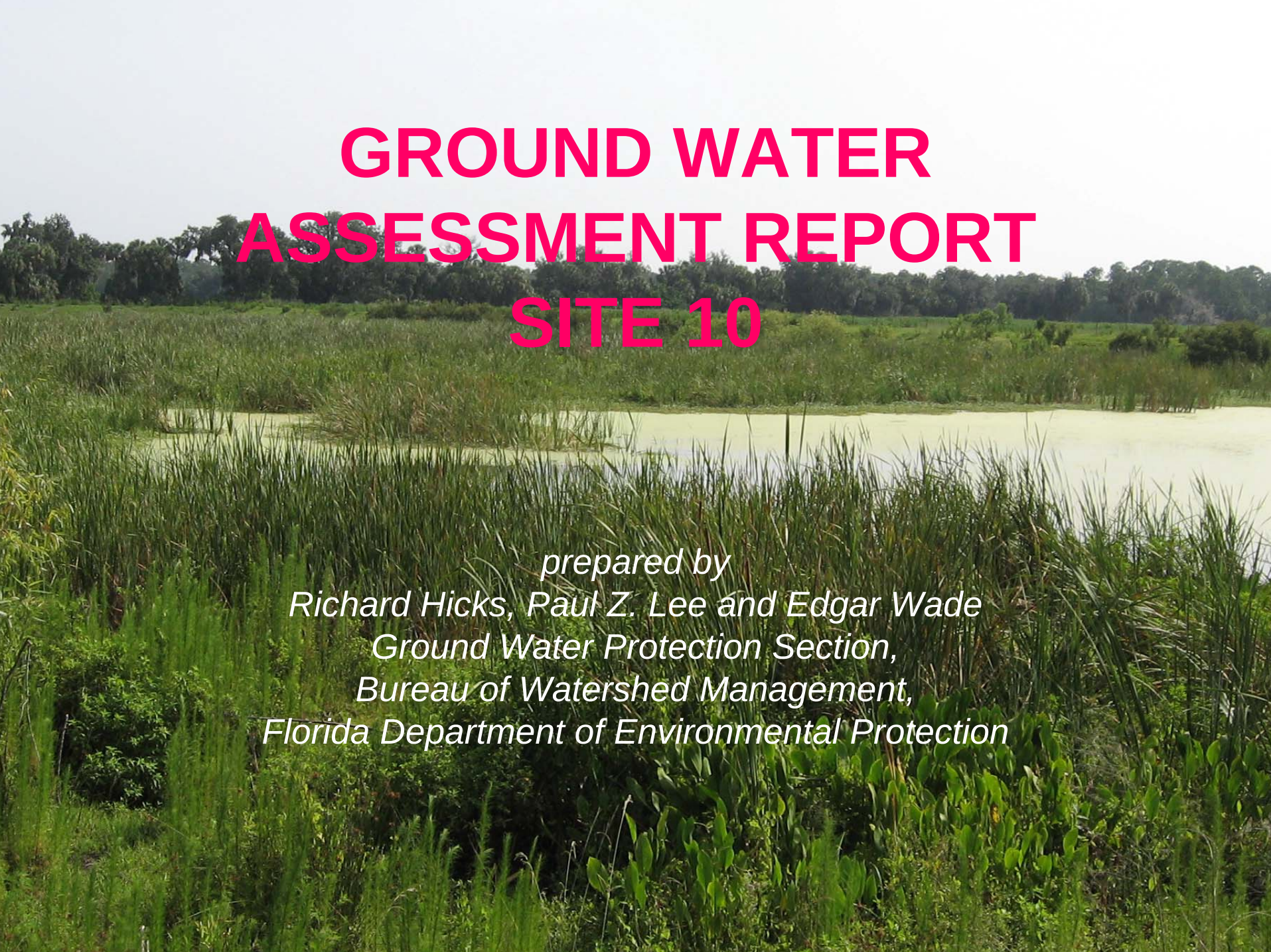




GROUND WATER ASSESSMENT REPORT SITE 10

*prepared by
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Ground Water Protection Section,
Bureau of Watershed Management,
Florida Department of Environmental Protection*

What Preceded this Assessment

- Feb 07 CDM report to the City of Sanford, providing simplified model of ground water flow to the lake and an estimate of nitrate loading. Great report, but there were some data gaps related to ground water:
 - CDM used ground water quality and flow data from historical monitoring, mainly from citrus groves and mainly from outside Lk Jesup basin...not much hay-field specific data
 - CDM was not able to address ground water loading of phosphorus...insufficient data

Assessment Objectives

- Plug data gaps in CDM's nitrogen loading model
- Evaluate ground water conditions using current data
- Evaluate magnitude of potential phosphorus loading via ground water

Limitations/Disclaimer

- Budget constraints
- Snapshot of conditions, focusing on hay fields near the lake
- Calculations give you “ball park” numbers
- Only addresses ground water loading



CITY OF SANFORD

WATER RECLAMATION FACILITY



A satellite map of the Sanford, Florida area. The map shows a mix of urban, agricultural, and natural landscapes. A large body of water, Lake Jesup, is visible in the lower-left quadrant. A network of roads and highways crisscrosses the area. A specific location, Site 10, is marked with a red dot and a red callout box. The city of Sanford is labeled in the upper-left quadrant.

Sanford

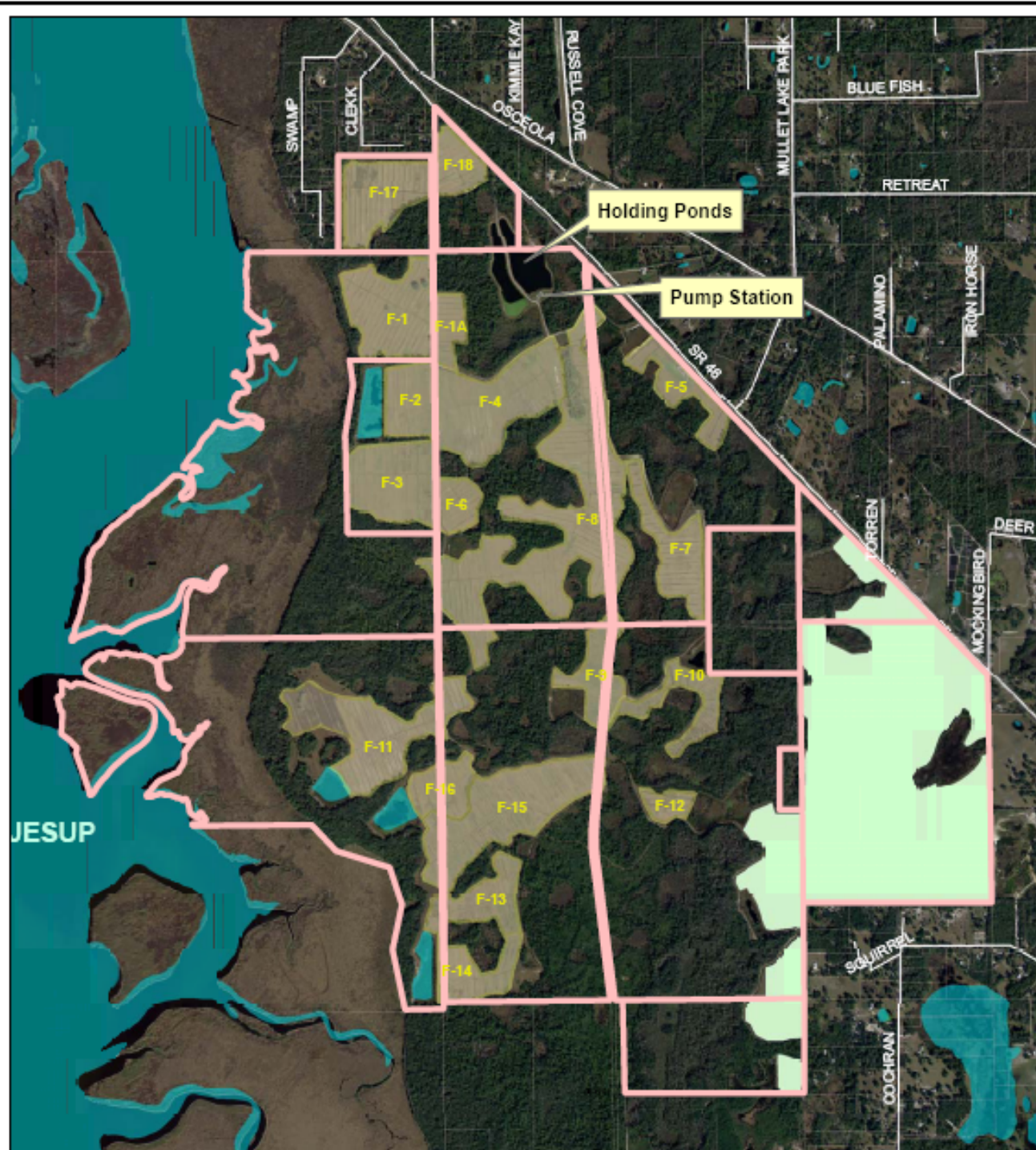
Site 10

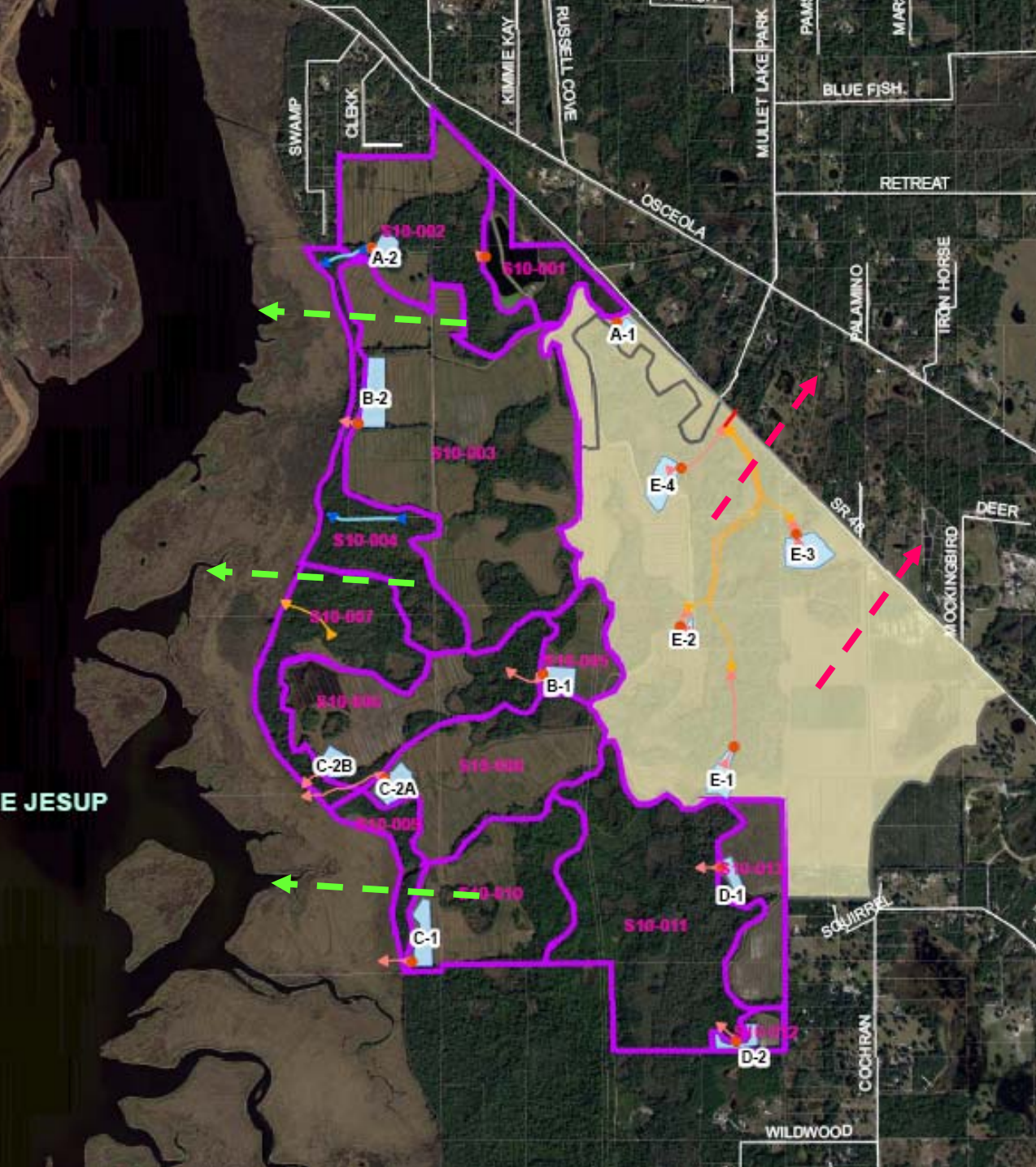
Lk Jesup



Site 10

- Facility consists of 1,868 acres on 2204-acre site
- Receives reclaimed wastewater and residuals
- 620 acres of hay fields
- 270 acres in citrus
- Remainder wooded wetland (about half the site)





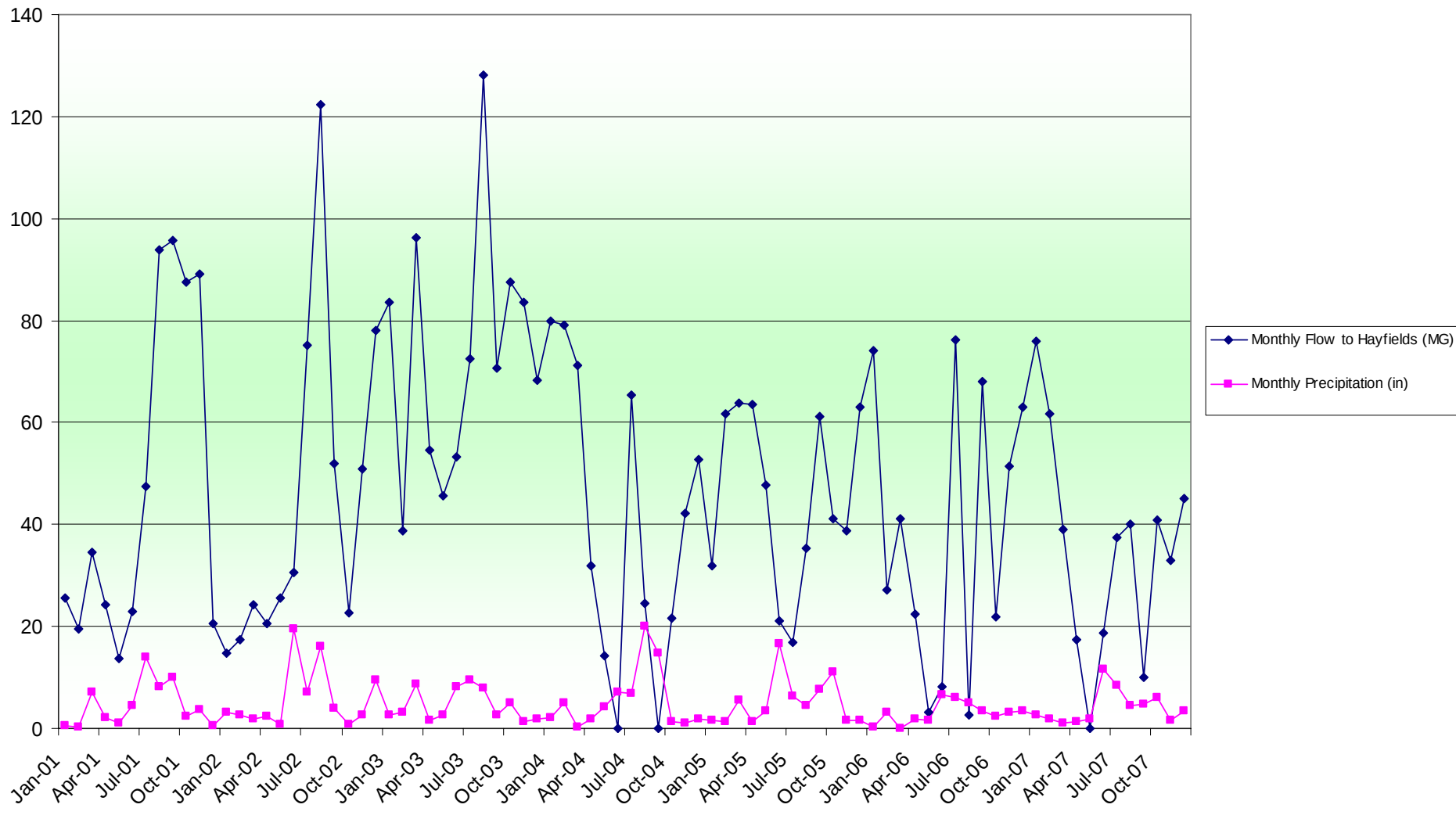
Site 10 Drainage

- Onsite drainage divided between 2 basins
- Hay field drainage to s.w. ponds



Reclaimed Water Application

- Permitted for 1.94 MGD to hayfields
- Permitted for 0.9 MGD to citrus groves
- Wastewater delivered to hayfields via flood irrigation
- Microjet irrigation at groves



Monthly average reclaimed water flow to hay fields and precipitation (source: Richard Casella, Sanford Utilities)

Reclaimed Water Characterization

City of Sanford North (FL0020141) discharge data from November 2007 D001 DMR							
Date		TN mg/L		TP mg/L		Ammonia mg/l	
Nov. 1, 2007		11.3		2.3		0.07	
Nov. 2, 2007		11.5		2.4		0.06	
Nov. 3, 2007		10.4		2.4		0.16	

Source: David Smicherko, DEP Central District

Residuals Application

- Average 7-10 loads are spread on site, mainly hay fields
- 13-15 tons per load

Table 2
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Residual TN and TP Concentrations (% Dry Weight)

Year/Parameter	TN (%)	TP (%)
2002	7.22	3.22
2003	7.32	3.15
2004	6.43	3.02
2005	8.05	3.94

Table 3
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Field Nitrogen Loading Rates due to Biosolids and Reclaimed Water Application

NITROGEN LOADING
90,000 lb/year

Field No. ¹	Field Acreage ²	Field Acreage In Watershed	2003 Measured N Loading (lb/ac)	2004 Measured N Loading (lb/ac)	2005 Measured N Loading (lb/ac)	Average TN Loading Rate (lb/ac/yr)	TN Loading in Watershed (lb/yr)
F1	32.2	32.1	162.3	91.8	92.5	115.5	3,707.6
F2	15.3	15.3	371.0	91.8	92.5	185.1	2,832.0
F3	29.3	29.3	365.5	152.7	282.3	266.8	7,817.4
F4	42.5	41.6	398.7	91.8	373.7	288.1	11,985.0
F6	9.5	9.5	162.3	91.8	365.2	206.4	1,960.8
F8	97.1	58.8	343.9	91.8	168.6	201.4	11,842.3
F9	16.8	16.3	363.9	361.3	247.8	324.3	5,286.1
F11	42.3	42.3	162.3	374.1	92.5	209.6	8,866.1
F13	17.0	17.0	314.9	317.9	307.45	313.4	5,327.8
F14	15.2	15.2	390.7	335.7	388.4	371.6	5,648.3
F15	47.8	47.8	389.3	347.1	370.3	368.9	17,633.4
F16	13.7	13.7	289.5	396.1	92.5	259.4	3,553.8
F17	24.7	24.7	162.3	91.8	92.5	115.5	2,852.9
F18	11.6	4.7	162.3	91.8	92.5	115.5	542.9
	Total:	368.3					89,856.4

1. Field 1A, although shown on Figure 3, was not included in the City memorandums that summarized TN loading rates by field.

2. Field acreages were obtained from a GIS layer originally provided by the City showing the field locations. These were then subsequently edited to match the extents shown on the CPH plans and verified using the 2004 aerial digital orthophoto quads available from the SJRWMD. Acreages were then calculated using GIS capabilities.

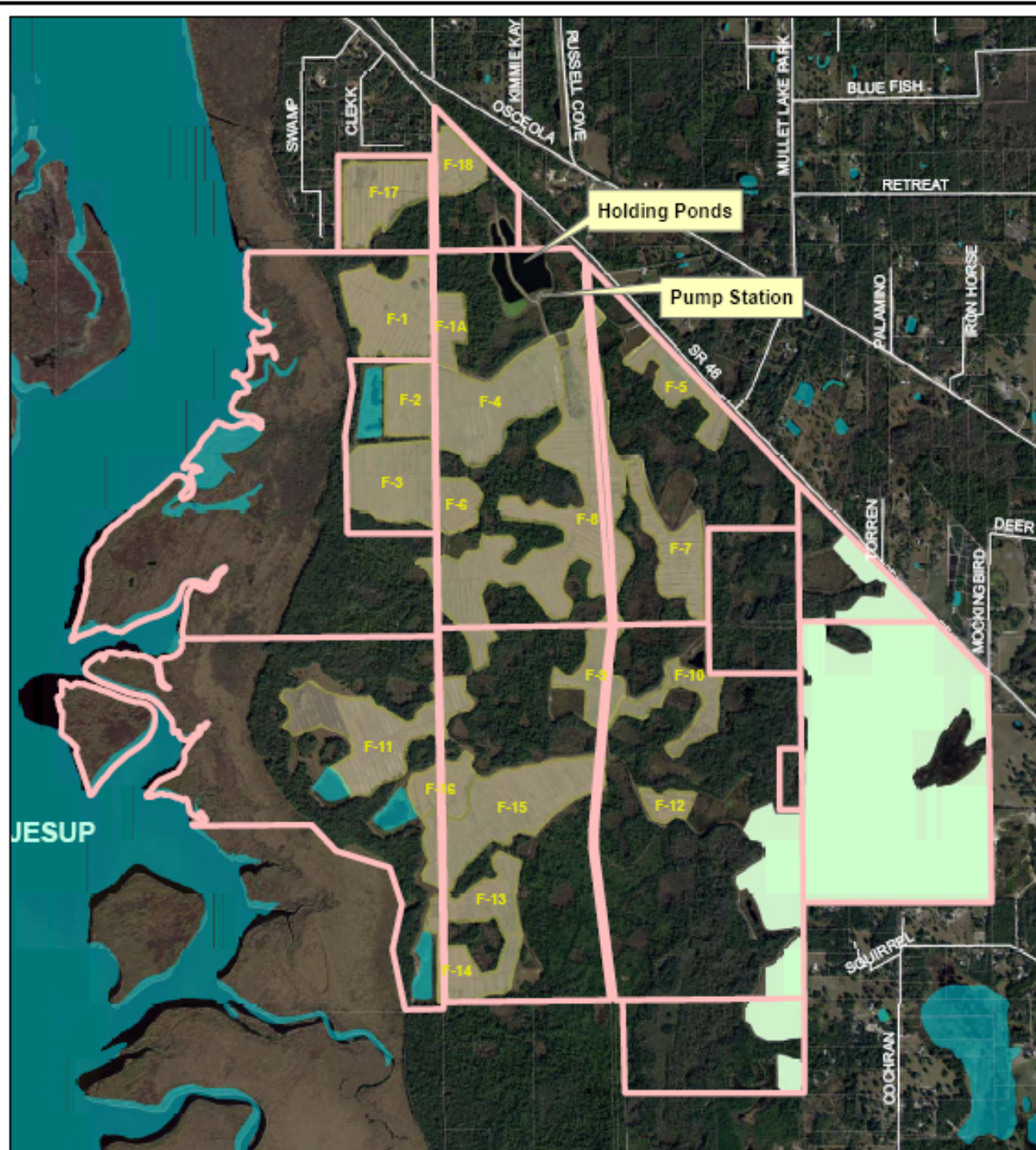


Table 5
City of Sanford
Wastewater Facility (Site 10) Data Evaluation
Field Phosphorus Loading Rates due to Biosolids and Reclaimed Water Application

PHOSPHORUS LOADING 40,000 LB/YEAR

Resulting TP Loading in Lake Jesup Watershed from Reclaimed Water (from Table 1): 10.4 lbs/ac/yr
Average Loading Rate of TP from Residuals applied to hayfields in watershed (Table 4): 164.8 lbs/ac/yr

Field No.	Total Acreage ¹	Acreage in Watershed	Estimated 2003 Loading Rate (lb/ac)	Estimated 2004 Loading Rate (lb/ac)	Estimated 2005 Loading Rate (lb/ac)	Average TP Loading Rate 2003-2005 (lb/ac/yr)	TP Loading in Watershed ² (lb/yr)
F1			R	R	R		
	32.2	32.1	10.4	10.4	10.4	10.4	333.8
F2			B&R	R	R		
	15.3	15.3	175.2	10.4	10.4	65.3	999.6
F3			B&R	B&R	B&R		
	29.3	29.3	175.2	175.2	175.2	175.2	5,133.4
F4			B&R	R	B		
	42.5	41.6	175.2	10.4	164.8	116.8	4,858.9
F6			R	R	B&R		
	9.5	9.5	10.4	10.4	175.2	65.3	620.7
F8			B&R	R	B&R		
	97.1	58.8	175.2	10.4	175.2	120.3	7,071.7
F9			B&R	B	B&R		
	16.8	16.3	175.2	164.8	175.2	171.7	2,799.3
F11			R	B&R	R		
	42.3	42.3	10.4	175.2	10.4	65.3	2,763.6
F13			B&R	B	B		
	17	17	175.2	164.8	164.8	168.3	2,860.5
F14			B	B&R	B		
	15.2	15.2	164.8	175.2	164.8	168.3	2,557.7
F15			B&R	B	B		
	47.8	47.8	175.2	164.8	164.8	168.3	8,043.1
F16			B&R	B	R		
	13.7	13.7	175.2	164.8	10.4	116.8	1,600.2
F17			R	R	R		
	24.7	24.7	10.4	10.4	10.4	10.4	256.9
F18			R	R	R		
	11.6	4.7	10.4	10.4	10.4	10.4	48.9
Total Acres in Watershed:		368.3	Total Loading in Watershed:				39,948.1

R - Reclaimed Only

B - Biosolids Only

B&R - Biosolids and Reclaimed

Ground Water Regime

- Surficial aquifer/intermediate confining zone/Floridan aquifer
- Surficial aquifer is aquifer of concern
- Sand, clayey sand, clay to a depth of approximately 30-40 feet
- Confining unit to approximately 60 feet
- Top of Floridan at approximately 60 feet; Florida discharging and brackish







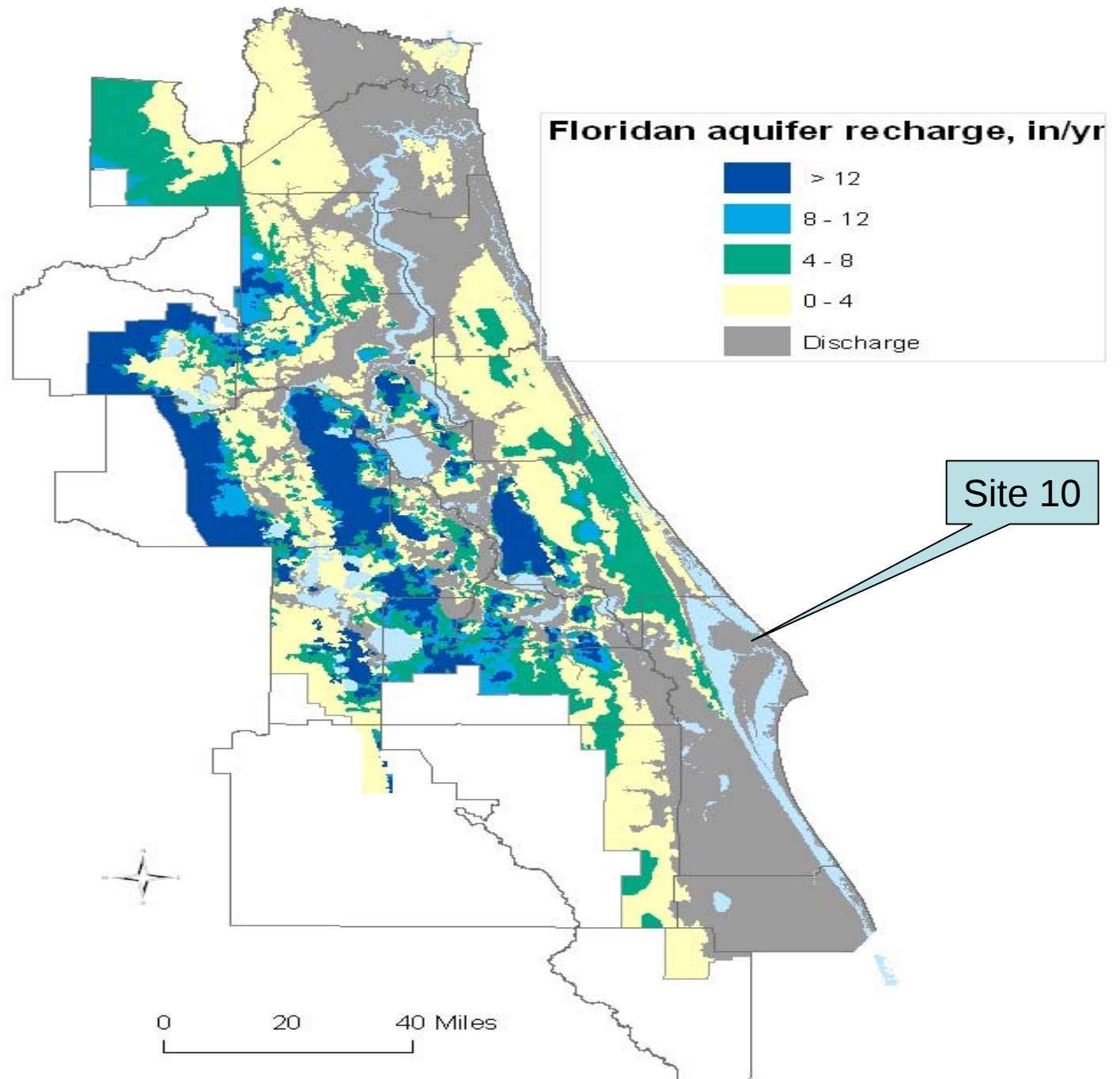




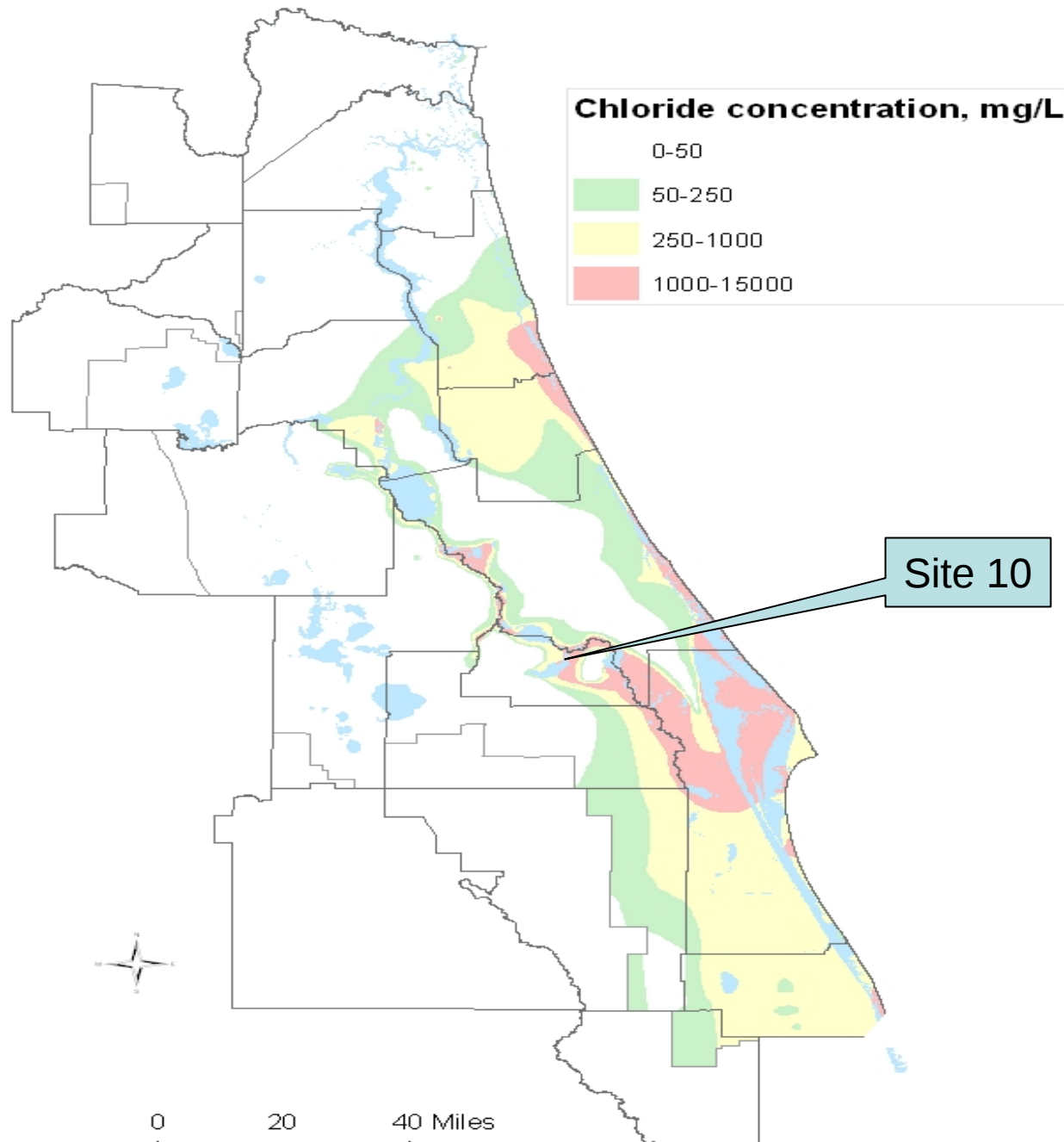
Other Geological Considerations

- Confining unit is Miocene-age Hawthorn group...typically phosphate rich
- Floridan aquifer discharges in this area, springs in the southern part of Lake Jesup
- Local chloride issue

Recharge to the Floridan Aquifer

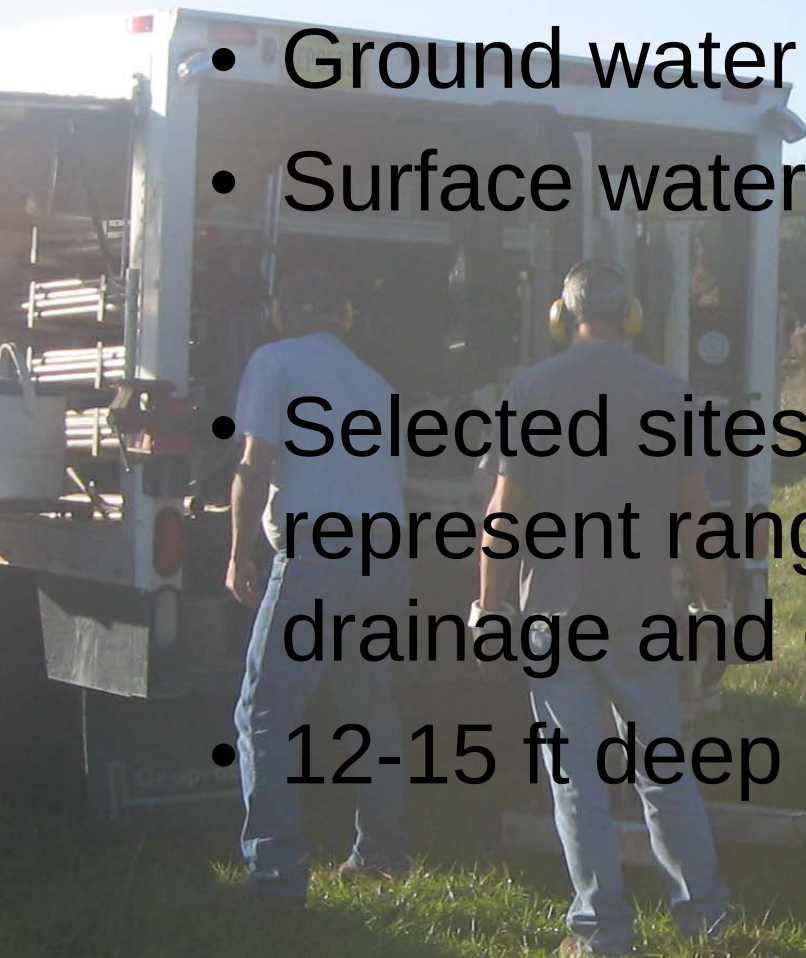


Chloride Concentrations - Upper Floridan Aquifer

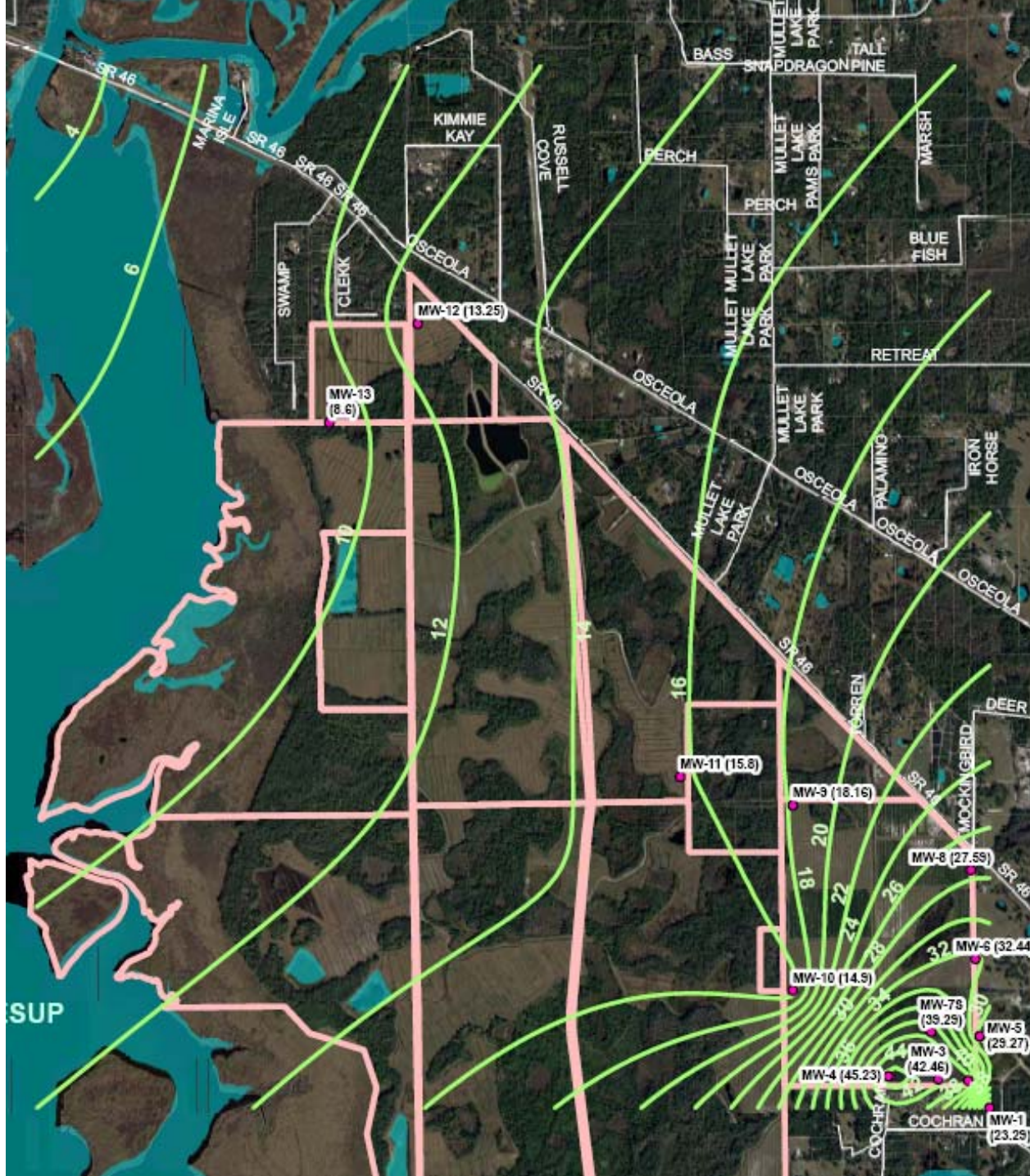


Study Design

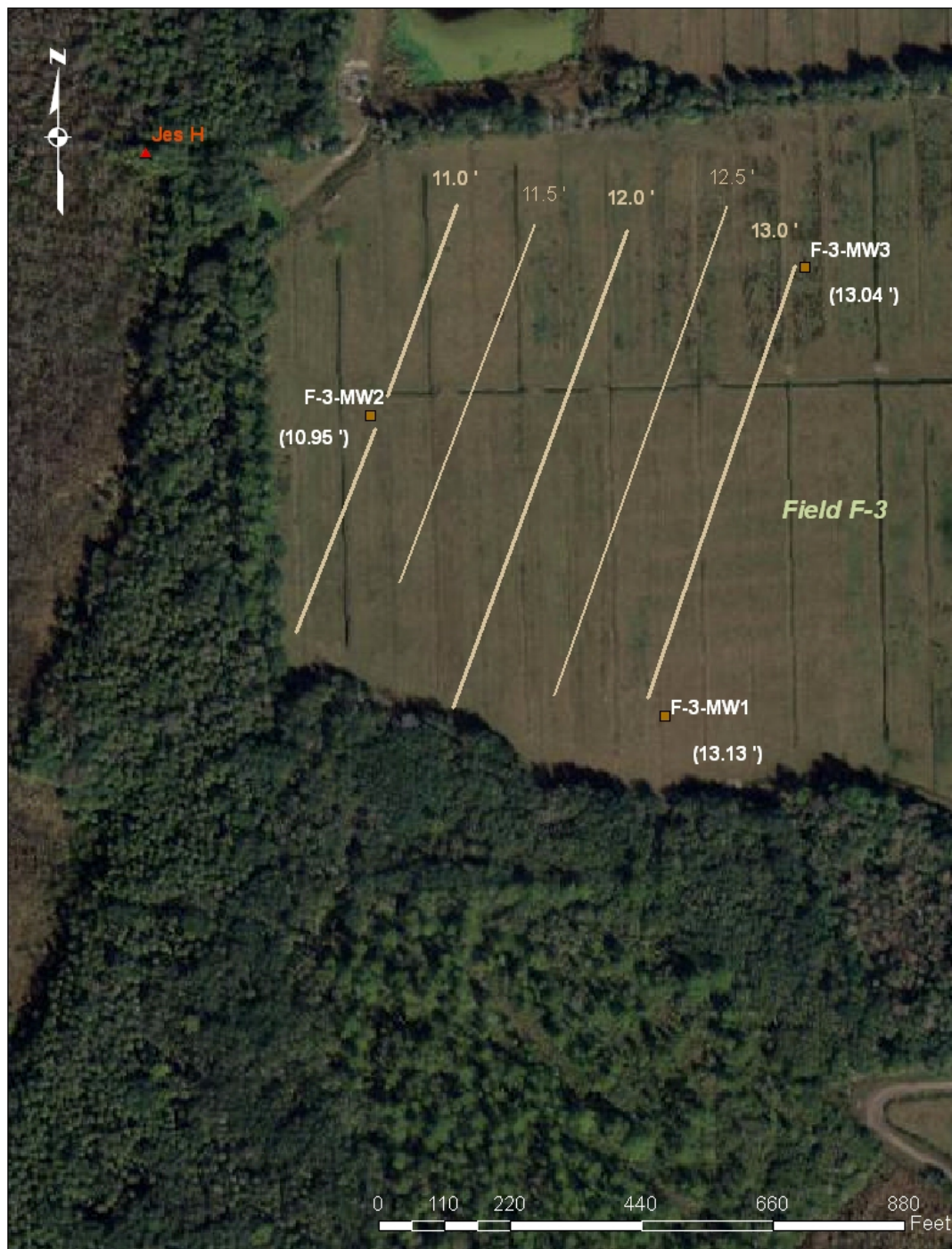
- Ground water flow evaluation
- Ground water nutrients
- Surface water quality (Seminole County)
- Selected sites for 4 well clusters that represent range of conditions within Jesup drainage and close to the lake
- 12-15 ft deep temporary wells











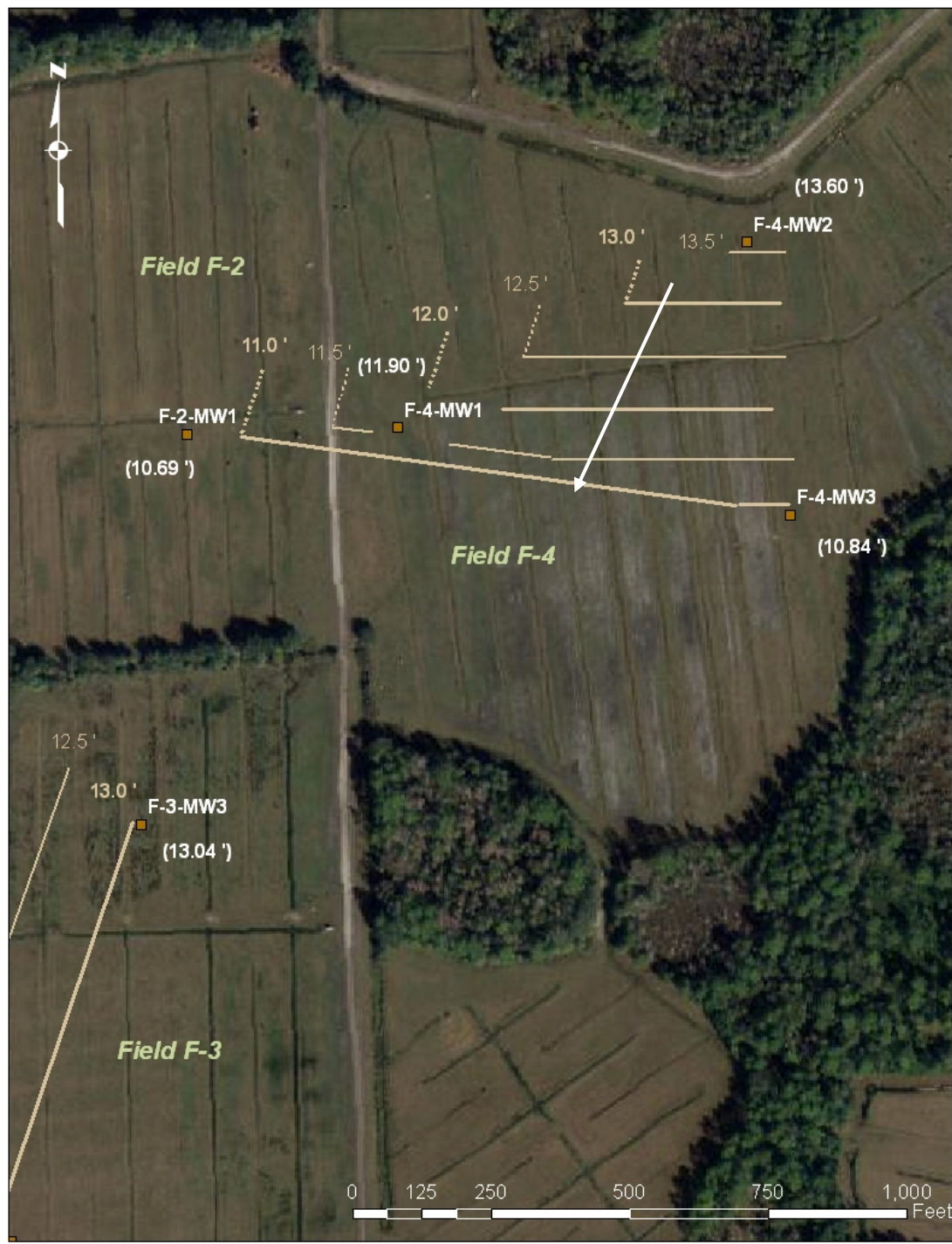




Table 2 Ground Water Elevation Data Summary for December 13, 2007



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.

Ground Water Monitoring

Nitrate+nitrite (as nitrogen)

Ammonia nitrogen

Total phosphorus (+dissolved replicates)

Chloride

Specific Conductance

pH

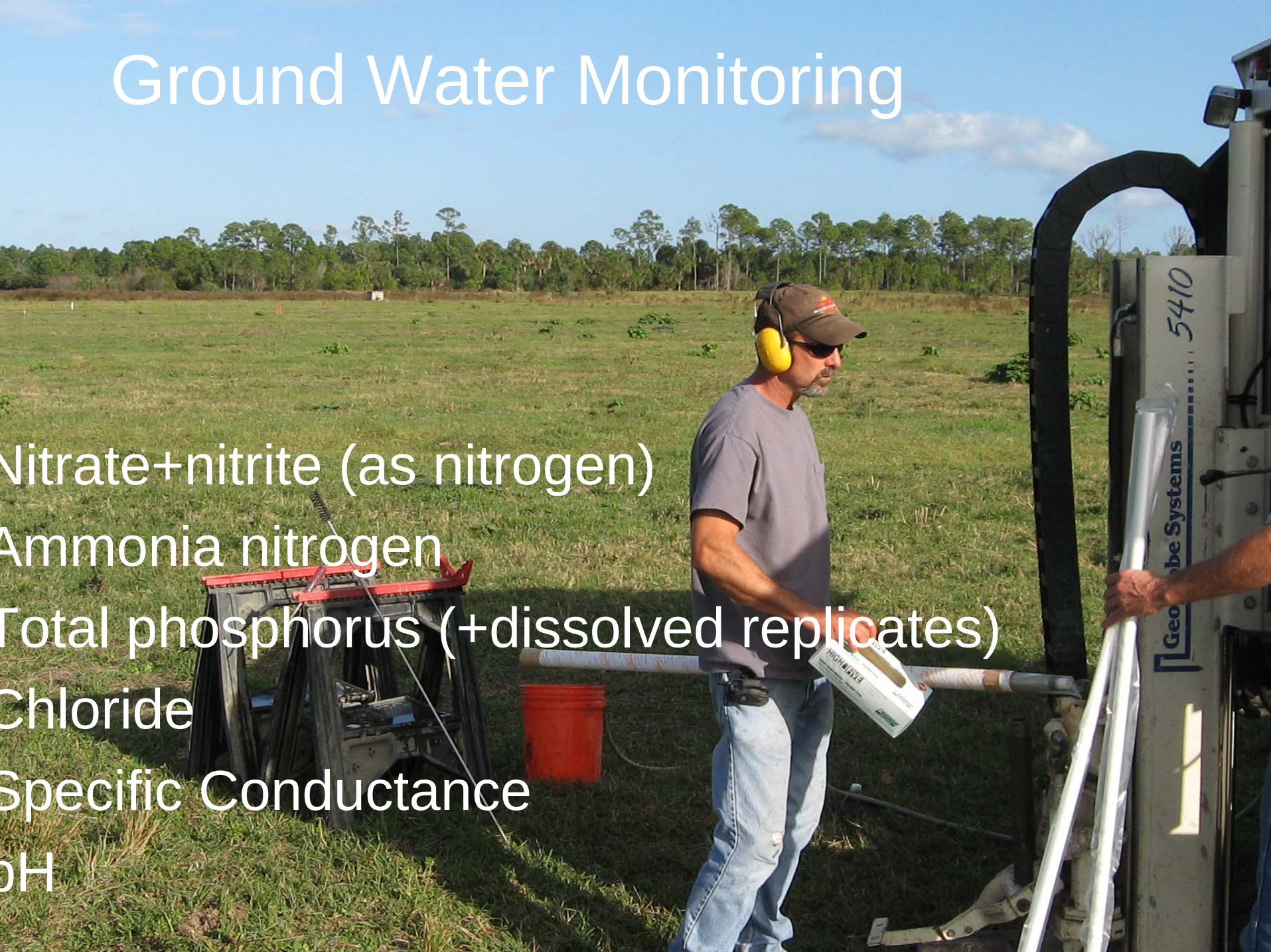


Table 4. Ground Water Quality Data

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 l	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 l	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 l	0.27	5.3	65	486	6.72
F-16-MW3(F) ¹	0.039 l	0.22	0.038 l	66	486	6.72
Median for All Fields⁴	0.033	1.1	0.76	94	614	6.04
Historical Median for Lake Jesup²	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.

⁴ Excluding filtered samples and duplicates

l -the reported value is between the laboratory method detection limit and the laboratory practical quantitation limit.



Surface Water Samples

- Collected by Seminole County
- 2 onsite locations
- Small streams below stormwater ponds





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 (°C)	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 Jesup¹	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

Potential Ground Water Loading Estimates

- Flow based on simple ground water flow equation (Dupuit equation); good for a ballpark estimate

The Dupuit equation can be used to estimate the groundwater flow rate in an unconfined aquifer, as follows:

$$q = \frac{K_h}{2x} (h_1^2 - h_2^2) = \frac{Q}{W}$$

Where:

q	=	flow per unit width of aquifer or specific discharge (ft ² /day);
K _h	=	horizontal hydraulic conductivity of the aquifer (feet/day);
x	=	the horizontal distance between two points h ₁ and h ₂ (feet);
h ₁	=	head at location 1 above the impermeable unit (feet); and
h ₂	=	head at location 2 above the impermeable unit (feet).

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)	h_1 (ft)	h_2 (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

Loading = Flow (quantity) X Concentration

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 <u>Jesup</u> (lb/year)
<u>Nitrate+nitrite</u>	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 x 10⁻⁶ lb

1 L = 0.035 ft³

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).

Conclusions-Nitrate

- Nitrate concentrations are very low
- Loading is negligible; 2 orders of magnitude lower than CDM estimate
- Low total N concentration in reclaimed water

Conclusions- Chloride

- Elevated chloride in many wells much higher than concentration in original wastewater, some similar to wastewater levels
- Probably major portion due to natural conditions, ambient high Cl concentrations in Lk Jesup
- Could be a tracer of Floridan aquifer discharge

Conclusions - Ammonia

- Highest nitrogen form in ground water, but still not extremely elevated
- Is likely attributable to residual and wastewater applications and maybe cattle
- Associated with incomplete nitrification of organic nitrogen
- Could have a natural component
- Potential loading of 129.66 lb/year

Conclusions - Phosphorus

- Phosphorus rich; Elevated concentration (0.76 mg/L median); higher concentrations in surface water discharge---both much higher than Jesup
- Ambient concentrations is elevated (0.3 mg/L for Seminole), may be related to Hawthorn
- Regardless of source, potential load from site is not negligible (89.43 lb/year)
- This estimated ground water load is less than 1/10 of estimated stormwater load



Comparison to Surface Loads

	Site 10 Surface Load (TMDL)	Site 10 Surface Load (BMAP)	Site 10 Groundwater Load (BMAP)	Smallest Local Govt. Surface Load in BMAP (Alt. Springs)
TP (lbs)	900	1,221	89	116

	Total Load (TMDL)	Site 10 Groundwater Load (BMAP)
TN (lbs)	1,221,140	127 (0.01% of TMDL load)

In the BMAP...

Current allocation strategy = surface loads only

Proposal:

- **Do *not* identify Site 10 groundwater loads as a separate allocation entity**
- **Do discuss groundwater load and City's planned actions in narrative portion of the BMAP**