CDM chose a surficial-aquifer thickness of 25 feet, which is conservative and would perhaps lend toward a higher estimate of flow and loading in the calculation.  FDEP did not encounter a distinct confining unit, but as mentioned above, there was a gradational increase in clay content with depth.  CDM estimated a ground water hydraulic conductivity (permeability) of 3.5 feet per day (ft/day) for the surficial aquifer, which is reasonable and perhaps somewhat high for the interbedded sand and clayey sand of the surficial aquifer at this site.

During this assessment, depth to ground water varied between sites, from a high of 0.9 feet BLS at Field 1 to a low of 5.9 feet BLS at Field 4.  The ground water gradients (slope) beneath all four sites are generally toward the lake or to the nearest stormwater pond that drains to the lake, which generally agreed with topographic slope and the flow directions in the ditch networks that carries excess water to the nearby stormwater ponds.  **Tables 2** and **3** provide the depths to ground water and elevation data and the estimated ground water gradients based on the elevations from this assessment.  Contour maps for the four fields are provided as **Figures 2** through **5**.  The overall gradient and flow direction across the hay fields that were derived by FDEP are similar to the potentiometric surface contours estimated by CDM for the hay field portion of the site (Figure 18 in CDM report, in **Appendix A**).

**Table 2  Ground Water Elevation Data Summary for December 13, 2007**

| Field/Well | Total Depth (feet) | Depth to Ground Water (feet below land surface) | Depth to Ground Water (feet below well casing) | Well Casing Elevation (feet)[1] | Ground Water Elevation (feet)[1] |
|---|---|---|---|---|---|
| **Field 1** | | | | | |
| F-1-MW1 | 12 | 0.9 | 4.17 | 20.00 | 15.83 |
| F-1-MW2 | 12 | 1.7 | 4.89 | 19.76 | 14.87 |
| F-1-MW3 | 12 | 1.7 | 5.03 | 20.17 | 15.14 |
| **Field 3** | | | | | |
| F-3-MW1 | 15 | 4.4 | 6.87 | 20.00 | 13.13 |
| F-3-MW2 | 15 | 4.4 | 7.32 | 18.27 | 10.95 |
| F-3-MW3 | 15 | 5.1 | 7.99 | 21.03 | 13.04 |
| **Fields 4 and 2** | | | | | |
| F-4-MW1 | 12 | 4.9 | 8.10 | 20.00 | 11.90 |
| F-4-MW2 | 12 | 3.2 | 6.39 | 19.99 | 13.6 |
| F-4-MW3 | 12 | 5.9 | 8.91 | 19.75 | 10.84 |
| F-2-MW1 | 12 | 4.7 | 7.87 | 18.56 | 10.69 |
| **Field 16** | | | | | |
| F-16-MW1 | 12 | 5.4 | 8.52 | 20.00 | 11.48 |
| F-16-MW2 | 12 | 3.7 | 6.90 | 20.07 | 13.17 |
| F-16-MW3 | 12 | 3.8 | 7.08 | 21.24 | 14.16 |

Notes:
[1] Top of casing and ground water elevations are in feet relative to an arbitrary elevation established at MW1 for each field. Elevations between fields are not comparable.

**Table 3 Estimated Ground Water Gradients for Site 10 fields.**

| Field | Gradient (foot/foot) | Direction |
|---|---|---|
| Field 1 | 0.0019 | NW |
| Field 3 | 0.0035 | W |
| Field 4 | 0.0027 | W-SW |
| Field 16 | 0.0048 | SW |
| Average Gradient | 0.0032 | W |

Note:  Gradients based on ground water elevation data for December 13, 2007.


**Figure 3 – Ground water contour map for Field 1, December 13, 2007.**

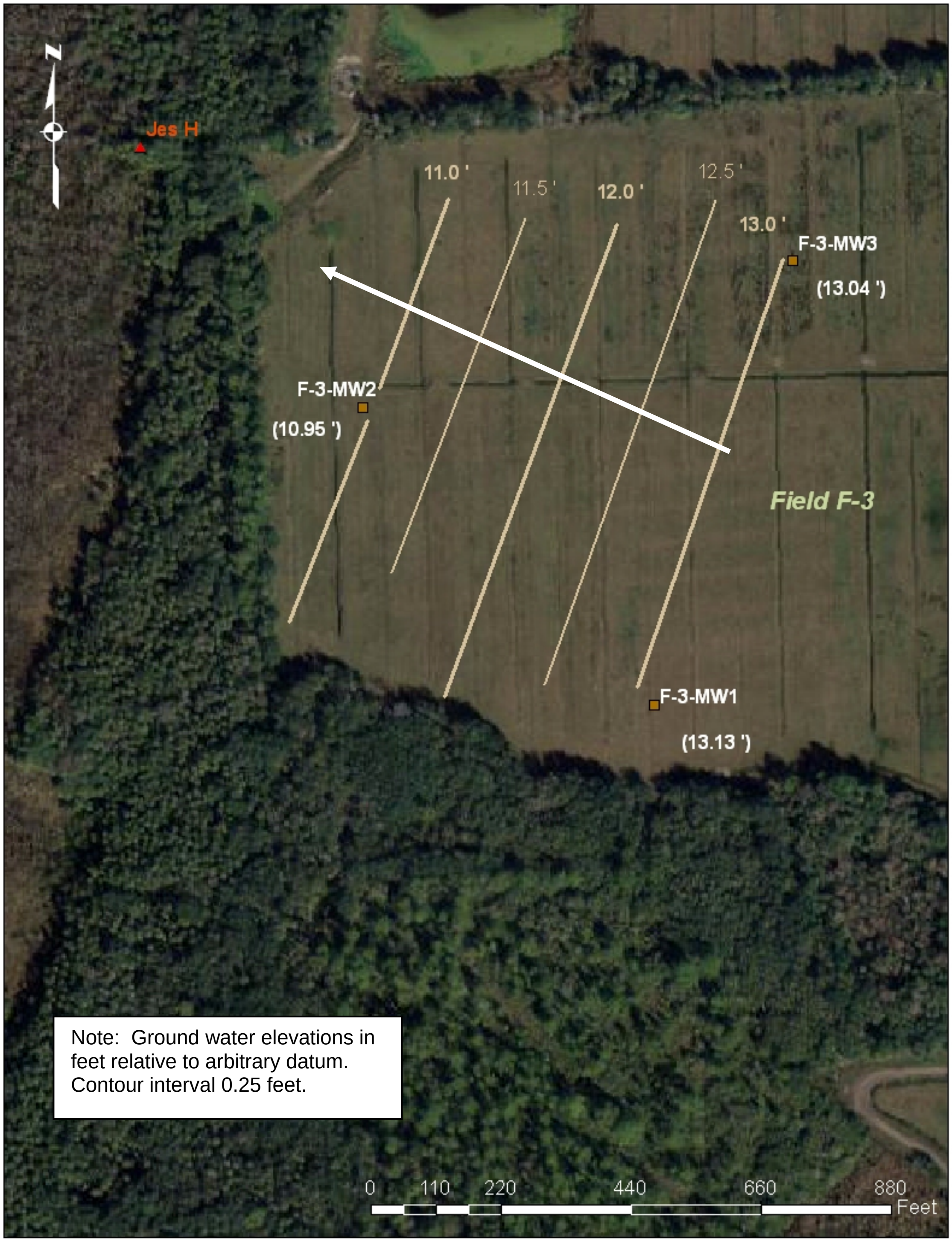



**Figure 3 – Ground water contour map for Field 3, December 13, 2007.**

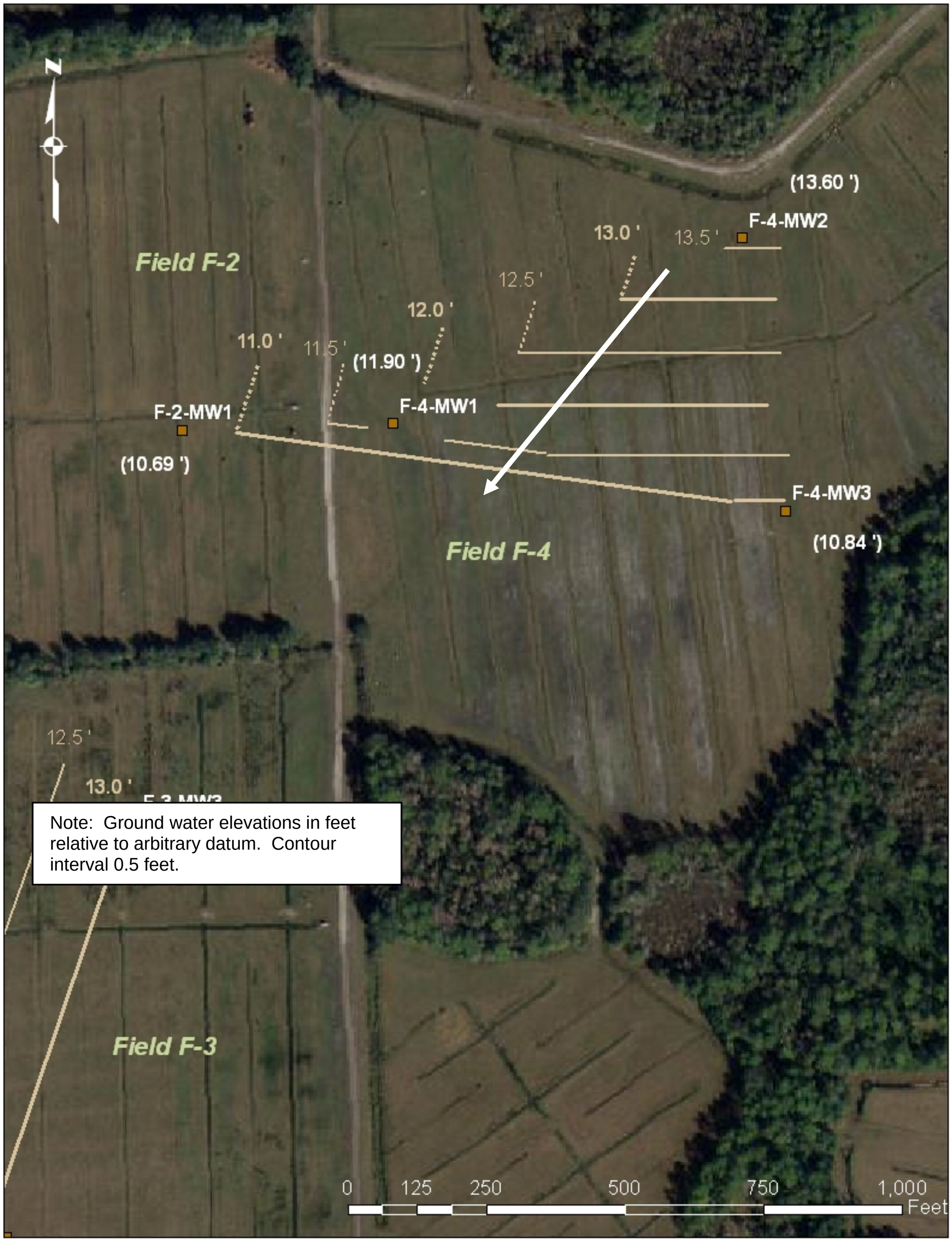



**Figure 5 – Ground water contour map for Field 4, December 13, 2007.**

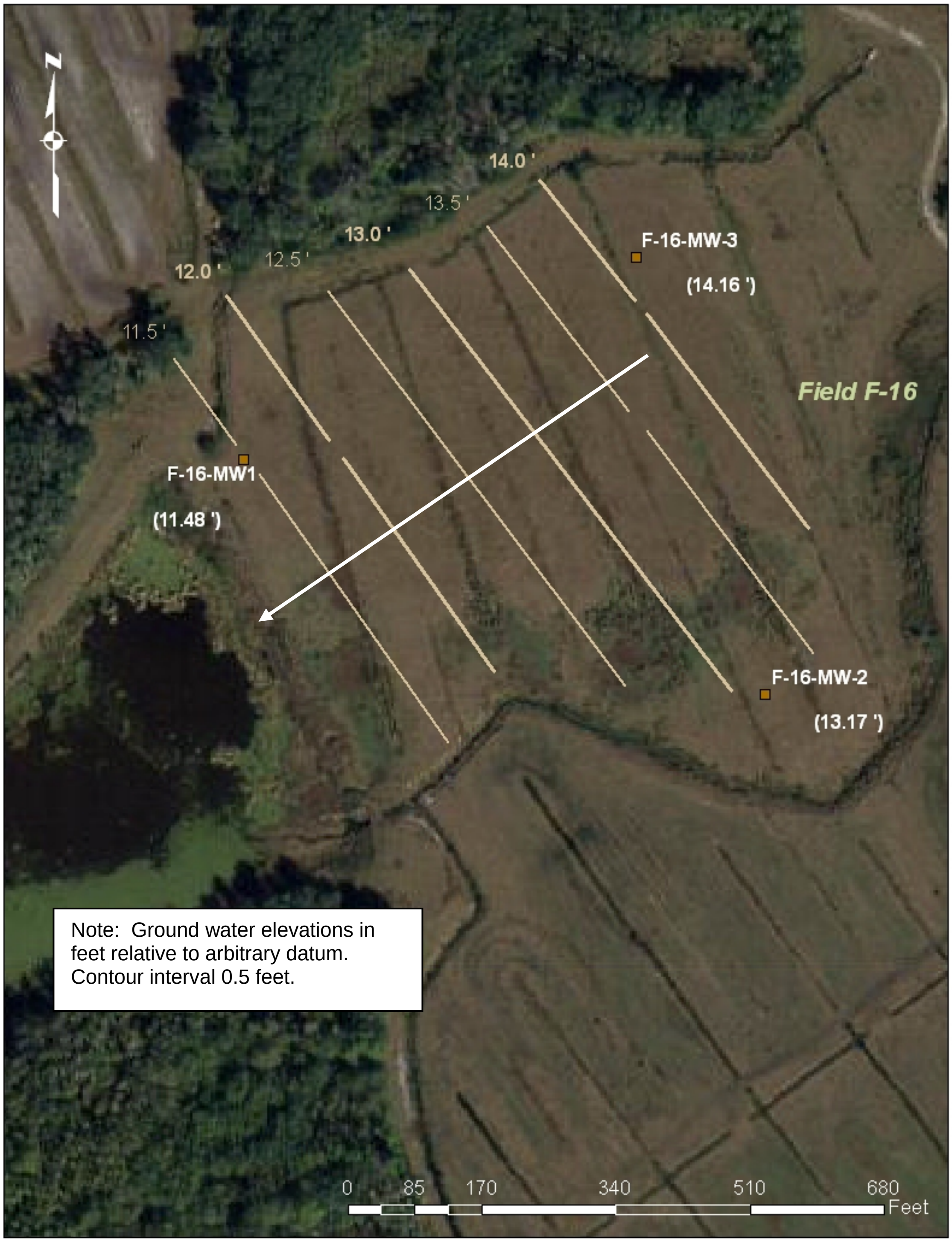



**Figure 6 – Ground water contour map for Field 16, December 13, 2007.**

## Ground Water Quality

Water quality samples were collected from the monitoring wells for nutrients (nitrate+nitrite, ammonia, and phosphorus) and chloride. The laboratory results as well as field parameters are presented in **Table 4**.

**Table 4 Ground Water Quality Data**

| Field/Sample | Nitrite+Nitrate as N | Ammonia and N | Total Phosphorus | Chloride | Specific Conductance | pH |
|---|---|---|---|---|---|---|
| **Field 1** | | | | | | |
| F-1-MW1 | 0.024 | 25 | 0.36 | 400 | 1754 | 5.65 |
| F-1-MW1(F) [1] | 0.022 | 26 | 0.15 | 410 | 1754 | 5.65 |
| F-1-MW2 | 0.012 | 0.33 | 0.15 | 130 | 966 | 6.77 |
| F-1-MW3 | 0.008 | 0.19 | 0.52 | 250 | 1428 | 7.55 |
| **Field 3** | | | | | | |
| F-3-MW1 | 0.053 | 0.11 | 0.88 | 77 | 551 | 6.76 |
| F-3-MW2 | 0.053 | 0.54 | 0.78 | 170 | 735 | 5.18 |
| F-3-MW2(F) [1] | 0.049 I | 0.6 | 0.17 | 180 | 735 | 5.18 |
| F-3-MW3 | 0.075 | 0.36 | 0.23 | 1200 | 4151 | 6.54 |
| F-3-MW3 duplicate | 0.074 | 0.37 | 0.27 | 1200 | 4151 | 6.54 |
| **Fields 4 and 2** | | | | | | |
| F-4-MW1 | 0.078 | 1.6 | 0.37 | 440 | 3238 | 6.37 |
| F-4-MW2 | 0.074 | 0.34 | 0.14 | 1300 | 4856 | 6.92 |
| F-4-MW3 | 0.028 | 0.68 | 0.2 | 2100 | 6975 | 6.63 |
| F-2-MW1 | 0.032 I | 0.23 | 0.17 | 210 | 1768 | 7.67 |
| **Field 16** | | | | | | |
| F-16-MW1 | 0.033 | 1.1 | 0.76 | 94 | 614 | 6.04 |
| F-16-MW2 | 0.02 | 4 | 0.16 | 810 | 3569 | 6.52 |
| F-16-MW3 | 0.1 I | 0.27 | 5.3 | 65 | 486 | 6.72 |
| F-16-MW3(F)[1] | 0.039 I | 0.22 | 0.038 I | 66 | 486 | 6.72 |
| **Median for All Fields[3]** | **0.033** | **1.1** | **0.76** | **94** | **614** | **6.04** |
| **Historical Median for Lake Jesup[2]** | **0.008** | **0.025** | **0.148** | **170** | **802** | **8.79** |

Notes: All analyte concentrations in milligrams per liter except specific conductance (micromhos per centimeter) and pH (standard units)
[1] Filtered replicate sample.
[2] Data obtained from Impaired Waters Rule 2007 dataset used for run 28.1.
[3] Excluding filtered samples and duplicates
I -the reported value is between the laboratory method detection limit and the laboratory practical quantitation limit.

Nitrate+nitrite, ammonia and phosphorus were the key nutrients evaluated because of their potential to exist in ground water beneath the site and adversely affect the lake. Chloride was evaluated as a potential indicator of wastewater.

This assessment shows that nitrate+nitrite concentrations (generally equivalent to nitrate alone due to the minor contribution of nitrite) are low in the wells monitoring the four hay fields, with a median concentration of 0.033 milligrams per liter (mg/L). These findings are similar to 2003-2006 nitrate concentrations in the City of Sanford hay field wells (MWC-11, MWC-12 and MWC-13 in the CDM report, Table 7 in **Appendix A**). The median background concentration for nitrate+nitrite in the surficial aquifer in Seminole County is 0.017 mg/L (from FDEP Oracle-based Ground Water Information System [OGWIS] water quality database). Nitrate is the most stable and most mobile form of nitrogen in ground water and it migrates at the same rate as ground water.

Ammonia was detected in one well in Field 1, which was most recently flooded, at a concentration of 25 mg/L (**Table 4**). In addition to the elevated level in Field 1, two other fields (Fields 4 and 16) had ammonia detections above 1 mg/L. These exist as not-unexpected artifacts of the wastewater application and/or waste from the cattle that are pastured on site if the water table is high, particularly when the fields are intermittently flooded (efficient mineralization of ammonia to nitrite and nitrate depends on aerobic conditions). The median background concentration for ammonia in the surficial aquifer of Seminole County is 0.092 mg/L (from OGWIS database), which is considerably lower than the median ammonia concentration for the four fields, 0.37 mg/L.

Total phosphorus concentrations ranged from non-detect to as high as 5.3 mg/L, with a median for the four hay fields of 0.76 mg/L (**Table 4**). Total phosphorus includes both dissolved and suspended concentrations of phosphorus. To evaluate the suspended versus dissolved concentrations of phosphorus, replicate samples from three of the wells were analyzed for dissolved (filtered) phosphorus. Filtered samples were many times to several times lower than their unfiltered replicates and the median dissolved phosphorus concentration was 0.15 mg/L for the three filtered samples. Historically, phosphorus was included as a ground water monitoring parameter at Site 10, but monitoring for phosphorus was removed from the permit in 1997 (CDM report). The historical average phosphorus concentrations in Seminole County wells MWC-11, MWC-12 and MWC-13 for 1992-1997, are 2.97, 0.24 and 0.16 mg/L, respectively, which are similar to the concentrations detected in this assessment. Median background total and dissolved phosphorus concentrations in the surficial aquifer of Seminole County are 0.3 and 0.18 mg/L, respectively (from OGWIS database).

Chloride is a typical constituent of wastewater and it was found at elevated concentrations in most of the wells. Across the site, concentrations ranged from 77 to 2,100 mg/L, with a median for all wells of 250 mg/L. According to Watts (1989), 100 mg/L is a typical chloride concentration for secondarily treated municipal wastewater. Several of the concentrations in wells at this site exceed that concentration by an order of magnitude. Therefore another source for elevated chloride must be considered. Publications and personal communications (Barraclough, 1962; Spechler and Halford, 2001; Toth and Boniol email communication, 2008) on the condition of the surficial aquifer in this part of Seminole County have indicated that ground water in the Site 10 vicinity has naturally elevated chloride concentrations. Lake Jesup is documented as a discharge area for the Floridan aquifer, which is highly brackish (chloride concentrations 1,000-15,000 mg/L) in an area that includes the northern part of

Lake Jesup and a larger area to the southeast (Boniol, 2008). Upward seepage of high-chloride water from the upper Floridan aquifer in this area is a well-known local phenomenon and is apparent in the elevated chloride concentrations in the lake. The historical median chloride concentration in Lake Jesup is 170 mg/L, 3 times higher than the statewide median for lakes (56.3 mg/L, in FDEP, 2004). Points where chloride is highest could be those where the intermediate confining unit is less competent and upwelling from the Floridan is greater. The top of the Floridan aquifer is at an elevation of -50 feet (Spechler and Halford, 2001) or approximately 65 feet below land surface at the site, but its potentiometric surface is at an elevation of approximately +20 feet (Kinnaman, 2005). The head difference between the surficial and Floridan aquifers and the permeability and thickness of clay between the surficial aquifer and the Floridan would dictate the rate of seepage.

## Surface Water Quality

Seminole County's surface water results for samples collected at and near Site 10 are summarized in **Table 5**. The two sampling stations on Site 10 are at very small discharges from culverts at the outfall ends of stormwater ponds. Station JES E is downgradient of pond A-2, which would receive excess water from Fields 1 and 14. Station JES H is downgradient of Pond B-2, which would receive drainage from Fields 2, 3 and 4. At the time of sampling, both ponds contained some water but there was not enough water in the ponds to overflow. The similarity between specific conductance and pH values for these two stream samples and the shallow ground water samples suggests that the water from the streams is primarily from ground water seepage. Total phosphorus was high in both of the two onsite surface water samples collected in December 2007, an order of magnitude higher than the median for Lake Jesup. Phosphorus concentrations in the two outfall samples were also considerably higher than the ground water concentrations beneath the hay fields. Total nitrogen and total Kjeldahl nitrogen concentrations in the two samples were slightly lower than the median for Lake Jesup and similar to the previous surface water samples (**Table 5**). Fecal coliform counts from the two onsite samples were elevated, particularly in the sample from JES E and these could be possibly due to the cattle grazing. Ground water samples collected in this assessment were not analyzed for total nitrogen, TKN or fecal coliform, so these results could not be compared.

**Table 5 Seminole County's Surface Water Sample Results from Site 10 Vicinity.**

| Sample Site | Un-ionized Ammonia (mg/L) | Color (CU) | Total Kjeldahl Nitrogen (mg/L) | Total Nitrogen (mg/L) | Total Phosphorus (mg/L) | Chlorophyll-A (mg/L) | Fecal Coliform CFU/100mL | Conductivity (uMhos/cm) | Total Dissolved Solids (g/L) | Water Temperature (ºC) | pH (std units) | Dissolved Oxygen (mg/L) | Turbidity (NTU) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **November 13, 2006** | | | | | | | | | | | | | |
| JES-A | 0.009 | 66 | 4.0 | 4.0 | 0.16 | 0.0930 | 40 | 889 | 0.576 | 20.65 | 8.16 | 0.88 | 12.1 |
| JES-C | 0.015 | 56 | 1.3 | 1.7 | 0.98 | 0.0013 | 4000 | | | 20.00 | 7.78 | | |
| JES-E | 0.009 | 210 | 2.4 | 2.5 | 1.50 | 0.0040 | 13000 | 1323 | 0.860 | 17.74 | 7.35 | 8.16 | 8.3 |
| JES-H | 0.009 | 76 | 1.7 | 1.8 | 0.32 | 0.0044 | 270 | 3653 | 2.375 | 19.02 | 7.34 | 6.34 | 4.5 |
| JES-J | 0.009 | 150 | 1.9 | 1.9 | 0.12 | 0.0230 | 34 | 525 | 0.341 | 18.35 | 6.40 | 0.96 | 13.3 |
| **December 13, 2007** | | | | | | | | | | | | | |
| JES-E | 0.009 | 250 | 2.1 | 2.1 | 1.20 | 0.0110 | 3500 | 1784 | 1.161 | 18.64 | 6.79 | 7.21 | 15.50 |
| JES-H | 0.009 | 84 | 1.4 | 1.4 | 2.60 | 0.0100 | 350 | 2075 | 1.349 | 19.23 | 6.85 | 4.63 | 0.00 |
| | | | | | | | | | | | | | |
| **Historical Median for Lake Jesup**[1] | 0.004 | 80 | 2.4 | 2.4 | 0.148 | 54.4 | 5.5 | 802 | NA | 24.09 | 8.79 | 9.22 | 11 |

Notes:
JES-A=main canal of Orange Boat Club boat ramp just west of SR417
JES-C=small agricultural ditch immediately east of Black Hammock Fish Camp boat ramp
JES-E=outfall tributary from large concrete weir at edge of Site 10 property
JES-H=outfall tributary from fields of Site 10, sample taken within wetland area under canopy
JES-J=at end of environmental studies center boardwalk just north of Soldiers Creek
Locations of all sites are shown in **Appendix C**.
mg/L=milligrams per liter
CU=color units
CFU/100 ml= colonies per 100 milliliters of sample
Umhos/cm=micromhos per centimeter
ºC=degrees Celsius
NTU=nephelometric turbidity units
[1] Data obtained from Impaired Waters Rule run 2007-28.1.

Data provided by Shannon Wetzel, Seminole County.

## *Ground Water Loading of Nutrients*

### Nitrogen

A main purpose of this assessment was to provide ground water quality and flow information that can be used to fill data gaps and help calibrate CDM's ground water transport model for predicting nitrate loadings of ground water to Lake Jesup from Site 10. In this assessment, FDEP provided the ground water gradient information and nitrate concentrations in the shallow ground water beneath hay fields representative of the area that drains to Lake Jesup, which was not available for use in the CDM model.

The CDM model was partly based on monitoring wells installed in the citrus groves in the southeastern part of Site 10 and there was initial concern that many of these wells were actually in an area that does not drain to Lake Jesup. Because of that, the ground water gradient and nitrate loading developed from them may not have been representative of the part of the site inside the Lake Jesup drainage basin. This assessment was conducted to evaluate the ground water flow gradient and ground water quality imputs from the hay fields in the Lake Jesup Basin, adjacent to the lake.

The ground water gradients calculated for the 12 FDEP monitoring wells in the hay field area (representative of December 2007) ranged between 0.0048 in Field 16 to 0.0019 in Field 1, with an average of 0.0032. In comparison, CDM calculated linear gradients between individual monitoring wells and the lake calculated that were between 0.0015 and 0.0046, with an average of 0.0030 (Table 10 in **Appendix A**). These "long range measured gradients" are very consistent with the hay field-specific results that were calculated from the December 2007 FDEP data.

The December 2007 nitrate concentrations measured in the 12 shallow ground water locations in the hay fields were actually considerably lower than the concentration used for the CDM model, which was based on nitrate levels from wells mainly in the citrus grove area. The median nitrate concentration for the FDEP hay field wells was 0.033 mg/L in comparison to the 1.54 mg/L used for the model. The citrus groves are fertilized and the higher nitrate concentrations in the grove monitoring wells are most likely due to the fertilizer.

Based on these findings, any modeling scenario that would use the nitrate concentrations representative of the December 2007 data and a similar gradient or flow rate would produce very low loadings of nitrate to the lake via ground water. The calculation by CDM that was based on the higher nitrate concentration produced an estimated loading of 0.50 lbs/day (182 lbs/year) (estimated value in Table 10, **Appendix A**), is orders of magnitude higher than one based on a nitrate concentration of 0.033 mg/L. Under the conditions observed in the December 2007 sampling, nitrate loading via ground water would be insignificant. FDEP used the median nitrate+nitrite concentration from the December 2007 sampling and CDM's rough estimate of ground water flow of 5173.7 cubic feet per day ($ft^3$/day) to roughly estimate the potential nitrate loading based on hay field representative values. This calculation is shown in **Table 5**. The potential loading of nitrate is only 3.85 lb/year.

**Table 5 Calculation of Potential Nutrient Loads to Lake Jesup via Ground Water Discharge**

| Nutrient | Median Concentration (mg/L) | Flow ($ft^3$/day) [1] | Potential Load to Lake Jesup (lb/year) |
|---|---|---|---|
| Nitrate+nitrite | 0.033 | 5173.07 | **3.85** |
| Ammonia | 1.1 | 5173.07 | **129.66** |
| Phosphorus | 0.76 | 5173.07 | **89.43** |

Notes:

Basic calculation is Concentration X Flow = Load

Conversion factors for units-
1 mg = $2.205 \times 10^{-6}$ lb
1 L = 0.035 $ft^3$
1 year = 365 days

**1**-Flow was obtained from CDM report and derived from an aquifer thickness of 25 feet, a hydraulic conductivity of 3.5 feet per day, a gradient of 0.0030, and a flow path width of 12,000 feet (representing the western boundary of the site).

Nitrate is the form of nitrogen that is most stable and moves most readily in ground water. However, this assessment found that, in comparison to nitrate, ammonia is in significantly higher concentrations in the ground water beneath the hay fields and it must be considered as a nutrient source to the lake. U. S. Geological Survey monitoring and modeling of the transport and fate of ammonia in ground water found that ammonia migrated at a somewhat slower rate than ground water but was stable as long as it remained under anaerobic conditions (Böhlke et al, 2006). If the median ammonia concentration from the December 2007 sampling is used (1.1 mg/L) and retardation was not taken into account in the flow rate developed by CDM, the potential nitrogen loading via ammonia could be as high as 129.66 lb/year (**Table 5**).

## Phosphorus

CDM did not calculate phosphorus loadings from Site 10 to the lake via ground water because they did not have recent phosphorus data for ground water at the site. Modeling phosphorus transport in ground water is much more complicated than modeling the transport of nitrate due to the difference between chemical behaviors of the two nitrogen forms. Nitrate is conservative, migrates with ground water in a dissolved state and is less susceptible to attenuation by the aquifer media.  Phosphorus on the other hand exists in both the solid and dissolved state, and is readily adsorbed to iron and aluminum oxides and organics.  Also, phosphorus is not always a pollutant and a portion of the phosphorus in the ground water at this site is very likely from the aquifer matrix. Regardless of source, total phosphorus concentrations in the shallow ground water beneath the hay fields were much higher than the historical median concentration for Lake Jesup (0.148 mg/L) and almost five times the restoration target concentration selected for the Lake Jesup TMDL (0.073 mg/L, in Gao, 2005).  The difference between the phosphorus concentrations in the ground water at the site and the lake make it important to understand its potential for impacting the lake.

The median total phosphorus concentration for the 12 hay field wells was 0.76 mg/L and the median concentration for the three dissolved phosphorus replicate samples was 0.15 mg/L.  The dissolved phase samples are technically more representative of the ground water because phosphorus can also be detected in the suspended sediment and colloidal material in the samples.  However, colloidal phosphorus can also be transported with ground water.  The retardation and adsorption of phosphorus migrating in the aquifer is a function of its capacity to be adsorbed to iron and aluminum oxides in the matrix or to organic material. When phosphorus is present at high concentrations in the ground water, it is more likely to be mobile (Walter, et al., 1999).

Discounting the potential for attenuation along its pathway, assuming a median total phosphorus concentration of 0.76 mg/L and using the average volumetric flow from the CDM report, a highly conservative (assuming no retardation by the aquifer material) potential loading of phosphorus via ground water would be 89.43 lbs/year (**Table 5**).

## *Conclusions*

The December 2007 ground water assessment provided information related to the potential ground water contribution to nutrient enrichment of Lake Jesup under conditions similar to this measured on that date.  The following conclusions are offered.

- The hydrogeologic data used by CDM for the simplified ground water flow and transport model are valid and loads calculated using this methodology are conservative.
- This site was evaluated under near-optimum conditions for nutrient attenuation and maintenance of discharged water.  The December 2007 assessment was preceded by several months of below-average rainfall, and use of the site for reclaimed water application was lower than normal.  Under different conditions, ground water discharge and nutrient loading could be different than what is represented by the data from this assessment.

- Nitrate does not appear to be an issue at this site. Nitrate+nitrite concentrations beneath the hay fields that were monitored were all very low, including Field 1 which had received reclaimed water a few days prior to the assessment.
- Chloride concentrations in the shallow ground water samples from beneath the hay fields were high, but according to SJRWMD and other sources of information chloride is naturally elevated in this area and high concentrations of chloride cannot be linked to reclaimed water application at the site.
- Ammonia is the form of nitrogen that was found at highest concentrations in the ground water beneath the site. In general, these concentrations are not high, but they are significantly higher than regional background concentrations. It is expected that ammonia would be attenuated to some extent as it migrates from the site and that it would most likely migrate at a slower rate than nitrate. More assessment work would be needed to provide an accurate characterization of ammonia loading, but a conservative estimate {considering no retardation or attenuation) would be 126.66 lb/year.
- Phosphorus is the nutrient of greatest concern for Lake Jesup restoration and was elevated in the shallow ground water samples from beneath the hay fields (0.76 mg/L median) and several times higher in the on-site stream samples collected by Seminole County (up to 2.60 mg/L). These concentrations may also include some naturally-occurring phosphorus, based on regional background data. Phosphorus is readily adsorbed to iron and aluminum oxides, but can still migrate from the site via ground water transport under certain conditions. A conservative loading of 89.43 lb/year was estimated for phosphorus loading to ground water.
- Site 10 is a potentially significant source of phosphorus inputs into the lake. However, of the potential pathways that exist for phosphorus transfer from the site to the lake, surface water discharge related to storm events is considered the most significant. Estimates of surface runoff total phosphorus load are in the range of 1,000 to 1,300 lbs/year (Gihring, FDEP, pers. comm., February 2008). Ground water total phosphorus loading was estimated as 89.43 lbs/year in this study. Although this ground water loading is not negligible, restoration efforts at Site 10 should first focus on managing surface water runoff from storm events as a higher priority. Some of the management action to address stormwater loading will also reduce nutrient loading via ground water.

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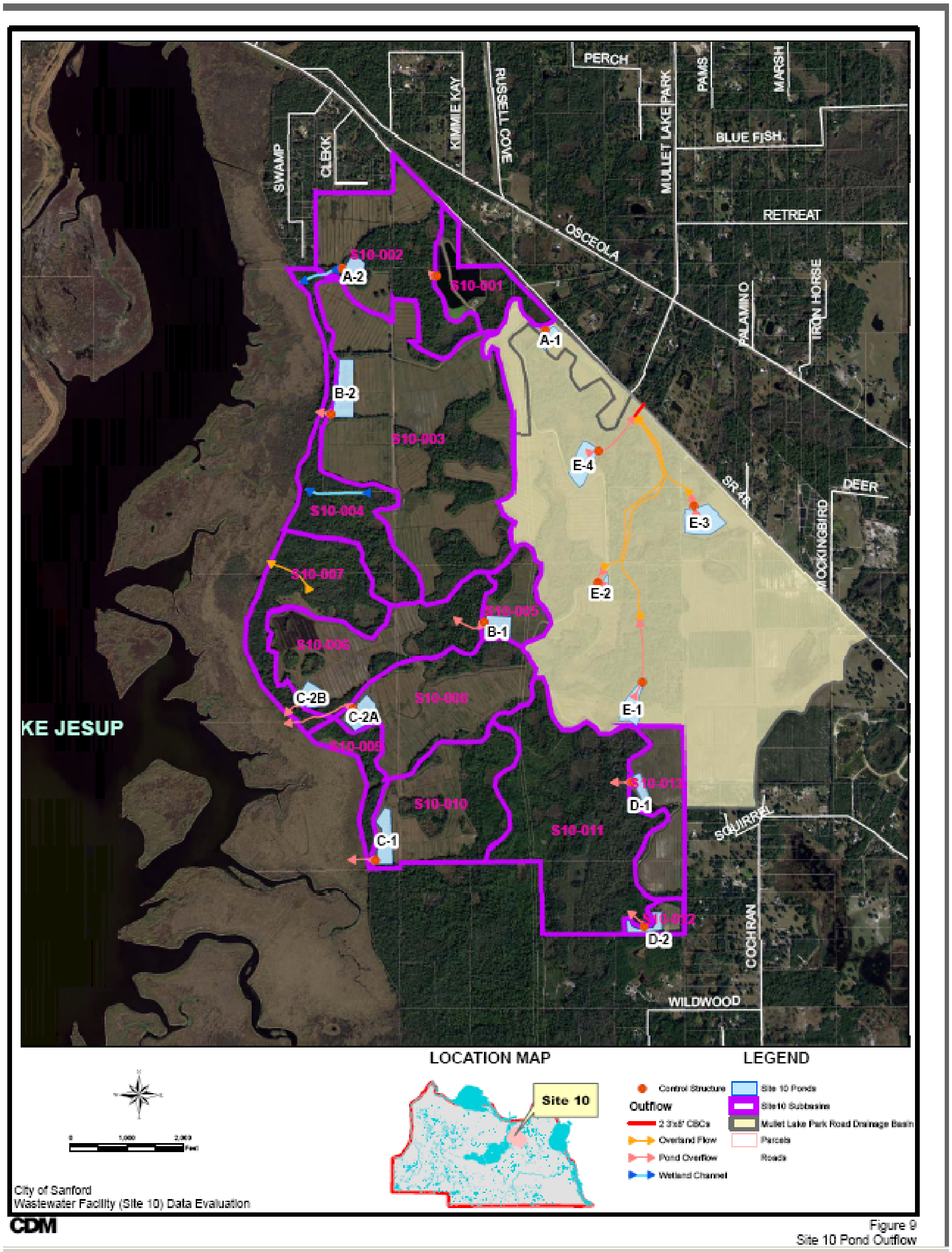
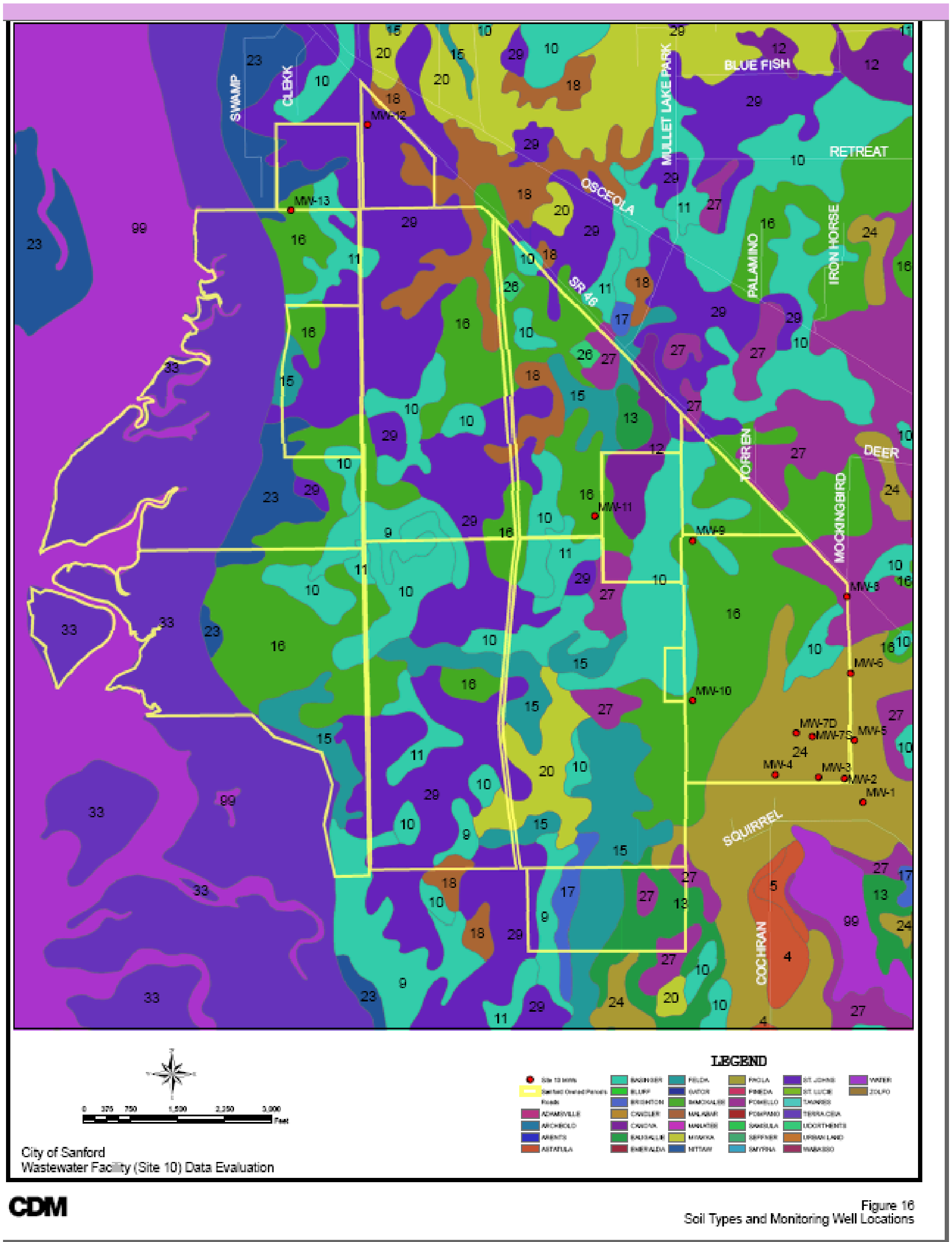
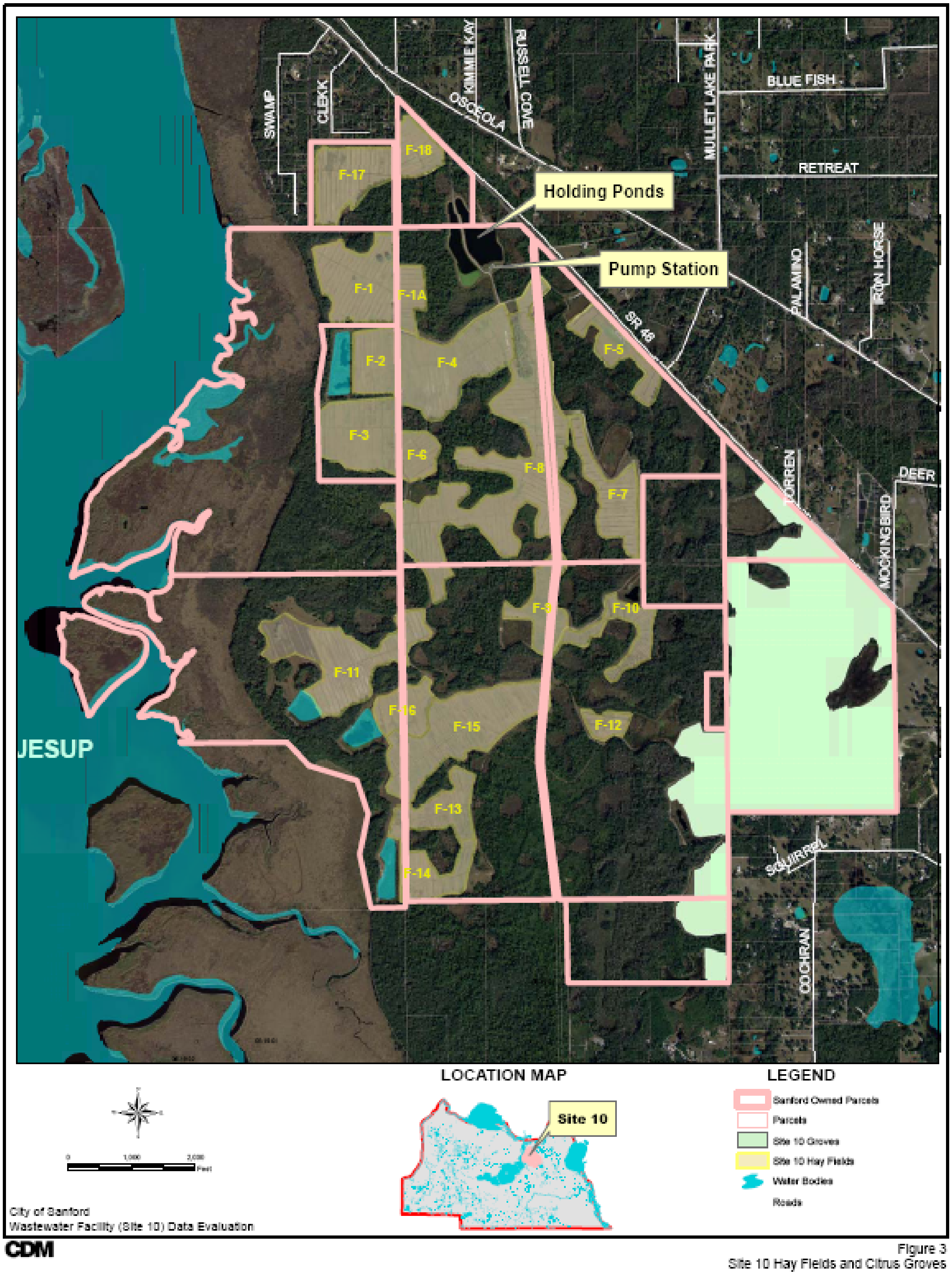
## Appendix A – Excerpted Figures and Tables from CDM Memo




**CDM Memo, Figure 9**




**CDM memo, Figure 16**




**CDM memo, Figure 3**

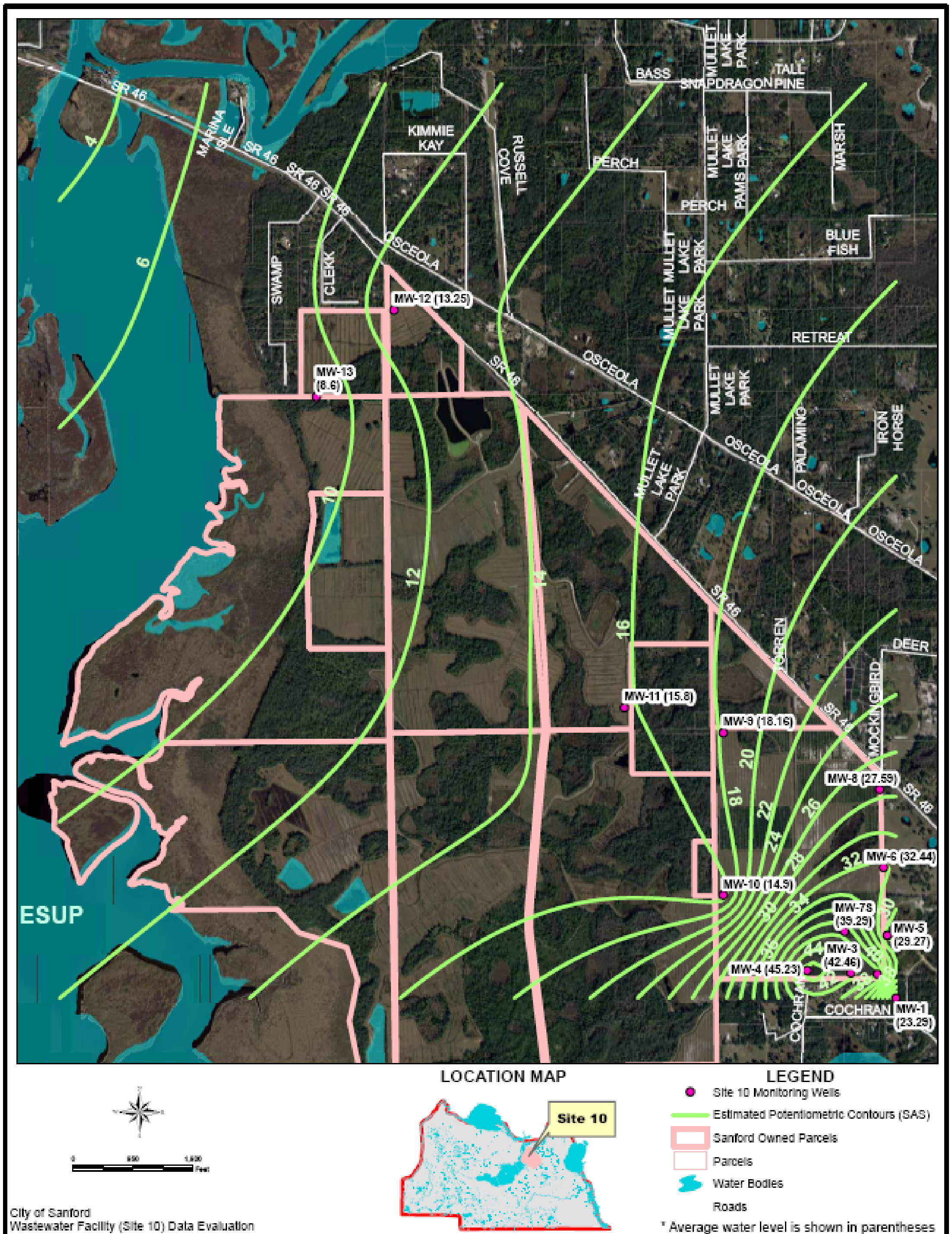



Figure 18
Estimated Potentiometric Contours for the Surficial Aquifer

**CDM memo, Figure 18**

# CDM report, Table 7

Table 7
Sanford Wastewater Facility (Site 10) Data Evaluation
Monitoring Well Data

| Facility MW Name | Permit Builder MW ID | MWAFR ID/# | Total Phosphorus mg/L (Average 1992-97)* | 31-Mar-03 | | 30-Jun-03 | | 30-Sep-03 | | 31-Dec-03 | | 31-Mar-04 | | 30-Jun-04 | | 30-Sep-04 | | 31-Dec-04 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l |
| SITE 10 | | | | | | | | | | | | | | | | | | | |
| MW-1 | MWB-1 Site 10 | 6778 | 0.29 | 24.99 | <0.02 | 24.1 | <0.02 | 25.45 | <0.02 | 24.57 | <0.02 | 23.63 | <0.003 | 22.6 | 0.08 | 22.48 | <0.003 | 24.63 | <0.003 |
| MW-2 | MWC-2 Site 10 | 6777 | 0.05 | 41.83 | 0.02 | 41.02 | <0.02 | 41.42 | <0.02 | 40.16 | <0.02 | 38.87 | <0.003 | 37.97 | 0.01 | 41.3 | <0.003 | 40.66 | 0.006 |
| MW-3 | MWC-3 Site 10 | 6776 | 0.04 | 44.22 | 0.11 | 43.4 | 0.04 | 43.78 | 0.34 | 42.43 | 0.05 | 41.11 | 9.7 | 40.24 | 6.4 | 43.86 | 1.48 | 43.28 | 2.82 |
| MW-4 | MWC-4 Site 10 | 6775 | 0.17 | 42.64 | <0.02 | 43.89 | <0.02 | 44.29 | <0.02 | 43.11 | <0.02 | 42.01 | <0.003 | 41.83 | 0.004 | 45.77 | <0.003 | 44.69 | 0.014 |
| MW-5 | MWC-5 Site 10 | 6774 | 0.22 | 30.07 | 10 | 28.99 | 8.42 | 29.54 | 0.49 | 27.63 | 1.36 | 26.19 | 0.21 | 25.59 | 0.22 | 29.87 | 1.78 | 29.11 | 0.008 |
| MW-6 | MWC-6 Site 10 | 6773 | 0.04 | 33.72 | 6.56 | 33.66 | 4.29 | 33.48 | 2.24 | 32.76 | <0.02 | 32.14 | <0.003 | 31.22 | <0.003 | 33.87 | <0.003 | 33.26 | 5.34 |
| MW-7s | MWC-7 Site 10 | 6772 | 0.04 | 39.5 | 8.94 | 39.08 | 14.8 | 39.76 | 8.2 | 38.35 | 7.9 | 37.27 | 9.6 | 38.17 | 9.8 | 46.67 | 11.2 | 39.53 | 13.2 |
| MW-8 | MWC-8 Site 10 | 6771 | 0.04 | 27.53 | 0.02 | 27.79 | 0.27 | 27.63 | 0.04 | 26.94 | <0.02 | 26.33 | <0.003 | 25.65 | <0.003 | 28.25 | <0.003 | 29.08 | <0.003 |
| MW-9 | MWC-9 Site 10 | 6770 | 0.45 | 18.65 | <0.02 | 18.16 | 0.26 | 17.03 | 0.05 | 16.6 | <0.02 | 15.89 | <0.003 | 14.87 | <0.003 | 14.52 | <0.003 | 17.22 | <0.003 |
| MW-10 | MWC-10 Site 10 | 6769 | 0.19 | 20.99 | <0.02 | 20.23 | 0.04 | 0.05 | 20.51 | 19.6 | <0.02 | 20.22 | 0.03 | 18.31 | <0.003 | 21.04 | <0.003 | 20.15 | <0.003 |
| MW-11 | MWC-11 Site 10 | 6768 | 2.97 | 16.53 | 0.04 | 15.8 | <0.02 | 16.02 | 0.09 | 15.02 | <0.02 | 14.87 | <0.003 | 13.79 | <0.003 | 16.53 | <0.003 | 15.41 | <0.003 |
| MW-12 | MWC-12 Site 10 | 6767 | 0.24 | 13.87 | 0.02 | 12.6 | 0.05 | 13.25 | 0.05 | 12.86 | <0.02 | 12.12 | <0.003 | 11.44 | <0.003 | 13.92 | <0.003 | 12.53 | 0.006 |
| MW-13 | MWC-13 Site 10 | 6766 | 0.16 | 8.89 | <0.02 | 8.08 | 0.05 | 8.89 | 0.07 | 7.85 | <0.02 | 7.87 | <0.003 | 6.93 | <0.003 | 9.11 | <0.003 | 7.34 | <0.003 |

| Facility MW Name | Permit Builder MW ID | MWAFR ID/# | 31-Mar-05 | | 30-Jun-05 | | 30-Sep-05 | | 31-Dec-05 | | 31-Mar-06 | | 30-Jun-06 | | 30-Sep-06 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l | Water Level Relative to ft-NGVD | Nitrogen, Nitrate Total (as N) mg/l |
| SITE 10 | | | | | | | | | | | | | | | | |
| MW-1 | MWB-1 Site 10 | 6778 | 24.24 | <0.005 | 23.82 | <0.019 | 24.83 | <0.019 | 25.62 | 0.019 | 24.43 | <0.003 | 23.28 | 0.008 | 21.68 | 0.021 |
| MW-2 | MWC-2 Site 10 | 6777 | 39.36 | 0.023 | 39.17 | 0.019 | 39.88 | <0.019 | 41.06 | <0.019 | 38.65 | 0.01 | 37.62 | <0.0075 | 36.45 | 0.005 |
| MW-3 | MWC-3 Site 10 | 6776 | 41.67 | 1.94 | 41.2 | <0.019 | 42.92 | 0.019 | 43.33 | 9.8 | 41.17 | 11 | 40.41 | 7.1 | 39.1 | 6.3 |
| MW-4 | MWC-4 Site 10 | 6775 | 43.13 | <0.003 | 42.94 | <0.019 | 43.94 | 0.021 | 44.53 | <0.019 | 42.78 | 0.005 | 41.62 | 0.051 | 40.6 | <0.003 |
| MW-5 | MWC-5 Site 10 | 6774 | 26.63 | 0.041 | 26.67 | 0.689 | 27.58 | 3.98 | 29.21 | 2.5 | 26.37 | 0.66 | 25.67 | 0.3 | 24.84 | 0.14 |
| MW-6 | MWC-6 Site 10 | 6773 | 32.49 | 4.05 | 31.96 | 4.98 | 32.26 | 2.46 | 33.36 | 0.86 | 32.07 | 2.9 | 30.84 | 2.8 | 30.46 | 5.1 |
| MW-7s | MWC-7 Site 10 | 6772 | 37.7 | 11.5 | 37.92 | 9.32 | 38.42 | 9.47 | 39.33 | 7.5 | 37.19 | 9.7 | 37.09 | 9.3 | 37.15 | 7.9 |
| MW-8 | MWC-8 Site 10 | 6771 | 26.29 | 0.09 | 26.5 | <0.019 | 27.36 | <0.019 | 27.76 | <0.019 | 26.67 | 0.015 | 25.42 | <0.0075 | 24.58 | <0.003 |
| MW-9 | MWC-9 Site 10 | 6770 | 16.82 | <0.003 | 16.6 | <0.019 | 17.65 | 0.033 | 17.94 | <0.019 | 17.12 | <0.0030 | 14.97 | 0.01 | 13.35 | <0.003 |
| MW-10 | MWC-10 Site 10 | 6769 | 19.47 | <0.003 | 19.01 | <0.019 | 20.26 | 0.02 | 20.4 | <0.019 | 20.2 | 0.047 | 18.02 | 0.051 | 17.29 | 0.064 |
| MW-11 | MWC-11 Site 10 | 6768 | 15.51 | 0.021 | 16.03 | <0.019 | 16.76 | <0.019 | 15.91 | <0.019 | 15.38 | 0.0042 | 13.34 | 0.023 | 12.18 | <0.003 |
| MW-12 | MWC-12 Site 10 | 6767 | 11.64 | <0.003 | 13.74 | <0.019 | 13.14 | <0.019 | 13.28 | <0.019 | 12.59 | <0.0030 | 10.97 | 0.008 | 10.82 | <0.003 |
| MW-13 | MWC-13 Site 10 | 6766 | 7.9 | 0.033 | 9.21 | <0.019 | 8.64 | <0.019 | 8.39 | <0.019 | 7.97 | <0.0030 | 7.11 | 0.086 | 7.22 | <0.003 |

MWB = Background; MWI = Intermediate; MWC = Compliance

* Phosphorus sampling was removed from Permit requirements post 1997.

Table 9
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Groundwater Flow Rate Parameters

| Parameter | Description | Units | Average Value |
|---|---|---|---|
| $K_h$ | Horizontal hydraulic conductivity | ft/day | 3.5 |
| x | Horizontal distance between MW-13 and Lake Jesup | feet | 1,471 |
| $h_1$ | Head in MW-13 | feet | 33.6 |
| $h_2$ | Head in Lake Jesup | feet | 27.51 |
| q | Flow per unit width to Lake | $ft^2$/day | 0.44 |
| w | Cross-section width | feet | 12,000 |
| Q | Volumetric GW flow rate | $ft^3$/day | 5173 |

Table 10
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Mass Loading of Nitrate to Lake Jesup

| Well | Water Level (ft) | x (ft) | h1 (ft) | h2 (ft) | q ($ft^2$/d) | w (ft) | Q ($ft^3$/day) | C (mg/l) | M (lb/day) |
|---|---|---|---|---|---|---|---|---|---|
| MW-1 | 23.3 | 10514.4 | 48.3 | 27.5 | 0.26 | 12000 | 3145.9 | 0.02 | 0.003 |
| MW-2 | 41.2 | 10269.2 | 66.2 | 27.5 | 0.62 | 12000 | 7419.7 | 0.01 | 0.006 |
| MW-3 | 42.5 | 9840.0 | 67.5 | 27.5 | 0.67 | 12000 | 8097.8 | 3.81 | 1.925 |
| MW-4 | 45.2 | 9196.3 | 70.2 | 27.5 | 0.79 | 12000 | 9534.8 | 0.01 | 0.009 |
| MW-5 | 29.3 | 10483.7 | 54.3 | 27.5 | 0.37 | 12000 | 4382.6 | 2.05 | 0.562 |
| MW-6 | 32.4 | 10667.7 | 57.4 | 27.5 | 0.42 | 12000 | 5005.2 | 2.77 | 0.867 |
| MW-7s | 39.3 | 9778.7 | 64.3 | 27.5 | 0.60 | 12000 | 7250.9 | 9.89 | 4.476 |
| MW-8 | 27.6 | 10851.6 | 52.6 | 27.5 | 0.32 | 12000 | 3887.1 | 0.04 | 0.009 |
| MW-9 | 18.2 | 9012.3 | 43.2 | 27.5 | 0.21 | 12000 | 2577.1 | 0.03 | 0.005 |
| MW-10 | 14.9 | 8062.2 | 39.9 | 27.5 | 0.18 | 12000 | 2174.5 | 1.39 | 0.189 |
| MW-11 | 15.8 | 5119.3 | 40.8 | 27.5 | 0.31 | 12000 | 3724.1 | 0.02 | 0.004 |
| MW-12 | 13.3 | 3126.7 | 38.3 | 27.5 | 0.40 | 12000 | 4743.5 | 0.02 | 0.005 |
| MW-13 | 8.6 | 1471.4 | 33.6 | 27.5 | 0.44 | 12000 | 5306.7 | 0.02 | 0.008 |
| | | | | *Average* | *0.43* | *12000* | *5173.07* | *1.54* | *0.50* |

## Appendix B - Lithologic Descriptions from Monitoring Well Borings

**FIELD F-16 @ SITE 10** Well ID # F-16-MW1, F-16-MW2, & F-16-MW3

Field F-16 is comparably dry with cattle in field

**F-16-MW1** N 28°45'04.774" W 81°09'56.375"

Located on E side of Pond C-28

Soil Core Description (Lithology)

| | | | | |
|---|---|---|---|---|
| 0 - 4 ' | Sand w/ organics | very fine | dark gray (1.5' ) | |
| Over - | Sand | si | dark brown - black | highly organic w/ weak cementation |
| 4' - 8 ' | Sand | fine - medium | med. brown grading to gray | moist to saturated, wet @ ~ 6 ' |
| 8' - 12 ' | Sand (slightly clayey) | very fine - fine | gray | clay content increasing with depth<br>few clay streaks near 12 ', saturated |
| 12' - 16 ' | Sand (clayey) | very fine - fine | gray | |
| 16' - 20 ' | Sand (slightly clayey) | very fine - fine | | decrease in clay content |

Well set @ depth of 12 '

**F-16-MW2** N 28°45'01.675" W 81°09'49.002"

Located E-SE of F-16-MW1 in Field F-16
Well installed w/ Geoprobe to 12 ', no Lithology
Water table @ ~ 7 '

**F-16-MW3** N 28°45'07.184" W 81°09'50.708"

Located N of F-16-MW2 in Field F-16
Well installed w/ Geoprobe to 12 ', no Lithology

* All LAT/LONG coordinates captured w/ Trimble Geo XT GPS unit
Temporary wells consist of 5 ' prepack screen w/ solid riser & no sand pack or plug

**FIELD F-3 @ SITE 10** Well ID # F-3-MW1, F-3-MW2, & F-3-MW3

Field F-3 is mowed w/ no cattle visible

*Evidence found on-site of an unknown study including boreholes flagged w/ stakes & 2" wells/piezometers

**F-3-MW1** N 28°45'42.987" W 81°09'59.156"

S side of Field F-3

Located just W of unknown 2" well (ID # TH3-11) w/ piezometer marked @ "10"

Soil Core Description (Lithology)

| | | | | |
|---|---|---|---|---|
| 0 - 4 ' | Topsoil (3") over Sand | fine - medium | pale gray | loose |
| Over - | Sand | si | dark brown | highly organic w/ weak cementation |
| 4' - 8 ' | Sand (slightly clayey) | | clay - gray w/ orange mottles | clay content increases with depth to a clayey sand @ 8 ' - very moist |
| 8' - 12 ' | Sand (clayey) | very fine - fine | gray-green-gray | saturated |
| 12' - 16 ' | Sand | very fine - fine | gray | saturated & runny |
| 16' - 20 ' | Sand | very fine - fine | gray | saturated & runny |

Well set @ depth of 15 '

**F-3-MW2** N 28°45'48.065" W 81°10'04.560"

Located W side of Field F-3, ~ 300' S of unknown piezometer (TH3-1)

Well installed w/ Geoprobe to 18 ', no Lithology

**F-3-MW3** N 28°45'50.345" W 81°09'56.330"

Located NE side of Field F-3

Well installed w/ Geoprobe to 15 ', no Lithology

* All LAT/LONG coordinates captured w/ Trimble Geo XT GPS unit

Temporary wells consist of a 5 ' prepack screen w/ solid riser & no sand pack or plug

W side of Field F-4, just E of access road and Field F-2 pump station
*Strong organic odor present in well hole

Soil Core Description (Lithology)

| | | | | |
|---|---|---|---|---|
| 0 - 4 ' | Sand | si | dark brown | highly organic w/ weak cementation<br>moist - w/ appearance of residuals application |
| 4 - 8 '<br>Over - | Sand grading to Sand (clayey)<br>Clay (sandy) | very fine - fine | pale yellow - gray<br>gray - green (7-8 ') | saturated - clay content increases w/ depth to 8 '<br>roots & organics present |
| 8 - 12 '<br>Over -<br>Over - | Sand (very clayey)<br>Sand<br>Sand (slightly clayey) | <br>very fine - fine | gray-green (9 ')<br>clean pale green - white<br>yellow - tan | <br>saturated @ 10 ' |
| 12 - 16 '<br>Over - | Sand (slightly clayey)<br>Clay | <br>plastic (14.5 - 16 ') | gray-green<br>green-gray | saturated & runny |

well set @ depth of 12 '

| | | |
|---|---|---|
| **F-4-MW2** | N 28°46'00.466" | W 81°09'43.774" |

Located E-NE of F-4-MW1 in Field F-4
Well installed w/ Geoprobe to 12 ', no Lithology

| | | |
|---|---|---|
| **F-4-MW3** | N 28°45'55.592" | W 81°09'43.011" |

Located E-SE of F-4-MW1 on S edge of Field F-4
Located ~ 200 ' W of unknown piezometer (TH4-9)
Well installed w/ Geoprobe to 12 ', no Lithology

| | | |
|---|---|---|
| **F-2-MW1** | N 28°45'57.281" | W 81°09'55.232" |

Located W side of Field F-2 pumping station, just W of access road & F-4-MW1
Located near unknown piezometer (TH2-5)
Well installed w/ Geoprobe to 12 ', no Lithology

* All LAT/LONG coordinates captured w/ Trimble Geo XT GPS unit
Temporary wells consist of a 5 ' prepack screen w/ solid riser & no sand pack or plug

**FIELD F-1 @ SITE 10** Well ID # F-1-MW1, F-1-MW2, & F-1-MW3

Field F-1 is mowed w/ no cattle visible
Field F-1 is comparably wet - signs of recent wastewater application & past residuals application
*Evidence found on-site of an unknown study including boreholes flagged w/ stakes & 2" wells/piezometers

**F-1-MW1** N 28°46'06.376" W 81°09'58.125"

S side of Field F-1

<u>Soil Core Description (Lithology)</u>

| | | | | |
|---|---|---|---|---|
| 0 - 4 ' | Sand (silty) | medium | dark brown | moist w/ organics present |
| 4 - 8 ' | Sand (silty) 4 - 4.5 ' | medium | dark brown | moist w/ organics present |
| Over - | Silt 4.5 - 5 ' | peat-like | dark brown - black | highly organic |
| Over - | Sand | very fine - fine | brown | moist |
| 8 - 12 ' | Sand | very fine - fine | medium brown | saturated |
| Over - | Sand | very fine - fine | brown | saturated & runny |
| 12 - 16 ' | Sand | very fine - fine | brown | saturated & runny |
| 16 - 20 ' | Sand 16 - 18 ' | very fine - fine | brown | saturated & runny |
| Over - | Sand (clayey) | medium | brown | saturated & runny |
| | | | | clay content increases w/ depth |

Well set @ depth of 12 '

**F-1-MW2** N 28°46'11.024" W 81°10'00.375"

Located SW side of large Live Oak tree in center of Field F-1, N-NW of F-1-MW1
Well installed w/ Geoprobe to 12 ', no Lithology

**F-1-MW3** N 28°46'12.713" W 81°09'54.396"

Located N-NE of F-1-MW1 near 2 Live Oak trees in NE corner of Field F-1
Well installed w/ Geoprobe to 12 ', no Lithology

* All LAT/LONG coordinates captured w/ Trimble Geo XT GPS unit
Temporary wells consist of a 5 ' prepack screen w/ solid riser & no sand pack or plug

## Appendix C – Surface Water Sampling Locations