Section 3
Methodology

3.1 Stormwater Modeling

As part of the 1998 Study, a regional stormwater model for the main stem of the Little Wekiva River was developed using the Advanced Interconnected Pond Routing (adICPR), Version 2.20 stormwater model developed by Streamline Technologies®. For the purposes of this study, CDM converted the existing model to ICPR Windows Version 3.02. The model was then updated to reflect the most recent hydrologic and hydraulic conditions in the basin. A more detailed discussion of the model itself is presented in the following paragraphs. The hydrologic component of the model is used to evaluate rainfall, runoff, and infiltration characteristics of an area. Resultant runoff hydrographs are electronically delivered to the hydraulic routing model. The hydraulic model provides flood routing in channels, lakes, and control structures such as bridges, culverts, and weirs. The hydraulic model accounts for conservation of mass and energy, and it predicts looping, flow reversals and other similar events should they occur. A good understanding of water quantity helps determine the most effective methods of controlling flooding and protecting public safety.

3.1.1 Hydrologic Model

ICPR has three methods for generating stormwater runoff: the Soil Conservation Service (SCS) unit hydrograph method, the Santa Barbara method, and the Overland Flow method. For consistency purposes, the SCS unit hydrograph method was used in this model update as it had previously been used in the 1998 Study. The ICPR model has two components to the determination of the volume and rate of stormwater runoff. The first component is based upon the amount of directly connected impervious area (DCIA) to the PSMS represented by a percentage of the contributing area. The resulting runoff from rainfall over the DCIA does not pass over any pervious area and thus does not infiltrate into the soil. The second component consists of the pervious and impervious areas that are not directly connected to the PSMS and thus are subject to infiltration. The SCS unit hydrograph method uses a curve number (CN) to determine the runoff volume from this second component. The CN method relates rainfall to direct runoff as a function of soil type and land use cover. A more complete documentation of the model's background and theory can be found in the adICPR Version 2.20 User's Manual (September 1995) or in the ICPR Version 3.0 online help system.

3.1.2 Hydraulic Model

The hydraulic component of adICPR is a hydraulic flow routing model for open channel and/or closed conduit systems. It uses a link-node (conduit-junction) representation of the stormwater management system in its solution of the equations of gradually varied, unsteady flow. The hydraulic module receives hydrograph input at specific junctions by file transfer from the hydrologic module. The model performs hydraulic routing of stormwater flows through the PSMS to the points of discharge or outfalls. It simultaneously considers both the storage and conveyance aspect of stormwater management facilities. The program will simulate branched or looped networks; backwater due to tidal or non-tidal conditions; free-surface flow; pressure flow or surcharge; flow reversals; flow transfer by weirs, orifices; and storage at online or off-line facilities. Simulation output takes the form of water surface elevations and inundated areas at each junction and flows in each conduit.

3.2 Hydrologic Parameters

Hydrologic model parameters used for the model simulations are described below. For this project, the hydrology for the Little Wekiva River Basin defined in the 1998 Study was reviewed and updated by CDM where necessary. The hydrologic parameters compiled for each hydrologic unit included the contributing area, DCIA, time of concentration, and a CN. The sources of these parameters are discussed in the following paragraphs.

3.2.1 Topographic Data

Topographic data were used to verify hydrologic boundaries, time of concentration for each hydrologic unit, critical flood elevations, and stage-area-storage relationships. Topographic data were available in the Little Wekiva River Basin from the following sources:

<u>Hard Copy</u>

1. Aerial Photography with Contours for Seminole County, prepared by the SJRWMD 1992, contour interval of 1 foot (1 inch = 200 feet scale).

2. Aerial Photography with Contours for Orange County, prepared by the Continental Aerial Surveys, Inc., 1993, contour interval of 1 foot (1 inch = 200 feet scale).

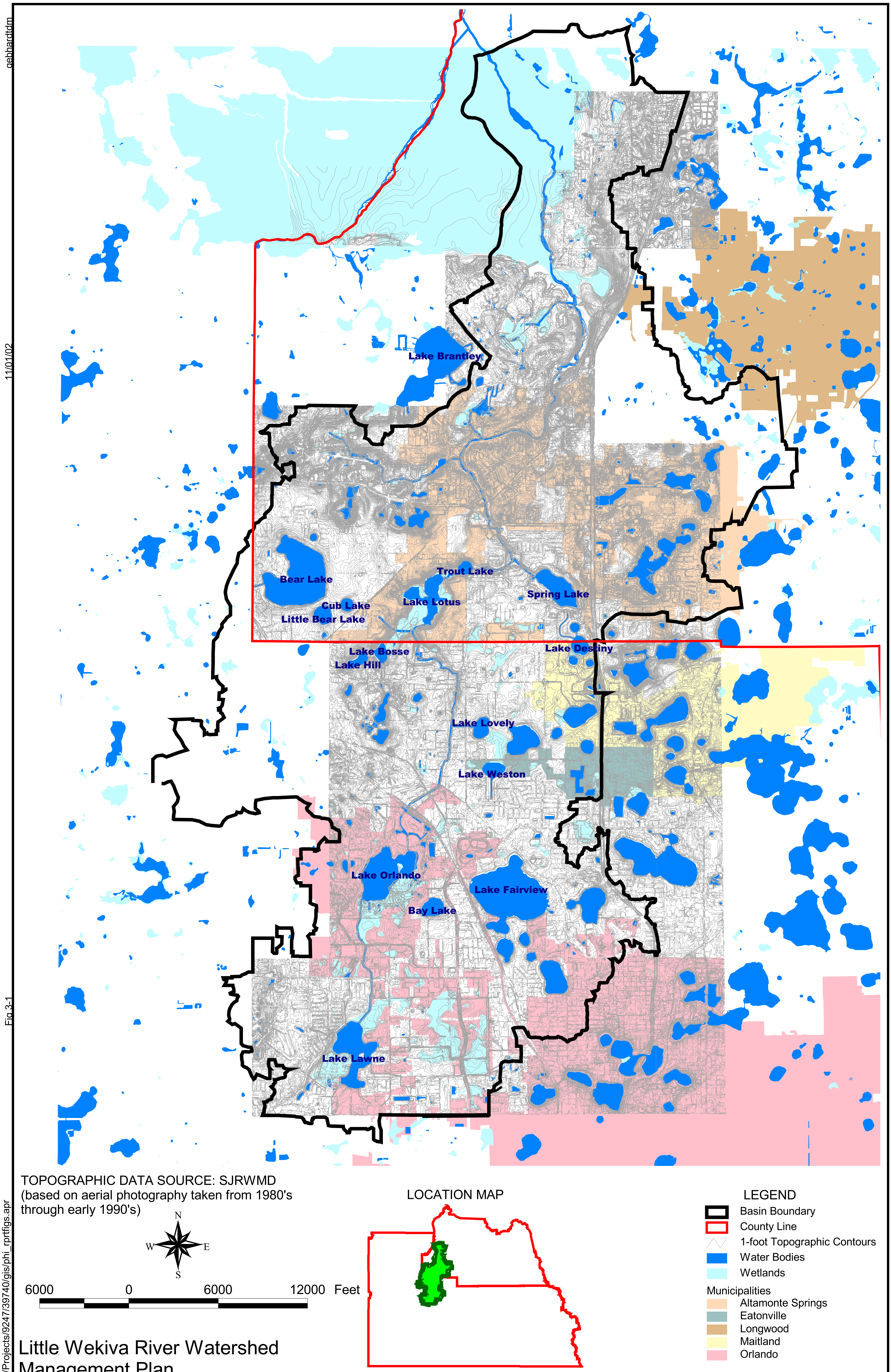
<u>Digital Format</u>

3. Digital 1-foot contour GIS coverage obtained from the SJRWMD. This data set was developed by the SJRWMD using aerial photography taken from 1980's through early 1990's. This coverage is not entirely complete for the study area and therefore the hard copy maps were used for areas not covered by digital data to estimate hydrologic parameters (i.e., time of concentration, available storage, etc.).

Figure 3-1 shows the topographic data available in digital format for the basin.

3.2.2 Hydrologic Unit Areas

Hydrologic unit delineations or boundaries in the Little Wekiva River Basin were refined using the existing delineation from the 1998 Study, topographic data previously described, Engineering Standards Manual ((ESM), formerly the Orlando



CDM

Figure 3-1
1-Foot Topographic Contours

Urban Stormwater Management Manual (OUSWMM)) Phase I Inventory, Seminole County stormwater inventory GIS, the City of Altamonte Springs stormwater inventory GIS, field reconnaissance, and as-built information. Hydrologic units are generally defined by natural physical features or constructed stormwater conveyance systems, which control and direct stormwater runoff to a common outfall. The following criteria were used to determine hydrologic unit boundaries:

- Large-scale physical features such as wetlands, railroad grades, and major roads were used to establish hydrologic divides.
- Hydrologic unit boundaries were delineated where structures or topographic features could appreciably impound water for the 25- and 100-year events.
- The present condition hydrologic unit delineations were considered to be approximately the same as the future case since future development will be regulated by the County and the Cities to maintain present peak discharges and overall flow schemes.
- Existing reports/studies were used, along with field verification, to verify ambiguous boundaries.

In this report, the major subbasins were assigned an identifier based on the water body or tributary serving the area. These included:

- CR – Cranes Roost
- LWR – Little Wekiva River
- TRIBA – Tributary "A"
- TRIBB – Tributary "B"
- TRIBC – Tributary "C"
- TRIBD – Tributary "D"
- TRIBE – Tributary "E"
- TRIBF – Tributary "F"
- TRIBG – Tributary "G"
- TRIBH – Tributary "H"
- TRIBI – Tributary "I"

A unique numerical identifier was then placed after the subbasin identifier to clearly define the location of each hydrologic unit (e.g., LWR-001). In some cases, hydrologic units not previously delineated in the 1998 Study (e.g., the Cranes Roost Subbasin) used the same nomenclature identified in the source where the information was taken from (e.g., Lake Adelaide (LA), Lake Florida (LF), Lake Mobile (LM) and UB (Upper Basin). However, these are all contained within the CR major subbasin. The subbasins are shown in **Figure 3-2**.

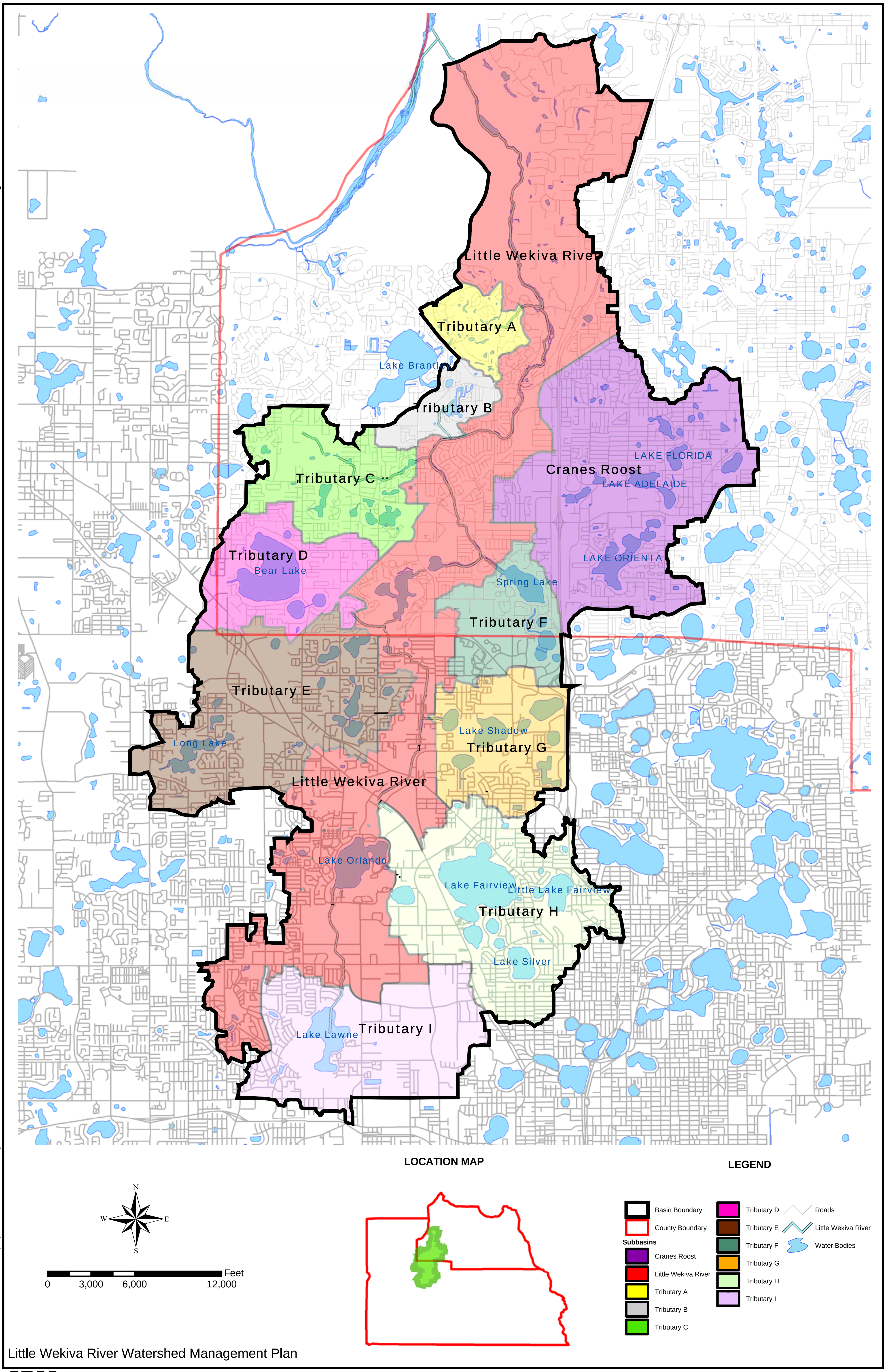
For modeling purposes, the 54.5-square mile Little Wekiva River Basin was subdivided into 305 hydrologic units for which land use, soil, and topographic characteristics were reviewed and refined as necessary from the 1998 Study. The delineation of the basin in the 1998 Study consisted only of that area directly tributary to the main stem of the Little Wekiva River itself. As noted in Section 2.5.7, there are three subbasins that discharge to the PSMS via pump stations and are otherwise closed subbasins (i.e., no positive outfall except through the pump station). These include the Woodsmere, Long Lake and Cranes Roost subbasins (Figure 2-13). For the purposes of this study and at the request of the SJRWMD, these subbasins were included in the hydrologic and hydraulic analysis. The hydrologic units are shown in **Figure 3-3**.

The tributary area of each hydrologic unit was measured using the contour topographic maps provided by the County. Areas were determined using the computational capabilities of the Geographic Information System (GIS) package ArcView©. The hydrologic units averaged approximately 114 acres in size with a minimum of 2.5 acres and a maximum of 1,562 acres.

3.2.3 Time of Concentration

Time of concentration values were previously computed for the 1998 Study. For the purposes of this study, the time of concentration was updated for hydrologic units whose delineation was modified since the 1998 Study. For subbasins not previously included in the 1998 Study (i.e., Woodsmere, Long Lake and Cranes Roost), the time of concentration values, as well as the hydrologic unit delineations, were taken from previous studies done in these areas which include:

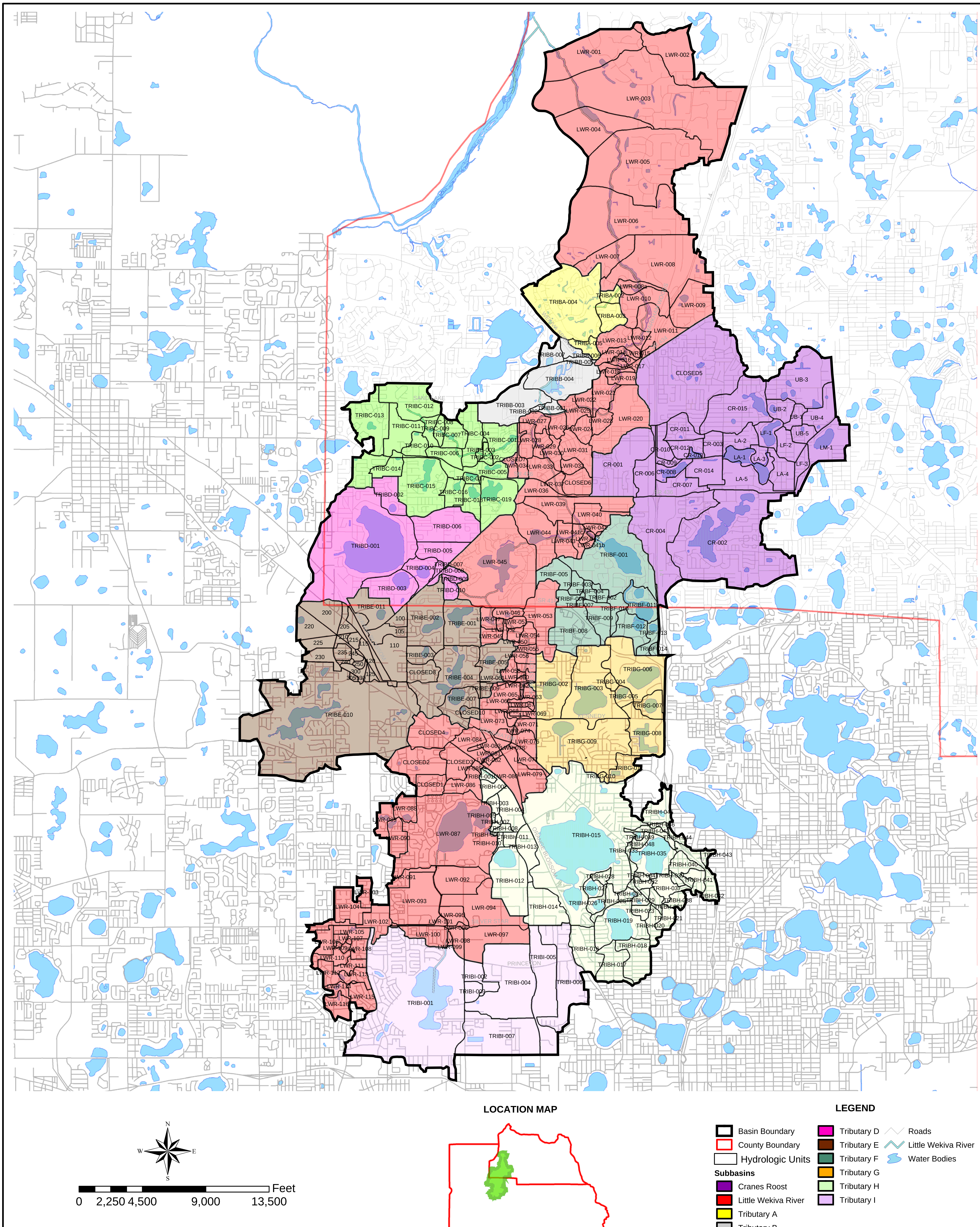
- Drainage Basin Study for Woodsmere Stormwater Pumping Station, Orange County, Florida (PEC, 1999)
- Stormwater Master Plan for the Beggs Road/Overland Road Area, Orange County, Florida (PEC, 1998)
- Land Locked Drainage Basin Study for Orange County: Lake Julia, Alpharetta, Long and Pleasant (DRMP, 1996)
- Cranes Roost Regional Drainage Facility Report, City of Altamonte Springs Florida (HNTB, 1989)



Little Wekiva River Watershed Management Plan

CDM

Figure 3-2
Subbasin Boundaries



Little Wekiva River Watershed Management Plan

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CDM

Figure 3-3
Hydrologic Unit Boundaries

The time of concentration is the time for stormwater runoff to travel from the hydraulically most distant point of the watershed to the point of interest (outflow from the area). For ponded areas, the point of interest chosen was the centroid of ponding. The time of concentration for each hydrologic unit was determined by identifying the longest flow path using the 1999 1-foot digital contour GIS coverage and the 1999 digital aerial maps provided by the County. Each flow path was then subdivided into three types of flow (sheet flow, shallow concentrated flow, and open channel/pipe flow). The total time of concentration is the sum of the travel times for each of the three types of flow. In most cases, the sheet flow component accounts for over 20 percent of the total time of concentration for the hydrologic unit, even though it makes up a small percentage of the total flow length. The calculated times of concentration for the modified hydrologic units along with a map showing the flow paths are provided in **Appendix I**.

3.2.4 Rainfall Intensities and Quantities

Rainfall data were used to generate the flows for stormwater evaluations. Data are generally characterized by amount (inches), intensity (inches per hour), frequency, return period (years), duration (hours), spatial distribution (locational variance), and temporal distribution (time variance).

As the basin is located in both Orange and Seminole Counties, it was necessary to use the rainfall distribution required by each governing entity. Both the Orange County and the SCS Type II (Florida Modified) rainfall distributions were used. The Orange County rainfall distribution was developed by Orange County and is a requirement for any project within the County limits greater than 10 acres. The rainfall volumes applied to the Orange County distribution for the design storm events that were simulated with the regional stormwater model include:

- Mean Annual – 4.5 inches of rainfall
- 10-Year – 7.5 inches of rainfall
- 25-Year – 8.6 inches of rainfall
- 50-Year – 9.3 inches of rainfall
- 100-Year – 10.6 inches of rainfall

Both the SJRWMD and Seminole County require the use of the SCS Type II (Florida Modified) rainfall distribution. The rainfall volumes applied to this distribution for the design storm events that were simulated with the regional stormwater model include:

- Mean Annual - 5.3 inches of rainfall
- 10-Year - 6.8 inches of rainfall

- 25-Year - 8.4 inches of rainfall
- 50-Year - 10.1 inches of rainfall
- 100-Year - 11.4 inches of rainfall

Additionally, for new development occurring in positive outfall (riverine) drainage basins, the City of Altamonte Springs stormwater management design standards require the use of a 10-year/3-hour rainfall distribution. This distribution was provided by the SJRWMD and the rainfall volume applied to this distribution was 4.15 inches.

3.2.5 Land Use Data

The volume and the peak rate of runoff is a function of the type of land use that is present. Accurate representations of both the existing and future land uses are needed to determine a reasonable estimate of stormwater runoff in a watershed.

3.2.5.1 Existing Land Use

The existing land use coverage in computer aided design (CAD) format developed for the 1998 Study was provided by the SJRWMD. CDM compared this coverage to 2000 digital ortho-photo quads (DOQs) and existing land use GIS coverages provided by Seminole County and Orange County. Existing land use information for the municipalities had already been incorporated into both of the counties' land use coverage. The existing land use coverage from the 1998 Study was used as a base and then the appropriate changes were made to it based on comparisons with the 2000 DOQs and the land use data obtained from the Participants. To be consistent with the 1998 Study, Florida Land Use, Cover and Forms Classification System (FLUCCS) codes established by the FDOT were used for the land use categories. The updated existing land use coverage is provided on **Figure 3-4**. The breakdown of existing land use by acreage is provided in **Table 3-1**. The original FLUCCS codes from the 1998 Study are also shown as text on the figure to show the areas where the land use was updated.

3.2.5.2 Future Land Use

A future land use coverage, which represents build-out conditions, for the Little Wekiva River Basin was developed from future land use coverages obtained from Orange (2020) and Seminole (2020) Counties, the City of Maitland (2020), the City of Orlando (2010), and the Town of Eatonville (the future land use for the City of Altamonte Springs (2020) was already incorporated into Seminole County's coverage). These coverages were merged into one overall land use coverage and then compared to both the existing land use coverage and the 2000 DOQs in order to identify and correct any inconsistencies (e.g., the existing land use indicates an area already developed whereas the future indicates that it is not). The land use categories for both of the counties and the municipalities are provided in **Table 3-2** along with the FLUCCS codes that were assigned to them by CDM. The future land use is

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Fig 3-4

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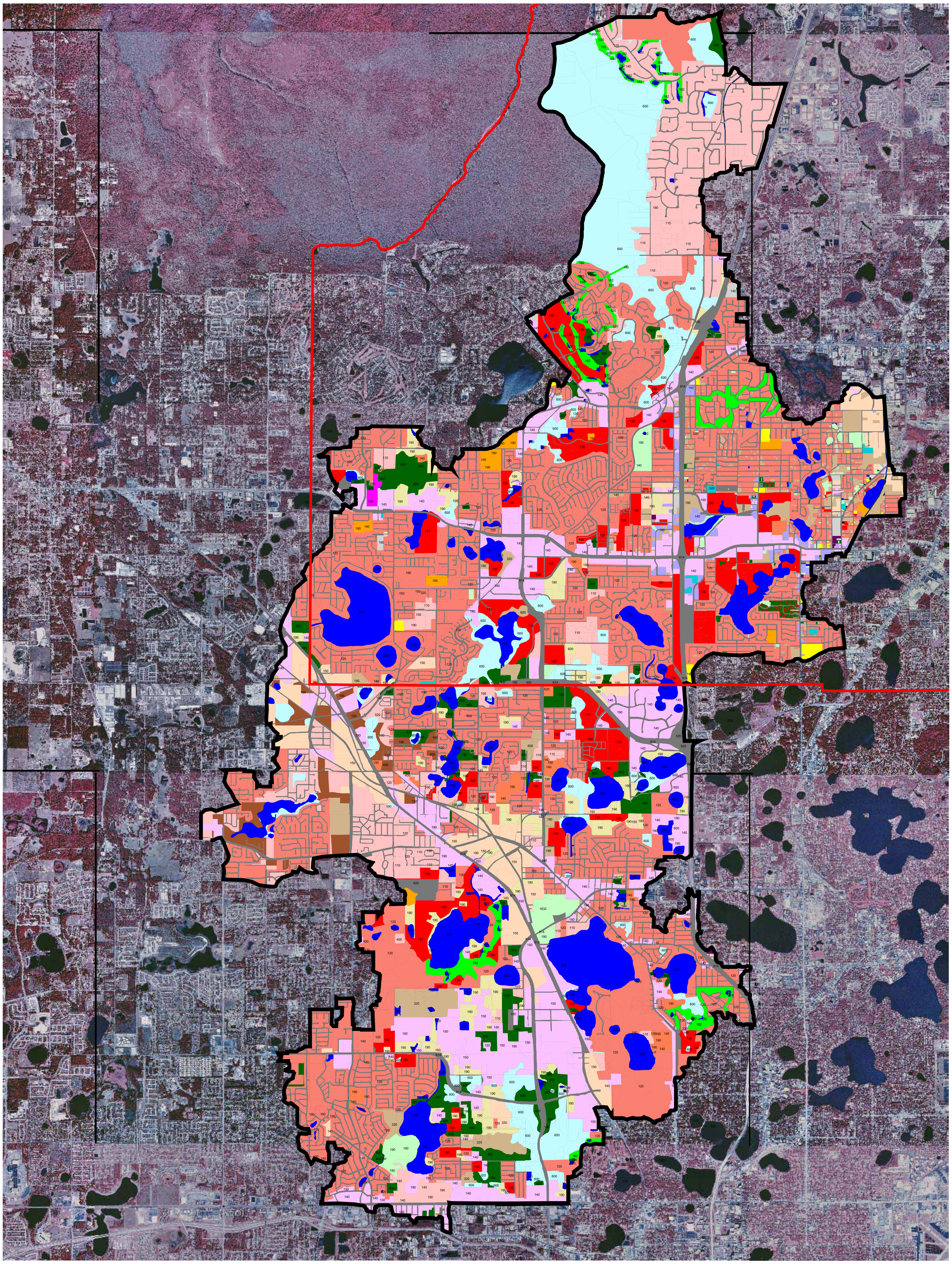

SOURCE: SJRWMD Digital Ortorectifiied
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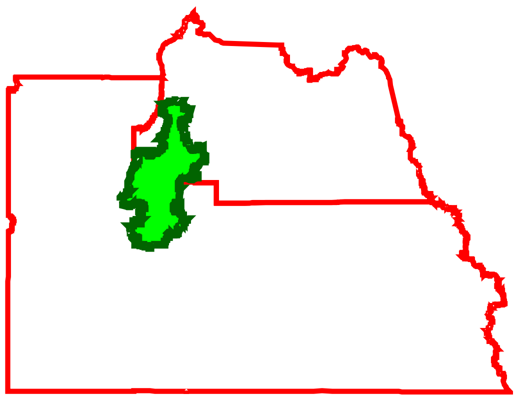


LEGEND

- County Line
- Basin Boundary

Updated Existing Land Use

- 110 - Low Density Residential
- 120 - Medium Density Residential
- 130 - High Density Residential
- 133 - Multiple Dwelling Units, Low Rise
- 140 - Commercial
- 143 - Professional Services
- 148 - Cemetery
- 150 - Industrial
- 170 - Institutional
- 171 - Educational Facilities
- 172 - Religious
- 175 - Government Building
- 180 - Recreation
- 182 - Golf Course
- 190 - Open Land
- 200 - Agriculture
- 320 - Shrub and Brushland
- 400 - Forest
- 500 - Water Body
- 530 - Stormwater Pond
- 600 - Wetlands
- 810 - Transportation
- 812 - Railroad
- 814 - Roads and Highways
- 830 - Utilities

Little Wekiva River Watershed
Management Plan

CDM

Figure 3-4
Existing Land Use

Table 3-1
Little Wekiva River Basin
Watershed Management Plan
Land Use Acreages

Land Use Category	Existing Land Use (acres)	Future Land Use (acres)	% Impervious
110 - Low Density Residential	2,804.1	3,708.1	30%
120 - Medium Density Residential	10,089.6	10,526.2	37%
130 - High Density Residential	1,911.4	1,944.1	71%
133 - Multiple Dwelling Units, Low Rise	3.8	3.8	71%
140 - Commercial	3,648.4	3,301.6	85%
143 - Professional Services	181.2	175.2	85%
148 - Cemetery	23.9	23.9	1%
150 - Industrial	1,220.5	3,378.9	71%
170 - Institutional	224.2	318.6	85%
171 - Educational Facilities	152.7	176.8	85%
172 - Religious	69.6	54.0	85%
175 - Government Building	12.2	10.9	85%
180 - Recreation	374.1	507.1	17%
182 - Golf Course	478.4	480.1	17%
190 - Open Land	914.7		0%
200 - Agriculture	328.6	29.2	0%
320 - Shrub and Brushland	940.4	14.7	0%
400 - Forest	1,051.0	91.3	0%
500 - Water Body	2,687.1	2,589.1	100%
530 - Stormwater Pond	32.9		100%
600 - Wetlands	2,963.4	2,803.1	100%
810 - Transportation	1.2	1.2	100%
812 - Railroad	28.5	20.5	63%
814 - Roads and Highways	4,595.4	4,595.4	100%
830 - Utilities	67.7	51.7	17%
Total:	**34,805**	**34,805**	

Table 3-2
Little Wekiva River Watershed Management Plan
Land Use Designations

Jurisdiction	Existing Land Use Code	Description	FLUCCS Code	FLUCCS Code Description
Orange County	C	Commercial	140	Commercial
	COMMERCIAL	Commercial	140	Commercial
	CONSERVATION	Conservation	600	Wetlands
	HD	High Density	130	High Density Residential
	I	Industrial	150	Industrial
	IN	Institutional	170	Institutional
	INDUSTRIAL	Industrial	150	Industrial
	INSTITUTIONAL	Institutional	170	Institutional
	LD	Low Density	110	Low Density Residential
	LM	Low-Medium Density Residential	120	Medium Density Residential
	LOW DENSITY RESIDENTIAL	Low Density	110	Low Density Residential
	MD	Medium Density	120	Medium Density Residential
	MEDIUM DENSITY RESIDENTIAL	Medium Density	120	Medium Density Residential
	O	Office	140	Commercial
	P/R	Park/Recreation/Open Space	180	Recreation
	PARKS AND RECREATION	Park/Recreation/Open Space	180	Recreation
	RURAL / AGRICULTURE	Agriculture	200	Agriculture
	WATER BODY	Water Body	500	Water Body
	WB	Water Body	500	Water Body
Seminole County	ACLF	Adult Living Facility	140	Commercial
	ADMIN	Administration	175	Government Building
	AG	Agriculture	200	Agriculture
	C_AREA	Common Areas	400	Forest
	CEMETERY	Cemetery	148	Cemetery
	CHURCH	Church	172	Religious Facility
	CLUB	Clubs	186	Community Recreation Facility
	COM	Commercial	140	Commercial
	CONS	Conservation Areas	600	Wetlands
	DAYCARE	Day Care	143	Professional Services
	DRAINAGE	Water Body	500	Water Body
	EASEMENT	Easements	830	Utility
	FIRE	Fire Departments	140	Commercial
	GOLFCOURSE	Golf Course	182	Golf Course
	HOTEL	Hotels	145	Tourist Services
	HDR	High Density Residential	130	High Density Residential
	HIP	High Intensity Planned Development	120	Medium Density Residential
	IND	Industrial	150	Industrial
	LDR	Low Density Residential	110	Low Density Residential
	MDR	Medium Density Residential	120	Medium Density Residential
	MFRH	Multi Family Residential (High)	133	High Density Residential
	MFRL	Multi Family Residential (Low)	133	High Density Residential
	MHRVPK	Mobile Home/RV Park	132	Mobile Home Units
	NATLAND	Natural Lands	400	Forest
	OFF	Office	143	Professional Services
	PARKPRIV	Private Parks	180	Recreation (Park)
	PARKPUB	Public Parks	180	Recreation (Park)
	PD	Planned Development	120	Medium Density Residential
	POSTOFF	Post Office	175	Government Building
	PUB	Public Lands	180	Recreation
	PUBC	Public - County Owned	180	Recreation
	PUBO	Public - Other Government Owned	180	Recreation
	PUBR	Public - Rest Area	180	Recreation
	PUBS	Public - School	171	Educational Facilities
	PUBU	Public - Utility	830	Utilities
	REC	Recreation	180	Recreation
	RETENTION	Retention Ponds	530	Stormwater Pond
	ROAD	Roads	814	Roads/Highways
	ROW	Right-of-Way	810	Roads/Highways
	RR	Railroad	812	Railroad
	SCHOOLPRIV	Public Schools	171	Institutional
	SCHOOLPUB	Private Schools	171	Institutional
	SE	Suburban Estates	110	Low Density Residential
	SFMH	Single Family Mobile Homes	132	Mobile Home Park

Table 3-2
Little Wekiva River Watershed Management Plan
Land Use Designations

Jurisdiction	Existing Land Use Code	Description	FLUCCS Code	FLUCCS Code Description
	SFR	Single Family Residential	120	Medium Density Residential
	SUBHSG	Subsidized Housing	120	Medium Density Residential
	TRANS	Transportation Facilities	800	Transportation
	UTIL	Utilities	830	Utility
	VACANT	Vacant Lands	320	Shrub (Open Land)
	WATER	Water Body	500	Water Body
City of Altamonte Springs	COMM	Commercial	140	Commercial
	CONS	Conservation	600	Wetlands
	HDR	High Density Residential	130	High Density Residential
	IND	Industrial	150	Industrial
	INST	Institutional	170	Institutional
	LDR	Low Density Residential	110	Low Density Residential
	MDR	Medium Density Residential	120	Medium Density Residential
	MOCL	Mixed Office Commercial, Low Intensity	140	Commercial
	MOCM	Mixed Office Commercial, Medium Intensity	140	Commercial
	MOIL	Mixed Office Industrial, Low Intensity	150	Industrial
	MORL	Mixed Office Residential, Low Intensity	120	Medium Density Residential
	MORM	Mixed Office Residential, Medium Intensity	120	Medium Density Residential
	MUD	Multi-Use Development	120	Medium Density Residential
	PARK	Parks & Recreational	180	Recreation
	PUDM	Planned Unit Development, Mixed/Other	120	Medium Density Residential
	PUDR	Planned Unit Development, Residential	120	Medium Density Residential
	ROW	Right-of-Way	810	Roads/Highways
	WATER	Water Body	500	Water Body
City of Maitland	CONS	Conservation	600	Wetlands
	H	High Density Residential	130	High Density Residential
	LM	Low-Medium Density Residential	130	High Density Residential
	MORC	Mixed Office/Residential/Commercial	140	Commercial
	PO	Professional Office	140	Commercial
	SF	Single Family Detached Residential	110	Low Density Residential
City of Orlando	COMM-AC	Community Activity Center	140	Commercial
	CONSERV	Conservation	520/600	Water Bodies/Wetlands
	INDUST	Industrial	150	Industrial
	INDUST/RES-PRO	Industrial/Resource Protection Overlay	150	Industrial
	MUC-MED	Mixed Use Corridor, Medium Intensity	140	Commercial
	NEIGH-AC	Neighborhood Activity Center	140	Commercial
	OFFICE-LOW	Office, Low Intensity	140	Commercial
	OFFICE-MED	Office, Medium Intensity	140	Commercial
	PUB-REC-INST	Public/Recreational & Institutional	170/180	Institutional/Recreational
	PUB-REC-INST/RES-PRO	Public/Recreational & Institutional/Resource Protection Overlay	180	Recreation
	RES-LOW	Residential, Low Intensity	110	Low Density Residential
	RES-LOW/RES-PRO	Residential, Low Intensity/Resource Protection Overlay	110	Low Density Residential
	RES-MED	Residential, Medium Intensity	120	Medium Density Residential
	RES-MED/RES-PRO	Residential, Medium Intensity/Resource Protection Overlay	120	Medium Density Residential
	UR-AC	Urban Activity Center	140	Commercial
Town of Eatonville	C-1	Planned Business	140	Commercial
	C-2	Planned Office	140	Commercial
	C-3	General Commercial	140	Commercial
	EC	Environmental Conservation	520/600	Water Bodies/Wetlands
	I-1	Industrial Use	150	Industrial
	P-0	Professional Office	140	Commercial
	R-1	Single Family Low Density	110	Low Density Residential
	R-2	Single Family Medium Density	120	Medium Density Residential
	R-3	Multi-Family High Density	130	High Density Residential

provided on **Figure 3-5**. The breakdown of future land use by acreage is shown in Table 3-1.

3.2.6 Soils Data

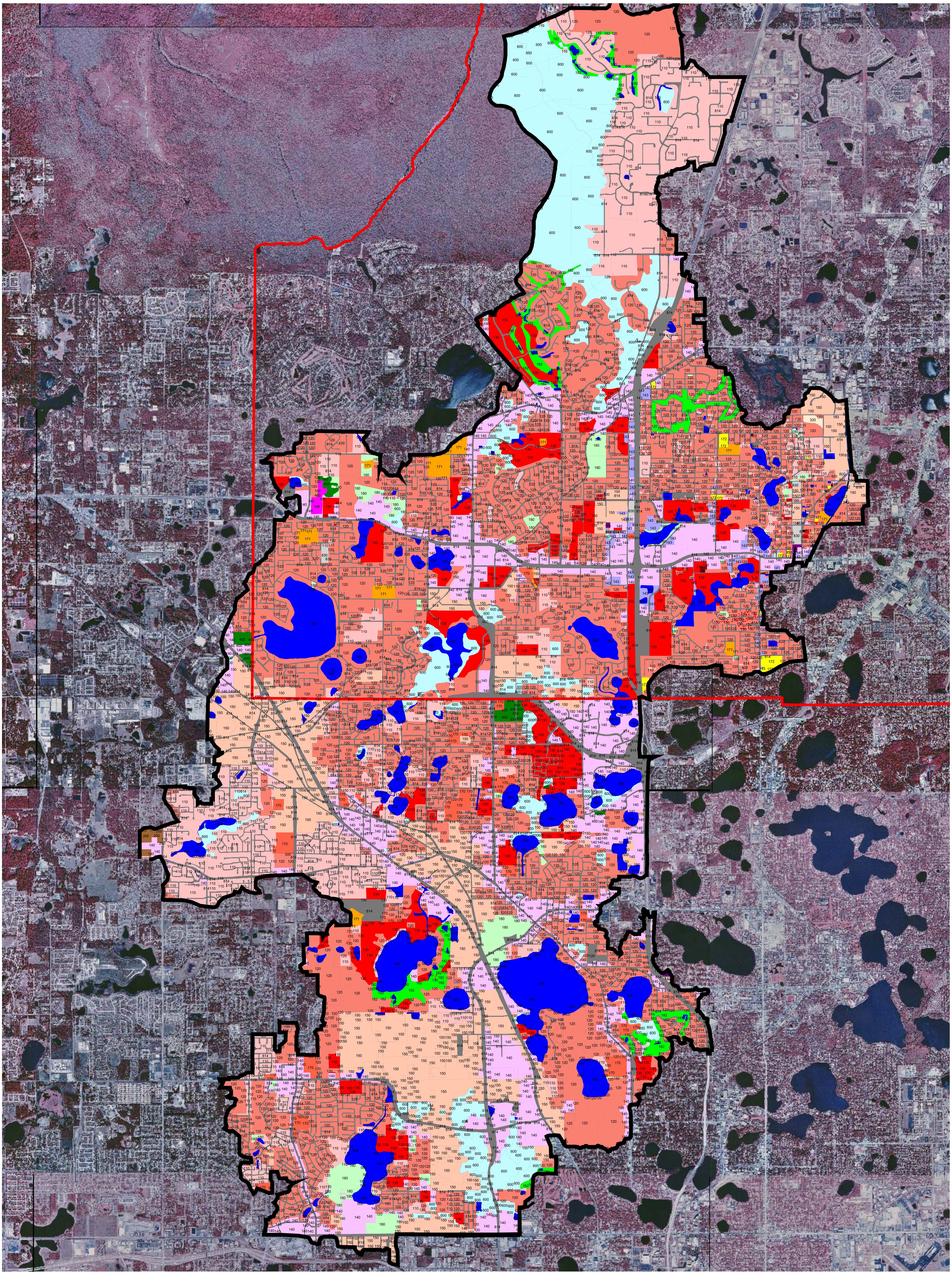
Soils data are used to evaluate stormwater runoff, infiltration, and recharge potential for pervious areas. Information on soil types was obtained from the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (formerly the Soil Conservation Service (SCS) Soil Survey of Orange County, Florida (NRCS, 1989) and Soil Survey of Seminole County (NRCS, 1990) as well as in digital format from the SJRWMD. Each soil type has been assigned to a soil association, a soils series, and to one of the four Hydrologic Soil Groups (A, B, C, or D) established by the NRCS. Hydrologic Soil Group A is comprised of soils having very high infiltration potential and low runoff potential. Those soils with moderate infiltration rates when thoroughly wetted are classified as Hydrologic Soil Group B. Group C soils are those soils with low infiltration rates while Hydrologic Soil Group D is characterized by soils with a very low infiltration potential and a high runoff potential. The other two categories fall between B and D soil groups. Dual class soils (e.g., B/D) are soils assigned to two hydrologic groups. The first letter represent drained areas and the second letter represents undrained areas. **Table 3-3** lists the acreages of soil series identified in the Little Wekiva River Basin and their corresponding NRCS hydrologic soils group classification.

The digital soils coverage was available from the SJRWMD and imported into ArcView© 3.2a. **Figure 3-6** shows a map of the NRCS hydrologic soils groups for the Little Wekiva River Basin study area.

3.2.7 Curve Numbers

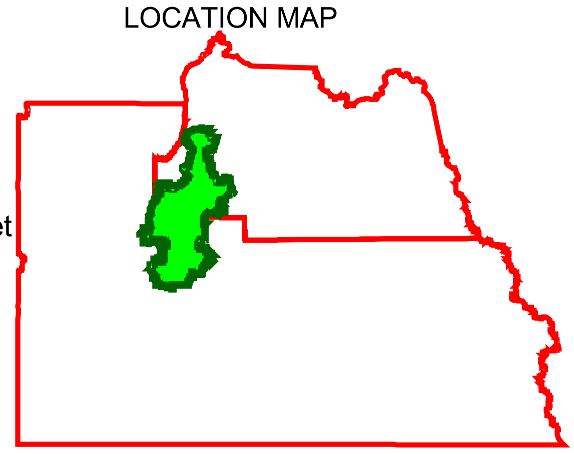
The curve numbers, which are used to determine how much of the rainfall will be converted to runoff, were calculated based on the land use distribution and hydrologic soil group distribution in each hydrologic unit. The SCS provides information on relating soil group types to the curve numbers as a function of soil cover, land use type, and antecedent moisture condition. **Table 3-4** shows the relationship between CN values, hydrologic soils group, and land use type based upon the SCS methodology. This relationship was used to compute a composite CN value for each hydrologic unit. A summary of the CN values under existing and future land use conditions by hydrologic unit is presented in **Appendix J**. Large changes in CN values indicate regions expecting substantial development.

It should be noted, the model results using the CN values calculated for future land use conditions do not include any potential flood attenuation impacts resulting from stormwater facilities that would be required for any new development. The SJRWMD requires that pre-development flow rates match post-development flow rates for new stormwater ponds that would serve new development. In theory, this would imply that flow rates in the primary stormwater management system (streams, canals, pipes) that convey stormwater runoff should not increase from new development.



SOURCE: SJRWMD Digital Ortorectifiied
Quarter Quads, 2000

LOCATION MAP



LEGEND

- Basin Boundary
- County Line

Future Land Use

- 110 - Low Density Residential
- 120 - Medium Density Residential
- 130 - High Density Residential
- 133 - Multiple Dwelling Units, Low Rise
- 140 - Commercial
- 143 - Professional Services
- 148 - Cemeteries
- 150 - Industrial
- 170 - Institutional
- 171 - Educational Facilities
- 172 - Religious
- 175 - Governmental
- 180 - Recreational
- 182 - Golf Course
- 200 - Agriculture
- 320 - Shrub & Brushland
- 400 - Forest
- 500 - Water Bodies
- 600 - Wetlands
- 810 - Transportation
- 812 - Railroads
- 814 - Roads & Highways
- 830 - Utilities

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Little Wekiva River Watershed
Management Plan

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Fig 3-5
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Figure 3-5
Future Land Use

Table 3-3
Little Wekiva River Basin
Watershed Management Plan
Soils Series and Hydrologic Groups

Hydrologic Group	Soil Name	Total Acreage	Percentage
A	ARCHBOLD	43.6	0.1%
A	ASTATULA	3743.2	10.8%
A	CANDLER	2160.8	6.2%
A	FLORAHOME	2.3	0.0%
A	LAKE	13.3	0.0%
A	PAOLA	224.5	0.6%
A	ST. LUCIE	46.4	0.1%
A	TAVARES	4088.2	11.7%
A	UDORTHENTS	80.1	0.2%
	Total A Soils	**10402.4**	**29.9%**
B/D	BASINGER	13.6	0.0%
B/D	BRIGHTON	141.1	0.4%
B/D	EAUGALLIE	75.9	0.2%
B/D	HONTOON	13.0	0.0%
B/D	IMMOKALEE	421.4	1.2%
B/D	MALABAR	3.5	0.0%
B/D	MYAKKA	811.6	2.3%
B/D	ONA	557.4	1.6%
B/D	SAMSULA	713.1	2.0%
B/D	SMYRNA	3822.6	11.0%
B/D	ST. JOHNS	361.6	1.0%
B/D	WABASSO	677.7	1.9%
	Total B/D Soils	**7612.5**	**21.9%**
C	ADAMSVILLE	247.9	0.7%
C	ARENTS	225.0	0.6%
C	POMELLO	803.6	2.3%
C	SEFFNER	196.2	0.6%
C	ZOLFO	962.2	2.8%
	Total C Soils	**2434.9**	**7.0%**
D	BASINGER	1917.6	5.5%
D	NITTAW	1832.7	5.3%
D	POMPANO	183.0	0.5%
D	SAMSULA	200.0	0.6%
D	SANIBEL	109.6	0.3%
	Total D Soils	**4243.0**	**12.2%**
	URBAN LAND	6743.5	19.4%
	WATER	2283.1	6.6%
	PITS	22.2	0.1%
	URBAN LAND	1041.7	3.0%
	UNKNOWN	21.7	0.1%
	Total Other	**10090.6**	**29.1%**
	Total	**34805.0**	**100.0%**

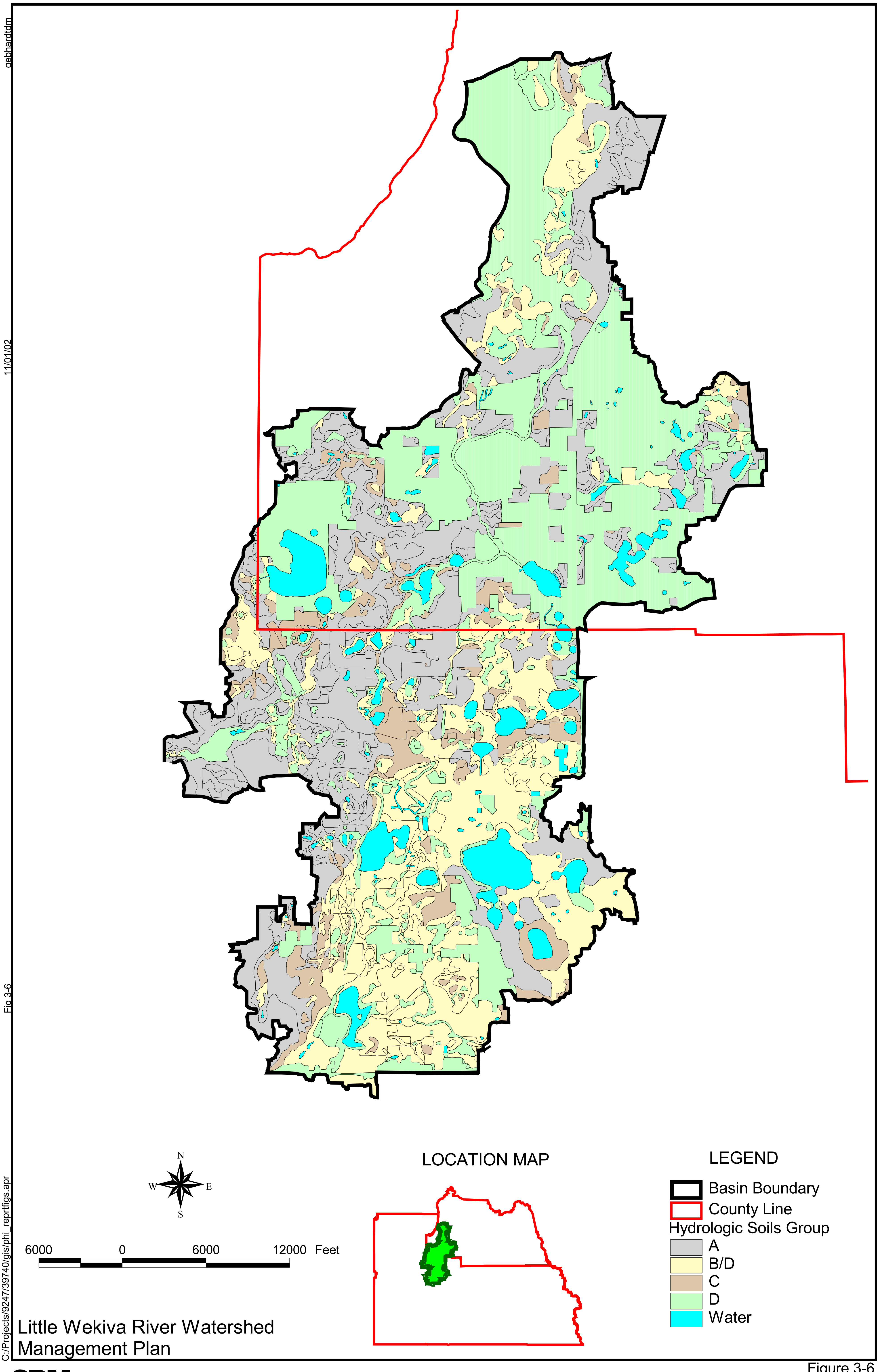

Figure 3-6
Hydrologic Soil Groups

Table 3-4
Little Wekiva River Watershed Management Plan
SCS Hydrologic Soils Group Curve Numbers by Land Use Category

Jurisdiction	Existing Land Use Code	Imperviousness (%)	Curve Number for Each SCS Hygrologic Group			
			A	B	C	D
Orange County	C	85%	89	92	94	95
	COMMERCIAL	85%	89	92	94	95
	CONSERVATION	0%	36	60	73	79
	HD	71%	81	88	90	92
	I	71%	81	88	91	93
	IN	85%	89	92	94	95
	INDUSTRIAL	71%	81	88	91	93
	INSTITUTIONAL	85%	89	92	94	95
	LD	30%	57	72	81	86
	LM	37%	61	75	83	87
	LOW DENSITY RESIDENTIAL	30%	57	72	81	86
	MD	37%	61	75	83	87
	MEDIUM DENSITY RESIDENTIAL	37%	61	75	83	87
	O	85%	89	92	94	95
	P/R	17%	49	69	79	81
	PARKS AND RECREATION	17%	49	69	79	81
	RURAL / AGRICULTURE	0%	39	61	74	80
	WATER BODY	100%	DCIA	DCIA	DCIA	DCIA
	WB	100%	DCIA	DCIA	DCIA	DCIA
Seminole County	ACLF	71%	81	88	91	93
	ADMIN	85%	89	92	94	95
	AG	0%	39	61	74	80
	C_AREA	0%	36	60	73	79
	CEMETERY	1%	40	61	74	80
	CHURCH	85%	81	92	94	95
	CLUB	85%	89	92	94	95
	COM	85%	89	92	94	95
	CONS	0%	36	60	73	79
	DAYCARE	85%	89	92	94	95
	DRAINAGE	100%	DCIA	DCIA	DCIA	DCIA
	EASEMENT	17%	49	69	79	84
	FIRE	85%	89	92	94	95
	GOLFCOURSE	17%	68	79	86	89
	HOTEL	85%	89	92	94	95
	HDR	71%	81	88	90	92
	HIP	85%	89	92	94	95
	IND	71%	81	88	91	93
	LDR	30%	57	72	81	86
	MDR	37%	61	75	83	87
	MFRH	71%	81	88	90	92
	MFRL	35%	60	74	82	86
	MHRVPK	64%	77	85	90	92
	NATLAND	0%	36	60	73	79
	OFF	85%	89	92	94	95
	PARKPRIV	17%	49	69	79	81
	PARKPUB	17%	49	69	79	81
	PD	37%	61	75	83	87
	POSTOFF	85%	89	92	94	95
	PUB	17%	49	69	79	81
	PUBC	17%	49	69	79	81
	PUBO	17%	49	69	79	81
	PUBR	17%	49	69	79	81
	PUBS	85%	89	92	94	95
	PUBU	17%	49	69	79	84
	REC	17%	49	69	79	84
	RETENTION	100%	DCIA	DCIA	DCIA	DCIA
	ROAD	100%	98	98	98	98
	ROW	100%	98	98	98	98
	RR	63%	76	85	89	91
	SCHOOLPRIV	85%	89	92	94	95

Table 3-4
Little Wekiva River Watershed Management Plan
SCS Hydrologic Soils Group Curve Numbers by Land Use Category

Jurisdiction	Existing Land Use Code	Imperviousness (%)	Curve Number for Each SCS Hygrologic Group			
			A	B	C	D
Seminole County	SCHOOLPUB	85%	89	92	94	95
	SE	30%	57	72	81	86
	SFMH	64%	77	85	90	92
	SFR	37%	61	75	83	87
	SUBHSG	37%	61	75	83	87
	TRANS	100%	98	98	98	98
	UTIL	17%	49	69	79	84
	VACANT	1%	35	56	70	77
	WATER	100%	DCIA	DCIA	DCIA	DCIA
City of Altamonte Springs	COMM	85%	89	92	94	95
	CONS	0%	36	60	73	79
	HDR	71%	81	88	90	92
	IND	71%	81	88	91	93
	INST	85%	89	92	94	95
	LDR	30%	57	72	81	86
	MDR	37%	61	75	83	87
	MOCL	85%	89	92	94	95
	MOCM	85%	89	92	94	95
	MOIL	71%	81	88	91	93
	MORL	37%	61	75	83	87
	MORM	37%	61	75	83	87
	MUD	37%	61	75	83	87
	PARK	17%	49	69	79	84
	PUDM	37%	61	75	83	87
	PUDR	37%	61	75	83	87
	ROW	100%	98	98	98	98
	WATER	100%	DCIA	DCIA	DCIA	DCIA
City of Maitland	CONS	100%	DCIA	DCIA	DCIA	DCIA
	H	71%	81	88	90	92
	LM	71%	81	88	90	92
	MORC	85%	89	92	94	95
	PO	85%	89	92	94	95
	SF	30%	57	72	81	86
City of Orlando	COMM-AC	85%	89	92	94	95
	CONSERV	100%	DCIA	DCIA	DCIA	DCIA
	INDUST	71%	81	88	91	93
	INDUST/RES-PRO	71%	81	88	91	93
	MUC-MED	85%	89	92	94	95
	NEIGH-AC	85%	89	92	94	95
	OFFICE-LOW	85%	89	92	94	95
	OFFICE-MED	85%	89	92	94	95
	PUB-REC-INST	17%	49	69	79	84
	PUB-REC-INST/RES-PRO	17%	49	69	79	84
	RES-LOW	30%	57	72	81	86
	RES-LOW/RES-PRO	30%	57	72	81	86
	RES-MED	37%	61	75	83	87
	RES-MED/RES-PRO	37%	61	75	83	87
	UR-AC	85%	89	92	94	95
Town of Eatonville	C-1	85%	89	92	94	95
	C-2	85%	89	92	94	95
	C-3	85%	89	92	94	95
	EC	100%	DCIA	DCIA	DCIA	DCIA
	I-1	71%	81	88	91	93
	P-0	85%	89	92	94	95
	R-1	30%	57	72	81	86
	R-2	37%	61	75	83	87
	R-3	71%	81	88	90	92

Only stormwater runoff volumes should increase from the added impervious area. The problem with this assumption is that flow rate control facilities (ponds) do not always function as designed. In addition, ponds can change the hydrograph timing of a system and peak flows generated from small storm frequencies may increase because pre-post controls are for the 25 year/24-hour design storm event. Pond function variability can be from lack of maintenance, land surface re-grading, or a poor assumptions during the design phase. Situations like these can result in post-development peak flow rates exceeding those predicted for pre-development conditions leading to the under sizing of downstream facilities (e.g., culvert crossings). For these reasons, CDM took the more conservative approach in its analysis, as agreed to by the counties that flood attenuation under future land use conditions does not occur.

CDM developed routines in ArcView© to automate the CN calculation process. The CN routine superimposes the land use, SCS Hydrologic Soils Group, and water body (hydrologic) coverages over the hydrologic unit delineation coverage. ArcView© then calculates the CN value using predefined look-up tables and the percentages (by area) of the hydrologic coverages for each hydrologic unit. It should be noted that the percent of water body was not included in the calculation of the CN but was input to the model as DCIA.

3.3 Hydraulic Parameters

The hydraulic model representing the PSMS for the Little Wekiva River Basin was updated from several sources including as-built drawings, field reconnaissance, topographic maps, and survey data. As part of this project, CDM refined the detailed hydraulic representation of the Little Wekiva River Basin system to better understand the interactions of the river itself, related tributaries and depressional areas within the study area.

3.3.1 Structure Inventory

As part of the data collection effort, an inventory of the existing primary stormwater structures in the Little Wekiva River Basin was completed. Primary structures are defined as those structures with an equivalent diameter of 36 inches or greater. In addition to primary structures, a number of structures were identified in problem areas that were not previously included as part of the stormwater model developed as part of the 1998 Study. The majority of these structures are considered secondary systems but were included in the structure inventory as well. The primary stormwater structure inventory was developed by using the 1998 Study as a baseline and expanding on it using existing available reports, stormwater structure inventory GIS' developed by Seminole County and the City of Altamonte Springs, field reconnaissance and survey. A detailed discussion of this effort was included in Section 2.5.2.

3.3.2 Main Stem & Tributary Improvements

During the update of the ICPR model, several sedimentation control projects, done by others, along the main stem of the river had either been completed or were under design. The ICPR models for these projects were obtained and incorporated into the model updated by CDM. These include:

- Edgewater Drive Vegetated Slope
- Riverside Acres Subdivision Arch Pipe Rehabilitation, Orange County
- Sherry Drive Rip Rap Channel #3, Orange County

As mentioned in Section 2.5.5, several tributaries were modeled on a very coarse scale in the 1998 study. Previous studies were reviewed and field visits were made to these areas to verify the extent to which these systems were modeled. Based on these reviews, several of the structures and or channel cross-sections in these areas were included in the survey plan so that these systems may be more accurately represented in the updated stormwater model. Tributaries where additional detail was added include Tributary "A", Tributary "C", Tributary "D", Tributary "E", Tributary "F", Tributary "G", Tributary "H" and Tributary "I".

During the development of Part III (current phase) of this WMP, it was brought to CDM's attention by the Participants that some tributaries required additional detail in their hydraulic representation than what was previously provided in Parts I and II of this WMP. This included Tributary "E" (Long Lake Subbasin), Tributary "G" (Lake Shadow Subbasin), Tributary "H" and Tributary "I". A brief description of the modifications is provided in the following discussion.

Lakes Julia, Alpharetta and Long Lake Subbasins

The information for incorporation of these subbasins into the Little Wekiva River Watershed Management Plan (Parts 1 & 2) was originally taken from the *Landlocked Drainage Basin Study for Orange County: Lakes Julia, Alpharetta, Long and Pleasant* (DRMP, 1996). However upon inspection of both DRMP's model results and discussion with Orange County staff, the Lake Julia and Lake Alpharetta subbasins do not contribute flow to the Long Lake system, even for the 100-year/24-hour storm event. Further communication with the SJRWMD indicated that construction of the Maitland Blvd. Extension (SR414) will be impacting the area and essentially eliminating Lake Julia in its entirety. Therefore these subbasins and associated hydraulics and hydrology were removed from the ICPR model as well as the model schematic. The portion of the subbasin remaining includes the area tributary to Long Lake itself which discharges surface water to Lake Gandy and subsequently the Little Wekiva River system through a pump system.

CDM also obtained and reviewed the *Stormwater Master Plan for the Beggs Road/Overland Road Area* (PEC, 1998). Based on information presented in the report, CDM further refined the Long Lake subbasin (TRIBE-010) boundary to include the hydrologic units delineated in PEC's 1998 study and the PSMS that contributes flow to Long Lake. Only the hydraulic elements that comprise the PSMS (i.e., pipe size equivalent of 30 inches and greater in diameter) were incorporated into the Little Wekiva River Watershed ICPR model. CDM used the values for area, curve numbers and time of concentration reported in PEC's study for these hydrologic units. For consistency, CDM also used the same notation for hydrologic units, model nodes and conduits as used in PEC's study.

Lake Shadow System

This system, located on the east side of the watershed in Orange County is also identified as "Tributary G" in the Little Wekiva River Watershed Management Plan, consists of a series of interconnected lakes where conveyance occurs through culverts and/or overland flow. CDM made the following modifications based on review of available data:

1. The conduit connection between Lake Weston and Lake Shadow was updated to reflect a 117-foot 48-inch RCP crossing under Kennedy Blvd. based on review of the Construction Plans for Kennedy Blvd. From Forest City Road to Wymore Road (International Engineering Consultants, 2003).

2. An existing 36-inch RCP that extends from the Keller Road area to Lake Shadow and appears to convey water from the outfall channel from Lake Hungerford was also incorporated into the ICPR model based on review of the Construction Plans for Kennedy Blvd. From Forest City Road to Wymore Road (International Engineering Consultants, 2003).

3. A culvert connection between Lake Shadow and Lake Lovely was included based on discussions with Orange County and review of the Lake Index for Unincorporated Orange County, FL (2005). The Lake Index identifies a culvert as the control structure for this lake with an invert elevation of 81.33 ft-NGVD. No other information regarding the physical characteristics of this pipe was available. Orange County also provided an aerial map with recently obtained topographic contours. From inspection of this map, there appears to be an area (e.g., access road) in the forested section between Lake Shadow and Lake Lovely where a culvert crossing may exist. The length of this crossing was estimated to be approximately 40 feet long. Therefore a 36-inch RCP with a length of 40 feet and an upstream invert of 81.33 ft-NGVD and a downstream invert of 80.83 ft-NGVD was assumed. As the physical distance between these two lakes is approximately 1,836 feet and the area is fairly flat, an overland flow weir with an irregular cross-section (estimated based on available 1-foot topographic contours) was also modeled to more accurately represent flow conditions.

4. The Lake Lovely Erosion and Sediment Controls (Record Drawings) by URS were also reviewed to verify that these cross-sections were already previously incorporated into the ICPR model.

The changes were included in the model schematic shown on **Figure 3-7**.

Lake Silver, Lake Daniel and Lake Sarah (Tributary "H")
Additional detail was added to obtain a more accurate representation of the conveyance system from Lake Silver to Lake Fairview. The Draft North College Park Flood Study (2004) prepared by CDM was referred to obtain this detail. The hydrologic unit boundaries, loadings and hydraulics in this vicinity were updated in the ICPR model to reflect a more accurate representation of the conveyance system that flows from Lake Silver through Lake Daniel and Lake Sarah and finally into Lake Fairview. These changes were shown on Figure 3-7.

Tributary "I"
The hydraulics for Tributary "I" were revisited due to excessive stages predicted by the model. The canal that makes up Tributary "I" was originally modeled as a trapezoidal channel in the 1998 study with a width of 18 feet and side slopes of 2:1 (h:v), with no storage defined. It appeared that this representation of the canal may be causing water to "stack up" as the model recognizes an infinite side slope with no where defined for it to spill over once it reaches top of bank. These open channel cross-sections were redefined as irregular cross-sections and their shape and elevations were estimated from available 1-foot topographic data (obtained from the SJRWMD) with a cross-section large enough to account for floodplain storage.

All of the changes mentioned above are represented in the model schematic which is discussed in detail in the next sub-section.

3.3.3 Model Schematic

A digital version of the stormwater model schematic developed as part of the 1998 Study was provided by the SJRWMD. The model schematic is a representation of the actual PSMS system and provides a quick reference between the actual physical situation and the modeled system. It also aids in checking model input data and interpreting output data. The stormwater model schematic developed as part of the 1998 Study was updated by CDM based on: 1) more detailed inventory data obtained since the 1998 Study; and 2) survey data and data obtained from construction plans to better define conveyance systems in tributary subbasins. An updated hydraulic model schematic of the PSMS for the Little Wekiva River Basin system is included in Figure 3-7. The schematic shows conveyance channels and structures, as well as the linking junctions. Identification numbers for the model nodes are also shown on the schematic. The model schematic shown in Figure 3-7 is color coded to distinguish between open channels (blue), overland flow (brown), structure connections (pink), bridges (orange), drop structures (red), and stormwater force mains (green).

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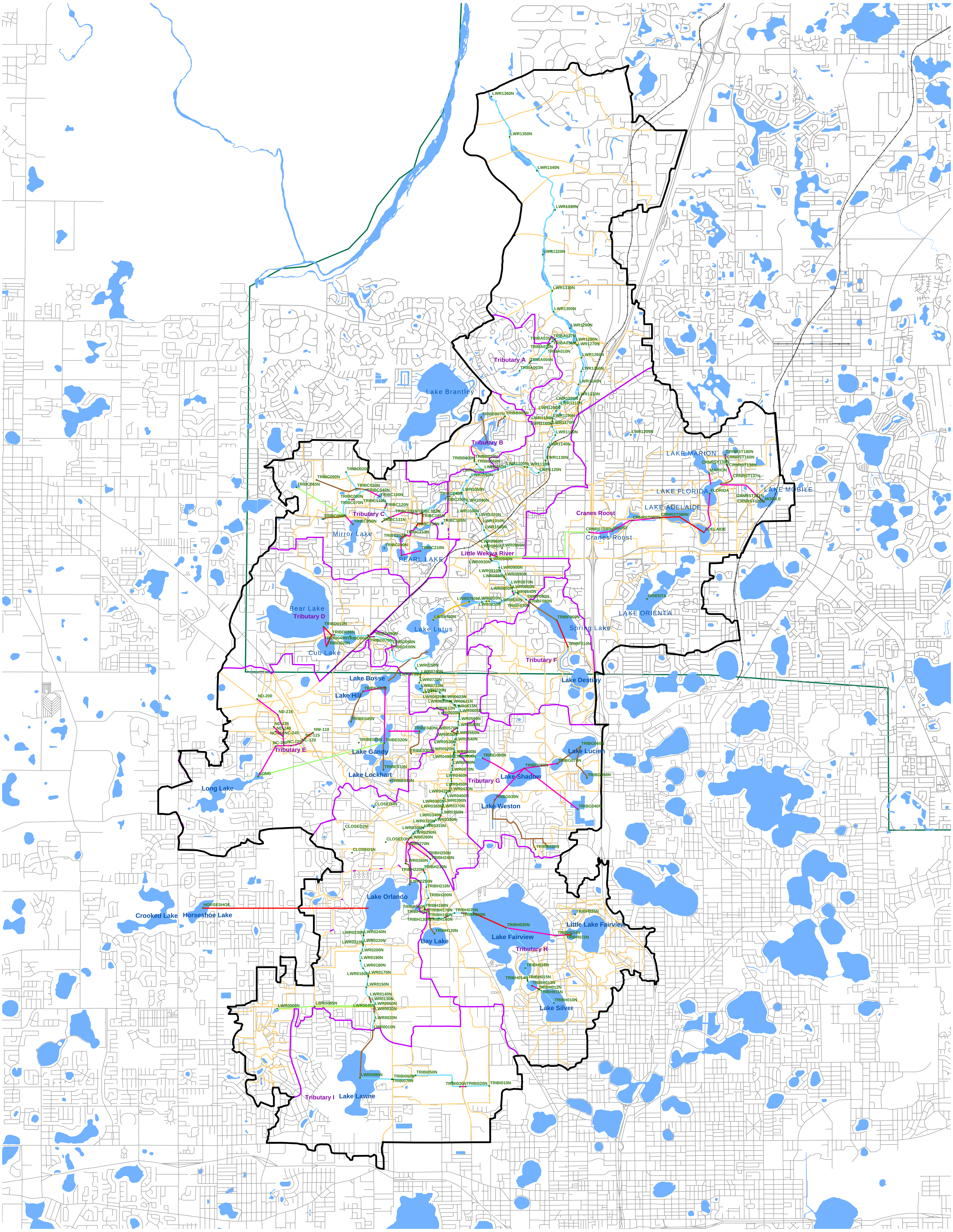
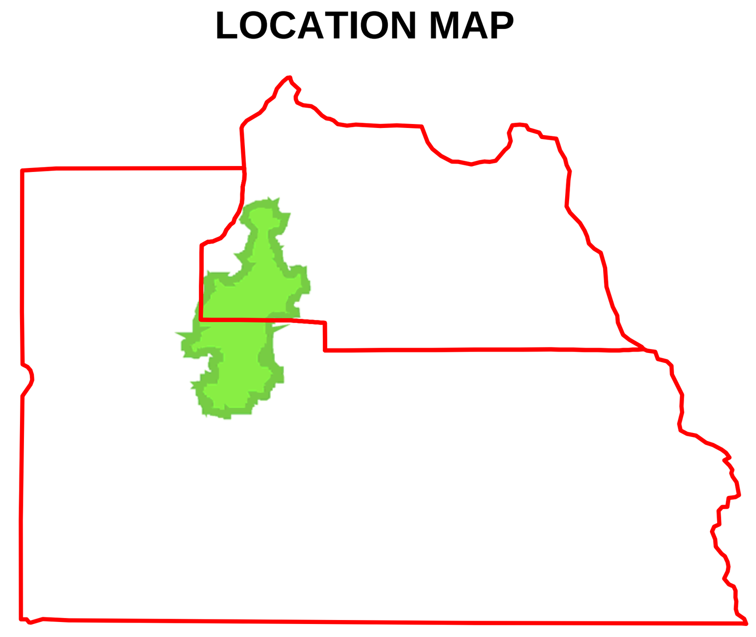


LOCATION MAP



LEGEND

Basin Boundary	Subbasin Boundary
Railroad	Hydrologic Units
Model Nodes	Roads
Bridge	County Boundary
Channel	WSA_water
Drop Structure	
Force Main	
Pipe	
Weir	

Little Wekiva River Watershed Management Plan

CDM

Figure 3-7
Model Schematic

3.3.4 Boundary Conditions

The SJRWMD provided the boundary conditions for the nearest cross-section to the Little Wekiva River and Wekiva River confluence based on their Hydrologic Engineering Center's River Analysis System (HEC- RAS) model developed for Wekiva River Minimum Flows and Levels Project. The values provided by the SJRWMD were used as the boundary condition in the ICPR model and are shown in **Table 3-5**.

Table 3-5
Little Wekiva River Watershed Management Plan
Boundary Condition for Little Wekiva River/Wekiva River Confluence

Return Period	Elevation (ft NGVD29)
2-Yr	12.5
5-Yr	13.3
10-Yr	13.7
25-Yr	14.3
50-Yr	14.7
100-Yr	15.0

3.3.5 Local Losses

Local losses at the entrance to a channel or pipe can be directly input to adICPR. These coefficients are multiplied by the velocity head at the entrance to a channel or pipe. Bend losses are added to manhole losses and are a function of the angle between a pipe entering a manhole and a pipe leaving the same manhole. A more detailed discussion on local losses can be found in the adICPR Users Manual. The guidelines in **Tables 3-6** and **3-7** will be used when assigning local loss coefficients as part of the Phase II modeling effort.

3.4 Levels of Service

Proper level of service (LOS) decisions are an essential component of the Little Wekiva River WMP. The LOS is defined as the measurement indicating the degree of service provided by, or proposed for a facility based on the operational characteristics of that facility. This includes LOS requirements for retrofit to address known flooding problems. The LOS decisions will directly affect the size and cost of any recommended alternative. As the Little Wekiva River Basin encompasses portions of the Cities of Orlando and Altamonte Springs and Orange and Seminole Counties, the LOS standards for each were considered separately.

City of Orlando

The City of Orlando defines the LOS standards for stormwater in Chapter 59 (Concurrency Management) of their Code of Ordinances. Section 59.206 (Stormwater LOS) states that stormwater LOS standards for new development shall be consistent with the Orlando Urban Stormwater Water Management Manual as shown in **Table 3-8**.

Table 3-6
Little Wekiva River Watershed Management Plan
Entrance Loss Coefficients (From SFWMD, 1989)

Type of Structure and Design of Entrance	Coefficient K_{ent}
Pipe, Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wingwalls	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radium = 1/12 D)	0.2
Mitered to conform to fill slope	0.7
End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Pipe, or Pipe-Arch, Corrugated Metal	
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls square-edge	0.5
Mitered to conform to fill slope, paved or unpaved slope	0.7
End-Section conforming to fill slope	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wingwalls)	
Square-edged on 3 edges	0.5
Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wingwalls at 30° to 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwall at 10° to 25° to barrel	
Square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square-edged at crown	0.7
Side- or slope-tapered inlet	0.2

Table 3-7
Little Wekiva River Watershed Management Plan
Exit and In-Pipe Loss Coefficients

Description	K
Inlet to manhole	0.25
Manhole in straight section of closed circuit	0.10
Manhole at a 45 degree bend	0.25
Manhole at a 90 degree bend	0.50
Exit closed conduit to lake	1.00
Exit closed conduit to open channel	0.30 - 0.70

Table 3-8
Little Wekiva River Watershed Management Plan
City of Orlando LOS Stormwater Standards

Facility	LOS
City Primary	Design Storm: 25-year/24-hour. Max. Flood Stage: 100-year/3-day below flood elevation.
City Secondary	Design Storm: 10-year/6-hour. Max. 10-year Hydraulic grade line (HGL): 1' below gutter elevation.
	Check Storm: 10-year/6-hour. Max. Hydraulic Grade Line (HGL): at gutter elevation.
City Tertiary	Design Storm: 10-year/6-hour. Max. 25-year HGL: at gutter elevation.
	Check Storm: 25-year/6-hour. Max. HGL: at gutter elevation.
Arterial Road	Roadway Section and Inlet Design: 10-year/6-hour storm.
Collector Road	Roadway Section and Inlet Design: 5-year/6-hour storm.
Minor Road	Roadway Section and Inlet Design: 3-year/6-hour storm.
Travel Lane Spread	12 feet for all roads; roads with parking lane, width measured from face of curb to centerline of the outermost travel lane; clearance between design water surface and top of curb: 1".
Maximum Run Distance	400 Feet to first Inlet.
Retention Ponds	Retain the greater of: first 1/2 inch of runoff or the first 1 inch of rainfall; separate from detention system.
Detention Ponds	Design Storm: 25-year/6-hour. Detain the volume necessary to restrict post-development peak runoff to pre-development peak runoff.
Detention Ponds (landlocked basins)	Same as above plus volume storage on-site for the 100-year/24-hour storm.
Flood Prone Areas	Development allowed in 100-year floodplain with compensatory storage loss and floodstage increases less than one foot from the base elevation.

Orange County

Orange County currently defines their LOS standard for stormwater in Chapter 30 (Planning and Development) of their Code of Ordinances. Section 30-520(5) (Performance Standards) states that the LOS standard for stormwater shall be based on the stormwater quantity and quality criteria shown below in **Table 3-9**.

Table 3-9
Little Wekiva River Watershed Management Plan
Orange County LOS Stormwater Standards

Facility	Design Storm (24-hour duration)
Bridges	50-year
Canals, ditches, or culverts for drainage external to the development	25-year
Crossdrains, storm sewers	10-year
Roadside swales for drainage internal to the development	10-year
Detention basins	25-year
Retention basins (no positive outfall)	100-year

Additionally, Orange County requires that the freeboard for open drainage ways and ponds shall be a minimum of one (1) foot above the design high water elevation. Section 34-266 of the County's code also requires that a stormwater management system shall be designed and will contain features to provide for:

(1) Pollution abatement. Pollution abatement will be accomplished by retention, or detention with filtration, of one-half (1/2) inch of runoff from the developed site or the runoff generated from the first one (1) inch of rainfall on the developed site, whichever is greater. The depth of runoff generated from the first inch of rainfall shall be estimated by multiplying the Rational Method Runoff Coefficient (C) for the developed site by one (1) inch of rainfall.

(2) Recharge where possible. Recharge in designated areas where the soils are compatible (Hydrologic Soil Group Type "A" soils as indicated on the soils survey map for the county prepared by the U.S.D.A. Soil Conservation Service) will be accomplished by providing for retention of the total runoff generated by a 25-year frequency, 24-hour duration storm event from the developed site. Where a positive outfall is not available, the site shall be designed to retain 100-year frequency/24-hour duration storm on-site.

(3) Protection from flooding. Post-development shall be less than or equal to pre-development for Orange County's 25-year/24-hour storm event. All residential, commercial and industrial structures shall be flood free from Orange County's 100-year/24-hour storm event.

Seminole County

For new development, design criteria for stormwater facilities have been adopted by Seminole County as described in its 1991 Comprehensive Plan Update. These design criteria are presented in **Table 3-10**. In addition to these criteria, new development must meet all other applicable local, state, and federal design criteria (e.g., SJRWMD).

Table 3-10
Little Wekiva River Watershed Management Plan
Seminole County Design Storm Criteria

Facility Type	Design Storm
Retention/Detention Basins (with positive outfall) ■ sites ■ subdivisions	25-year/24-hour 25-year/24-hour
Retention/Detention Basins (land locked)	100-year/24-hour Total Retention
Retention/Detention Basins (adjacent to public right-of-way with no positive outfall)	25-year/24-hour Total Retention
Closed Drainage System (internal to development)	10-year/3-hour
Roadside Swales	10-year/3-hour
Arterial and Collector Streets	10-year, hydraulic grade line 1.0 ft. below gutter line
Local Streets	10-year, hydraulic grade line 0.5 ft. below gutter line
Canals	25-year
Bridges	100-year

Source: 1991 Comprehensive Plan Update

In addition to design criteria Seminole County adopted the following LOS definitions in their 1991 Comprehensive Plan (updated in 1999):

LOS A: Flow Contained within Systems

No flooding of major roadways, minor roadways, yards or buildings. The hydraulic grade line (free water surface) is generally at or below the inlet throats of storm sewer systems and/or within the top of bank in channels.

LOS B: Water Contained within Right-of-Way

Flooding of major roadways is limited to the outer lane but does not prevent travel. Flooding of minor street crowns is of limited duration. Flooding of yards is generally limited to the right-of-way but no flooding of buildings occurs. The hydraulic grade line is at or slightly above the inlet throat and/or encroaches on top of curb but does not breach the top of bank in channels.

LOS C: Water Contained within the Property

Flooding of major roadways precludes the use of the outer lanes and travel in inner lanes is possible but difficult. Prolonged flooding of minor streets precludes travel. Flooding of property up to the front face of building occurs, but no flooding of the building. The hydraulic grade line is significantly above the inlet, beyond road rights-of-way and beyond the normal channel in the floodplain.

LOS D: Structure Flooding

Extensive flooding of streets, yards and buildings for prolonged periods (24 hours or longer).

Figure 3-8 presents these four levels of service criteria. They have been formulated to establish improvement goals. The primary focus of these goals is public safety by protecting against flooding of houses/buildings and maintaining emergency and evacuation route access.

CDM used the information presented in Tables 3-7, 3-8 and 3-9 to develop guidelines for assigning the critical design storm event for stormwater structure types typically evaluated as part of a basin plan. The assigned critical design storm event is then used to determine if an existing structure is deficient. CDM then assigned the applicable critical design storm event to each PSMS structure evaluated based upon its assigned function (i.e., bridge, roadway crossdrain, stormwater pond, closed system conveyance, etc). The guidelines used to assign the critical duration design storm are summarized below:

1. A 100-year/24-hour design storm LOS will be assigned to bridges with spans greater than 20-feet and to any modeled stormwater structure intended to keep evacuation routes and emergency service buildings operational.

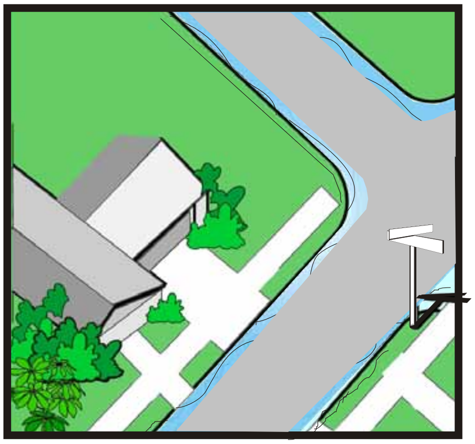
2. A 50-year/24-hour design storm LOS will be assigned to all cross drains and bridges with spans less than 20-feet intended to keep operational evacuation routes and emergency services buildings operational.

3. A 25-year/24-hour design storm LOS will be assigned to the primary stormwater management system and retention/detention facilities included in the stormwater model that are not subject to the criteria listed above.

4. A 10-year/24-hour design storm LOS will be assigned to closed pipe conveyance systems and roadside swales included in the stormwater model that are not subject to the criteria listed above.

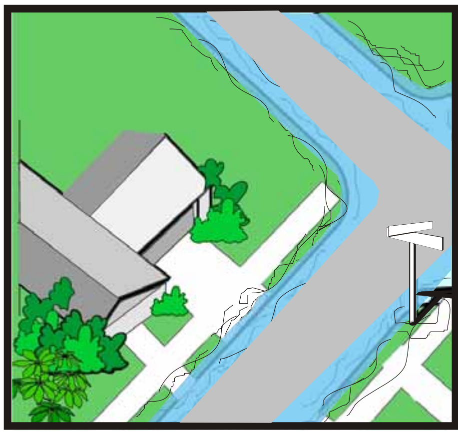
Once a critical design storm was assigned to each PSMS structure, a critical elevation was then determined. For the purposes of this study, the critical elevation for roadways was the crown of the road and for open channel segments the critical elevation was the top of bank. It should be noted that each model segment might

Figure 3 - 8
Levels-of-Service



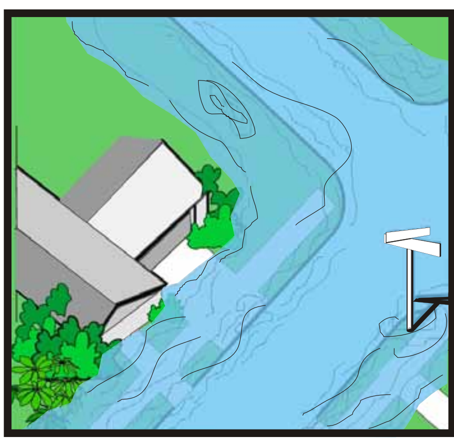
Service Level A

FLOW CONTAINED WITHIN SYSTEMS



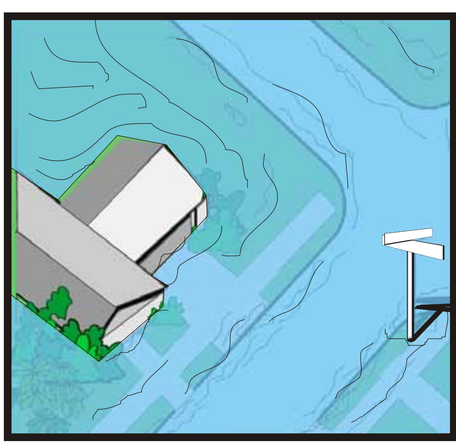
Service Level B

WATER CONTAINED WITHIN RIGHT-OF-WAY



Service Level C

WATER CONTAINED WITHIN FRONT YARD



Service Level D

STRUCTURE FLOODING

Note: Service Level descriptions apply to Street Facilities only.

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have two critical elevations. One elevation representing the top of channel bank or top of road (which ever is applicable) and one representing the finished floor of the lowest house along the same model segment. In cases where there are two potential critical elevations, the one that produces the lowest LOS rating (worst case) will be reported in the flood summary tables.

For the portion of the Little Wekiva River PSMS within Seminole County, CDM determined the LOS for each structure using the following guidelines. These guidelines were based upon the Seminole County LOS definitions.

<u>LOS for 10-year design storm criteria (primarily local roadways and swales)</u>

A = Predicted flood stage is less than or equal to the critical elevation minus 3 inches (expected edge of pavement elevation).

B = Predicted flood stage is less than or equal to the critical elevation and LOS A criterion is exceeded.

C = Predicted flood stage is less than or equal to critical elevation plus 1 inch (flow over crown of road) and LOS B criterion is exceeded.

D = Predicted flood stage is greater than critical elevation plus 1 inch.

<u>LOS for 25 year design storm criteria (primarily canals and stormwater ponds)</u>

A = Predicted flood stage is less than or equal to the critical elevation (usually top of bank elevation).

B = Predicted flood stage is less than or equal to the critical elevation plus 2 inches and LOS A criterion is exceeded.

C = Predicted flood stage is less than or equal to critical elevation plus 6 inches and LOS B criterion is exceeded.

D = Predicted flood stage is greater than critical elevation plus 6 inches.

<u>LOS for 50-year design storm criteria (primarily arterial/collector roadways)</u>

A = Predicted flood stage is less than or equal to the critical elevation minus 0.48 feet (assumed edge of pavement elevation for large roads).

B = Predicted flood stage is less than or equal to the critical elevation minus 0.355 feet and LOS A criterion is exceeded (approximate to on half of travel lane is flooded).

C = Predicted flood stage is less than or equal to critical elevation plus 1 inch and LOS B criterion is exceeded (flow over crown of road by a maximum of 1 inch).

D = Predicted flood stage is greater than critical elevation plus 1 inch (flow overtops roadway crown by more than 1 inch, roadway floods).

<u>LOS for 100-year design storm criteria</u>

A = Predicted flood stage is less than or equal to the critical elevation minus 6 inches.

B = Predicted flood stage is less than or equal to the critical elevation minus 2 inches and LOS A criterion is exceeded.

C = Predicted flood stage is less than or equal to critical elevation and LOS B criterion is exceeded.

D = Predicted flood stage is greater than critical elevation (finished floor elevation is exceeded, structure flooding).

City of Altamonte Springs

The City of Altamonte Springs defines its LOS for stormwater facilities under Policy 6-4.1.3 in its Comprehensive Plan, adopted in 2002. The City establishes the following LOS standards for stormwater quantity and quality which shall apply to all development and redevelopment:

1. The lowest floor elevation of a habitable structure must be at least one foot above the 100-year base flood elevation (BFE) floodplain as set by the Federal Emergency Management Agency (FEMA).

2. Sites shall conform to the following design standards shown in **Table 3-11**.

3. Flooding of major arterial roadways shall be limited to one half of the outer travel lane width using a peak intensity for the 10 year storm.

4. Flooding of local streets shall be limited from exceeding 1(one) inch above the crown of the road.

5. Local streets shall not flood to such an extent that they become impassable to emergency vehicles.

6. Any existing structure with a first floor elevation below the 100 year floor elevation will be treated as a nonconforming use.

7. Any new development will be built in such a manner that the development will not exceed the downstream capacity for rate and volume of runoff for the storm events listed above.

8. Discharge to natural water bodies shall be consistent with state standards as stated in 62.302.560, F.A.C., and the NPDES Stormwater Standards.

Table 3-11
Little Wekiva River Watershed Management Plan
City of Altamonte Springs Stormwater LOS

Development Type	Standard
Landlocked drainage basin-primary system design standard:	
New Development	Retain the difference in pre-development versus post-development run-off volume during the 100 year, 24 hour storm event and the St. John's River Water Management District (SJRWMD) criteria for water quality treatment, independent of project size.
Redevelopment	Retain the difference in pre-development versus post-development run-off volume during the 100 year, 24 hour storm event and the St. John's River Water Management District (SJRWMD) criteria for water quality treatment, independent of project size.
Infill Development	Retain the difference in pre-development versus post-development run-off volume during the 25 year, 6 hour storm event and the St. John's River Water Management District (SJRWMD) criteria for water quality treatment, independent of project size.
Positive Outfall (Riverine) drainage basis-primary system design standard:	
New Development	Detain the difference in pre-development versus post-development run-off volume and rate of the 10 year, 3 hour storm event and the SJRWMD criteria for water quantity and quality, independent of project size.
Redevelopment	Detain the difference in pre-development versus post-development run-off volume and rate of the 10 year, 3 hour storm event and the SJRWMD criteria for water quantity and quality, independent of project size.
Infill Development	Detain the difference in pre-development versus post-development run-off volume and rate of the 10 year, 3 hour storm event and the SJRWMD criteria for water quantity and quality, independent of project size.
For secondary system such as roads and storm sewer systems, the design storm shall be the 10 year storm event, using the "Rational method."	

3.5 Best Management Practices

This section presents various BMPs that may be considered for use in the Little Wekiva River Basin study for retrofit treatment. The BMPs are grouped as structural (constructed facilities) and non-structural (regulation or ordinances). The following BMPs are described in this section:

Structural Stormwater Controls

- Dry detention ponds
- Dry retention ponds
- Wet detention ponds
- Exfiltration trenches
- Shallow grassed swales

- Water quality inlets and baffle boxes

Non-Structural Source Controls

- Public information programs
- Fertilizer application controls
- Pesticide and herbicide use controls
- Operation and maintenance

3.5.1 Structural BMPs

This section presents a comparison of BMPs for the treatment and management of stormwater runoff. The use of a specific BMP depends on the site conditions and objectives such as water quality protection, flood control, aquifer recharge, or volume control. In many cases, there are multiple goals or needs for a given project. Therefore, BMPs can be "mixed and matched" to develop a "treatment train". The treatment train concept maximizes the use of available site conditions from the point of runoff generation to the receiving water discharge in order to maximize water quantity (flood control), water quality (pollutant load reduction), aquifer recharge, and wetlands benefits. The following comparative discussion of BMPs presents discussion on benefits and limitations of each BMP type.

Dry Detention Ponds

Detention refers to the temporary storage of excess runoff onsite prior to gradual release after the peak of the storm inflow has passed. Runoff is held for a period of time and is slowly released to a natural or manmade watercourse, usually at a rate no greater than the pre-development peak discharge rate. For water quantity, detention facilities will not reduce the total volume of runoff, but will redistribute the rate of runoff over a longer period of time by providing temporary storage for the stormwater. Another objective of a detention facility is to remove pollutants produced from the tributary area.

Dry detention ponds (sometimes referred to as extended dry detention ponds) combine the beneficial features of retention ponds (dry, grassed bottom) and wet detention ponds (flood waters detention and high pollutant removal efficiencies for settleable solids) in a hybrid design (retention refers to the capture of stormwater runoff in a holding pond and subsequent use of the captured volume for irrigation of landscape of natural pervious areas). However, they do not necessarily use certain valuable features of retention ponds (volume control and aquifer recharge) or wet detention ponds (high dissolved nutrient removal efficiencies) unless they are designed with some upstream retention prior to detention or they incorporate a small permanent pool, respectively.

Dry detention ponds increase detention times to provide treatment for the captured first-flush runoff to enhance solids settling and the removal of suspended pollutants. Extended detention facilities are drawn down through a control structure at a rate that is slow enough to achieve maximum pollutant removal by sedimentation. These types of detention ponds can be designed to achieve heavy metal loading reductions (e.g., 75 percent for lead and 40 percent for zinc) that are similar to wet detention ponds, since heavy metals in urban runoff tend to be primarily in suspended form. However, wet detention pond BMPs can achieve greater loading reductions for nutrients, which tend to appear primarily in dissolved form in urban runoff. Dry detention ponds require much less storage and cost less than wet detention ponds because they rely solely upon sedimentation processes without the expense of additional storage for the pool (i.e., portion of the pond that holds water at all times). However, in many retrofit cases, a certain fixed amount of open water area typically needs to be excavated to reduce flooding. Since this area needs to be at least six feet deep to discourage undesirable aquatic weeds, some wet detention will occur as an additional benefit. It should be noted that extended dry detention may be useful in areas where retrofit of BMPs is required. Dry detention is permittable for new development as approved by SJRWMD.

Potential Benefits of a Dry Detention Pond

- Reduction of downstream flooding problems by attenuating the peak rate of flow.
- Some removal of pollutant loadings to receiving bodies of water for suspended pollutants.
- Reduction in cost for downstream conveyance facilities.
- Creation of fill that may be used on site or sold (pond sediment removal).
- Low frequency of failure as compared with filtration systems.

Potential Limitations of a Dry Detention Pond

- Does not remove dissolved pollutants (nutrients).
- No permanent pool to store sediment inflow.
- Occasional nuisance problems such as debris and mosquitoes.
- Regular maintenance is required to prevent nuisance plant species from emerging and to remove accumulated sediments.
- Must be off-line according to the SJRWMD.

Dry Retention

According to the Florida Erosion and Sediment Control Inspector's Manual (FDEP, 2002) a dry retention pond is defined as a surface area used to store runoff for a selected design storm or specified treatment volume. Stormwater is retained on site, with the storage volume recovered when the runoff percolates into the soil or evapotranspires. Its purpose is to reduce stormwater volume, peak discharge rate, and pollutants; and to recharge ground water and base flow. When retention systems are vegetated as recommended, the runoff needs to percolate within 24 - 36 hours to assure viability of the vegetation.

Potential Benefits of a Dry Retention Pond

The retention treatment volume is retained and percolates into the ground where the soil removes particulate pollutants. This is especially beneficial if groundwater recharge is desired. Properly designed and functioning dry retention ponds can have very high removal efficiencies because most of the stormwater runoff infiltrates into the ground and does not discharge to a receiving water source. Dry ponds have been successfully integrated into multiple-use facilities such as parks and recreation areas, and with appropriate landscaping become an amenity. They also serve to recharge groundwater supplies (England, 2001).

Potential Limitations of a Dry Retention Pond

Applicability of this practice is primarily dependent upon the ability of the soils to percolate runoff, and the availability of adequate land area for a retention area or for modifications of an existing system. Geologic, topographic, and soils conditions must be considered in determining site suitability. Besides soil infiltration rates, the single most significant limiting factor in many cases is the availability of sufficient land area to provide the necessary storage volume. This is particularly true in densely urbanized areas where land is scarce and property values are high. The soil and water table conditions must also be such that the system can, in a maximum of 72 hours following a stormwater event, provide for a new volume of storage through percolation and/or evapotranspiration. Retention systems do not release stored waters for surface discharge.

Wet Detention Ponds

A wet detention system includes a permanent pool of water, a shallow littoral zone with aquatic plants, and the capacity to provide detention for an extended time necessary for the treatment of a required volume of runoff. In wet detention ponds, pollutant removal occurs primarily within a permanent pool during the period of time between storm events. They are typically sized to provide at least a 2-week hydraulic residence time during the wet season. The primary mechanism for the removal of particulate forms of pollutants in wet detention ponds is sedimentation. Wet detention ponds can also achieve substantial reductions in soluble nutrients due to biological and physical/chemical processes within the permanent pool. The facility consists of a permanent storage pool (i.e., section of the pond that holds water at all times), and for new developments or where site conditions allow, an overlying zone of temporary storage to accommodate the attenuation of peak flows. Pollutant removal within the wet detention pond can be attributed to the following important pollutant removal processes that occur within the permanent pool: uptake of nutrients by algae and rooted aquatic plants; adsorption of nutrients and heavy metals onto bottom sediments; biological oxidation of organic materials; and sedimentation of suspended solids and attached pollutants.

Uptake by algae and rooted aquatic plants is probably the most important process for the removal of nutrients. Sedimentation and adsorption onto bottom sediments are probably the most important removal mechanisms for heavy metals. Absorption conditions at the bottom of the permanent pool will maximize the uptake of phosphorus and heavy metals by bottom sediments and minimize pollutant releases from the sediments into the water column. Since ponds that exhibit thermal stratification (i.e., separation of the permanent pool into an upper layer of high temperature and a lower layer of low temperature) are likely to exhibit anaerobic bottom waters during the summer months, relatively shallow (6 to 12 feet deep) permanent pools that maximize vertical mixing are preferable to relatively deep ponds. Water depth should be great enough to prohibit nuisance aquatic plant species in the open water portion of the pond (greater than six feet). A minimum depth of 6 to 12 inches should also be maintained in the littoral zone of the permanent pool to suppress mosquito breeding.

Wet detention BMPs do offer some other advantages that should be considered in BMP selection. Wet detention ponds are usually more visually appealing than dry ponds, particularly if there is desirable wetland vegetation around the perimeter of the permanent pool. When properly designed and constructed, wet detention ponds are actually considered as property value amenities in many areas. Also, wet detention ponds offer the advantage that sediment and debris accumulate within the permanent pool. Since these accumulations are out-of-sight and well below the pond outlet, wet detention ponds tend to require less frequent cleanouts to maintain an attractive appearance and prevent clogging. Sediment forebay areas (or sumps) are recommended whenever possible.

If the contributing area is too small, storm runoff and dry weather inflows into the wet detention ponds may be too small to maintain a permanent pool during "dry" seasons. While excessive drawdown of the permanent pool does not pose a nonpoint pollution control problem, it may cause aesthetic problems.

While it can be argued that wet detention ponds can be designed to produce new wetland systems and that the additional water quality protection justifies potential wetlands impacts, extreme care and precautions must be exercised where stormwater treatment is provided through the use of existing wetlands. In these cases, the pond should be designed to re-establish wetland benefits to impacted wetlands and some swale pretreatment of pollutants should be provided.

Potential Benefits of a Wet Detention Pond

- Reduction of downstream flooding problems by attenuating the peak rate of flow.
- Reduction in pollutant loadings to receiving waters for dissolved and suspended pollutants.
- Reduction in cost for downstream conveyance facilities.
- Creation of local wildlife habitat.
- Possible higher property values as an aesthetic annuity for lots adjacent to properly designed, constructed, and maintained ponds.
- Creation of fill that can be used on site or sold.
- Low frequency of failure.
- Can be used in areas with high water tables and less permeable soils.
- Pollutant removal can be optimized with pretreatment such as retention swales.

Potential Limitations of a Wet Detention Pond

- Occasional nuisance problems such as odors, algae, debris, and mosquitoes.
- Regular maintenance of the littoral zone is required to prevent nuisance plant species from dominating this zone.
- Eventual need for sediment removal from the permanent pool or sediment forebay.

Exfiltration Trenches

An exfiltration trench is the onsite retention of stormwater accomplished through underground exfiltration. The trench can be off-line or on-line, with on-line volume requirements being greater than off-line. The subsurface retention facilities most commonly used are excavated trenches with perforated pipe backfilled with coarse graded aggregate. Stormwater runoff is collected for temporary storage and infiltration. Water is exfiltrated from the pipe and trench walls for groundwater recharge and treatment. The addition of the pipe increases the storage available in the system and helps promote infiltration by causing the runoff waters to be more effectively and evenly distributed over the entire length of the trench.

Exfiltration trenches are used to retain the "first flush" of stormwater runoff. This promotes pollutant load reductions to receiving waters, reduces the runoff volume and peak discharge rate from a site, filters suspended pollutants out of groundwater discharges, and promotes the recharge of groundwater.

Exfiltration trenches are practical in highly permeable soils (Hydrologic Group A) where the subsoil is sufficiently permeable to provide a reasonable rate of infiltration, and where the water table is sufficiently lower than the design depth of the facility to allow for recovery of the storage prior to the next storm event (generally required in 72 hours). It is frequently used for the disposal of runoff from roof drains, parking lots, and roadways. This practice is not recommended where runoff water contains high concentrations of suspended materials unless a presettling or filtering mechanism is provided. Likewise, grease and oil traps are also highly recommended prior to discharge to these systems. Providing sediment sumps in inlets or raising inlet tops above grade for pretreatment in swales will reduce sediment build-up in the trench. These precautions are primarily for maintenance since exfiltration systems are very susceptible to clogging and sediment build-up, which reduces their hydraulic efficiency and storage capacity to unacceptable levels.

Potential Benefits of an Exfiltration Trench

- They mimic the natural groundwater recharge capabilities of the site.
- Are relatively easy to fit into the margins, perimeters, and other space-constrained areas of a development site, including under pavement.
- Can provide offline treatment for environmentally sensitive waters (e.g., Class I, Class II, or OFW).
- Can be used to retrofit already developed sites where space is limited.

Potential Limitations of an Exfiltration Trench

- Require highly permeable soils to function properly.
- Difficulties in keeping sediment out of the structure during site construction.
- Not recommended for clayey or highly erodible soils.
- Have relative short life spans before replacement or extensive restoration/maintenance of system is required.
- Often more costly than other treatment alternatives, especially when operation and maintenance costs are considered.

Shallow Grassed Swales

Shallow grassed swales are natural or constructed shallow trenches shaped or gradually graded to required dimensions and established in suitable vegetation for the safe conveyance, storage, and treatment of runoff. A swale is defined by the SJRWMD as a manmade trench that:

- Has a top width-to-depth ratio of the cross-section equal to or greater than 6:1, or side slopes equal to or greater than 3 feet horizontal to 1 foot vertical.

- Contains contiguous areas of standing or flowing water only following a rainfall event.

- Is planted with or has stabilized vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake.

- Is designed to take into account the soil errodability, soil percolation, slope length, and drainage area to prevent erosion and reduce the pollutant concentration of any discharge.

Swales are normally used for conveyance systems to transport runoff offsite or to a stormwater facility. They are best suited at sites with soils of moderate-to-high infiltration capacity (usually Hydrologic Groups A or B). With slight modification (e.g., check dams, raised inlets, or swale blocks), swales can be used to add retention storage, control erosion, provide aquifer recharge, and/or reduce the pollutant load from concentrated stormwater runoff in urban areas. They also may be used as pretreatment in the overall treatment train stormwater system. Implementation examples of swales include outlet channels from detention systems; stormwater collection and treatment along roadways or residential areas; and pretreatment to reduce stormwater pollutant loads before conveying stormwater or other management practices or offsite.

Potential Benefits of Shallow Grassed Swales

- Usually less expensive than installing curb and gutters, and usually less expensive than other water quality treatment controls.

- Hardly noticeable if shallow swales (0.5 to 1.0 ft maximum depth) are designed and constructed with gradual slopes (4:1 to 6:1).

- Can provide off-line treatment for environmentally sensitive waters (e.g. Class I, Class II, or OFW).

- Can reduce peak rates of discharge by storing, detaining, or attenuating flows.

- Can reduce the volume of runoff discharged from a site by infiltrating runoff with a raised inlet or check dam.

- Maintenance can be performed by the adjacent land owner.

- Can be used in space-constrained areas such as along lot lines, rear of lots, and along roadside.

- Can be used as water quality treatment or pretreatment with other BMPs in a treatment train.

- Recovers storage and treatment volumes quickly where soils are permeable.

- Can be used as recessed landscape areas (part of green space requirement), and runoff collection becomes the source for irrigation and some nutrients (saving money) provided the use does not impact long-term maintenance or impact existing trees.

Potential Limitations of Shallow Grassed Swales

- Effective only as a conveyance system in unsuitable soils.
- Possible nuisances such as odors, mosquitoes, or nuisance plant species can occur if not designed, constructed, or maintained properly.
- Aesthetically unpleasing if improperly designed and constructed (deep with steep side slopes - looks like a ditch).
- May not be suitable or may require geotextile matting in areas that serve as vehicle parking areas.

Swales perform as infiltration BMPs in areas with permeable soils that are not restricted by a high water table. These controls can be very effective where suitable conditions exist (e.g., with Hydrologic Group A or B soils and a low water table; e.g., one to two feet below grade or lower), and these have the added benefit of increasing the recharge to the shallow water table. If swales are the only BMP used to provide water quality treatment, current Florida regulations (Chapter 62-25 FAC) require that swales be designed to percolate 80% of the runoff from a 3-year, 1-hour design storm within 72 hours (or 100% of the runoff from the 3-year, 1-hour design storm, depending on the receiving water body classification). Pretreatment uses for swales typically include 0.25 to 0.5 inches of treatment.

Water Quality Inlets and Baffle Boxes

Water quality inlets (WQIs) are designed to prevent sediment, oil and grease from entering storm drains and stormwater infiltration systems. WQIs are typically installed at catch basins, and baffle boxes are typically installed further downstream in the storm sewer.

According to the *Stormwater Best Management Practice Handbooks* prepared by CDM (2003) for the California Stormwater Quality Association, WQIs, also commonly called trapping catch basins, oil/grit separators or oil/water separators, consist of one or more chambers that promote sedimentation of coarse materials and separation of free oil (as opposed to emulsified or dissolved oil) from stormwater. Some WQIs also contain screens to help retain larger or floating debris, and many of the newer designs also include a coalescing unit that helps promote oil/water separation. A typical WQI consists of a sedimentation chamber, an oil separation chamber, and a discharge chamber.

WQIs are appropriate for capturing hydrocarbon spills, but provide very marginal sediment removal and are not very effective for treatment of stormwater runoff. These devices typically capture only the first portion of runoff for treatment and are generally used for pretreatment before discharging to other BMPs. WQIs are generally designed for sites of one acre or less. These inlets are typically used on commercial sites where high loads of sediments and oil are generated, such as gas stations, commercial stores, and small parking lots. Applications in residential areas are also becoming more frequent. Water quality inlets are typically designed to trap heavy sediments and/or oil and grease. Removal mechanisms are usually settling, filtration, and/or adsorption.

Precast oil/water separators are also available and can be installed on small commercial and industrial sites. The new coalescent plate separators are relatively efficient (50% to 80% removals are reported). These could be used for gas station and industrial area applications.

Potential Benefits of WQIs

- Can provide spill control.

Potential Limitations of WQIs

- WQIs generally provide limited hydraulic and residuals storage. Due to the limited storage, WQIs do not provide substantial stormwater improvement.
- Standing water in the devices can provide a breeding ground for mosquitoes.
- Certain designs maintain permanent sources of standing water where mosquito and other vector breeding may to occur.

Two basic designs of baffle boxes are described by Schueler (WASHCOG, 1987): the Montgomery County design and the Rockville design.

- The Montgomery County design consists of a rectangular concrete box divided into three chambers where sediment, grit, and oil are separated from stormwater runoff as it passes through the chambers before exiting through an outlet to the storm drain system. The first chamber is designed for sediment trapping, and the second chamber is designed for oil separation. Each chamber contains a permanent pool and is accessible through manhole covers. The third chamber is for final settling.
- The Rockville design also consists of three chambers. However, runoff is allowed to exfiltrate into the subsoil through weep holes located at the bottom of the chambers. These holes prevent the formation of permanent pools and provide additional pollutant removal through exfiltration.

Baffle boxes, when used in conjunction with pretreatment measures such as street sweeping, may be the most feasible water quality control device in areas where the other more traditional measures discussed previously may not be applicable due to various constraints. The design of a baffle box is identical to a primary clarifier with the addition of a skimmer for floatables. Target pollutant sizes are fine sands and larger size particles.

Maintenance requirements vary by device and application, but generally require a minimum of cleaning the chambers at least twice a year to remove pollutants. Frequent maintenance is essential for the effective removal of pollutants using these systems. The cleaning process from these devices includes pumping out the contents of each chamber into a tank truck. If the entire contents are pumped out as a slurry, they are then transferred to a sewage treatment system. If the runoff is separated from the sediments by onsite siphoning, the sediments can be trucked to a landfill for final disposal. These maintenance operations can be costly.

Potential Benefits of Baffle Boxes

- Internal baffling and other design features such as bypasses may increase performance over traditional wet vaults and/or reduce the likelihood of re-suspension and loss of sediments or floatables during high flows.
- Head loss is modest.

Potential Limitations of Baffle Boxes

- Concern about mosquito breeding in standing water
- The area served is limited by the capacity of the largest models.
- As the products come in standard sizes, the facilities will be oversized in many cases relative to the design treatment storm, increasing the cost.
- Do not remove dissolved pollutants.
- A loss of dissolved pollutants may occur as accumulated organic matter (e.g., leaves) decomposes in the units.

Skimmers

Oil and grease skimmers are a cost-effective method of prohibiting oil and grease from flowing onto receiving waterbodies. Oil and grease skimmers are easily installed and maintained. Skimmers should also be considered in the design phase of all storage/treatment facilities such as the wet detention ponds. The SJRWMD requires the use of skimmers or baffles at BMP outlets where oil and grease are expected (e.g., gasoline station) and where the upstream tributary has more than 50% of impervious surfaces. The skimmers are designed to retain the oils and greases at the surface of the retention/detention system to allow time for them to evaporate and biodegrade.

3.5.2 Nonstructural BMPs

Public Information Program

A public information participation plan provides a strategy for informing employees, the public, and businesses about the importance of protecting stormwater from improperly used, stored, and disposed pollutants. Many citizens do not realize that yard debris or trash thrown into ditches today will worsen flooding and pollute surface waters. Municipal employees must be trained, especially those that work in departments not directly related to stormwater but whose actions affect stormwater. Residents must become aware that a variety of hazardous products are used in the home and that their improper use and disposal can pollute stormwater. Likewise, improper disposal of oils, antifreeze, paints, and solvents can end up in streams and lakes, poisoning fish and wildlife. If care is taken by individuals to properly dispose of yard debris, trash, and hazardous materials, many problems can be reduced in magnitude or avoided. Increased public awareness also facilitates public scrutiny of industrial and municipal activities and will likely increase public reporting of incidents. Businesses, particularly smaller ones that may not be regulated by Federal, State, or local regulations, must be informed of ways to reduce their potential to pollute stormwater.

A key element of such a program is public awareness of the benefits of roadside swales. These BMPs cost-effectively provide both water quantity and water quality benefits. The perception by many citizens is that shallow ponding (four to six inches) for one or two days after storms during the wet season is a problem. In reality, this shallow ponding and infiltration is the onsite storage that saves money by reducing pipe sizes and cost-effectively providing water quality treatment.

Fertilizer Application Control

Fertilizer application control is a voluntary control mechanism by citizens who use fertilizer as part of their landscaping activities. Fertilizer application controls are implemented through a public information program by making the public aware of the principals of environmental landscape maintenance and the problems associated with overuse of fertilizers. Overuse of fertilizers will cause excessive runoff of nutrients to surface waters thereby wasting money for the homeowner and potentially degrading the receiving water body. This is especially true during heavy rainfall periods that produce yard and neighborhood flooding. Information programs should also be extended to professional fertilizer users.

Pesticide Use Control

Pesticide use control is also a voluntary control by citizens who use pesticides as part of their housekeeping and lawn maintenance activities. Some pesticides are priority pollutants (e.g., Endrin, Lindane, and Silvex), which can be toxic. Overuse of these chemicals can cause excessive runoff to surface waters and entry into the food chain. Many professional applicators of pesticides are using approved pesticides in a safe and proper manner. An information program on pesticide use will help to reduce the amount of pesticides entering the stormwater system.

Operation and Maintenance (O&M)

The Florida Department of Environmental Protection has reported that nearly 70 percent of existing treatment facilities in Florida are not properly maintained and therefore do not provide the intended pollutant removal effectiveness. One of the most effective non-structural BMPs is routine maintenance of existing treatment facilities. For publicly owned treatment facilities, routine maintenance and inspection should be performed. For privately owned facilities, maintenance is not typically performed by a municipality. There are several options that can be pursued by a municipality to help ensure that proper maintenance is being conducted. These options include a certification program initiated by a municipality that requires all approved subdivision ponds (private) to be recertified by the owner on a predetermined time interval. The recertification may be done by a state certified/trained inspector or engineer. Enforcement of maintenance of privately owned facilities is one of the most difficult problems for privately owned facilities. Potential enforcement measures may include City/County intervention (after sufficient notification) where critical maintenance is done by the municipality and the cost of the maintenance is billed to the owner or by other means as deemed necessary by the municipality. Another option would be to consider the assessment of fines.

Section 4
Pollutant Load Analysis

4.1 Introduction

As part of the Little Wekiva River WMP, CDM estimated the relative annual and seasonal pollutant loads for the Little Wekiva River Basin. Nonpoint source pollutant loads were estimated using the CDM Watershed Management Model (WMM), Version 4.17. The WMM was used to conceptually evaluate the 12 USEPA indicator pollutants (BOD_5, COD, TSS, TDS, TP, DP, TKN, NO_3 and NO_2, Pb, Cu, Zn, and Cd) for each of the eleven major subbasins in the Little Wekiva River Basin. The purpose of the evaluation was to identify relative changes in nonpoint source pollutant loadings due to changes in land use, areas served by septic tank, point sources and existing BMPs. This conceptual screening allows the SJRWMD and the Participants to identify areas suitable for water quality retrofit in order to address TMDL issues as well as areas that currently do not receive any water quality treatment for stormwater runoff. In order to best address the needs identified in this basin, CDM estimated pollutant loadings for several scenarios. These included:

- The entire watershed (on a subbasins basis) for existing and future (see Section 3.2.5.2 for planning horizons) land use conditions;
- Identified points of interest along the Little Wekiva River; and
- Impaired water bodies identified on FDEP's verified list that require the development of a TMDL.

The specifics of each of these scenarios will be discussed in more detail later in this section.

4.2 The Watershed Management Model (WMM)

WMM uses a database platform to estimate annual or seasonal pollutant loads from many sources within a basin. Data required to use WMM include storm water event mean concentrations (EMCs) for each pollutant type, land use, average annual precipitation. In addition, the areas served by septic systems identified, annual baseflow and average baseflow concentrations, point source flows and pollutant concentrations, and average combined sewer overflows (CSOs) and concentrations are needed if applicable. The model is a "stand alone" application that runs in Microsoft Windows 95® or greater. The following summarizes some of the features of the WMM:

- Estimates annual storm water runoff pollution loads and concentrations for nutrients (total phosphorus, dissolved phosphorus, total nitrogen, ammonia plus organic nitrogen), heavy metals (lead, copper, zinc, cadmium), and oxygen demand (BOD_5, COD) and sediment (total suspended solids, total dissolved solids) based upon EMCs, land use, percent impervious, and annual rainfall;

- Estimates stormwater runoff pollution load reduction due to partial or full-scale implementation of onsite or regional BMPs;
- Estimates annual pollution loads from stream baseflow;
- Estimates point source loads for comparison with relative magnitude of other basin pollution loads;
- Estimates pollution loads from failing septic tanks;
- Applies a delivery ratio to account for reduction in runoff pollution load due to settling of particulate matter in stream courses; and
- Imports data sets from land use data files from the spreadsheet version of WMM 3.30 into the data base version of WMM for Windows, Version 1.0.

Pollution control strategies that may be identified and evaluated using WMM include:

- Nonstructural controls (e.g., land use controls, buffer zones, etc.); and
- Structural controls (e.g., onsite and regional detention basins, grassed swales, dry detention ponds, CSO basin, sewer separation, etc.).

The model provides a basis for planning-level evaluations of the long-term (annual or seasonal) basin pollution loads and the relative benefits of pollution management strategies to reduce these loads. The WMM evaluates alternative management strategies (combinations of source and treatment storm water controls) to develop a proposed municipal NPDES stormwater management plan or other basin management plan.

Within a given basin, multiple subbasins can be evaluated. Subbasins are typically subdivided by tributary areas, outfalls, or other receiving water body within a basin. However, subbasins can be delineated based on non-hydrologic boundaries such as jurisdictional limits. This provides decision makers with information regarding the relative contribution of pollution loadings from various areas within a basin which can be used for targeting control measures to those areas which are responsible for generating the majority of the pollutant load.

The WMM consists of three major computational modules, the import utility, and numerous related database records. WMM was developed using Visual Basic® and MS Access®.

4.2.1 Basins and Pollution Sources

A "basin" is the land area which supplies all of the water that eventually flows into a downstream "receiving water" such as a river, lake, or reservoir. The major sources of water in a basin typically include rainfall runoff from the basin surface and seepage into streams from groundwater sources.

The major sources of pollutants in a basin are typically storm water runoff pollution from urban and agricultural areas and discharges from wastewater treatment plants (WWTPs) or industrial facilities. Storm water runoff pollution, traditionally referred to as "nonpoint source pollution" (NPS), discharges into streams at many dispersed points. A WWTP discharge or industrial process wastewater discharge, typically referred to as "point source pollution," releases pollution into streams at discrete points.

4.2.2 Rainfall/Runoff Relationships

Nonpoint pollution loading factors (lbs/acre/year) for different land use categories are based upon annual runoff volumes and event mean concentrations (EMCs) for different pollutants. The EMC is defined as the average of individual measurements of storm pollutant mass loading divided by the storm runoff volume. One of the keys to effective transfer of literature values for nonpoint pollution loading factors to a particular study area is to make adjustments for actual runoff volumes in the basin under study. In order to calculate annual runoff volumes for each subbasin, the pervious and impervious fractions of each land use category are used as the basis for determining rainfall/runoff relationships. For rural/agricultural (nonurban) land uses, the pervious fraction represents the major source of runoff or stream flow, while impervious areas are the predominant contributors for most urban land uses.

Annual Runoff Volume

WMM calculates annual runoff volumes for the pervious/impervious areas in each land use category by multiplying the average annual rainfall volume by a runoff coefficient. A runoff coefficient of 0.95 is typically used for impervious areas (i.e., 95% of the rainfall is assumed to be converted to runoff from the impervious fraction of each land use). A pervious area runoff coefficient of 0.20 is typically used. The total average annual surface runoff from land use L is calculated by weighting the impervious and pervious area runoff factors for each land use category as follows:

$$R_L = [C_P + (C_I - C_P)\, IMP_L\,] * I; \qquad \textit{(Equation 4-1)}$$

where:

R_L = total average annual surface runoff from land use L (in/yr);

IMP_L = fractional imperviousness of land use L;

I = long-term average annual precipitation (in/yr);

C_P = pervious area runoff coefficient; and

C_I = impervious area runoff coefficient.

Total runoff in a basin is the area-weighted sum of R_L for all land uses.

4.2.3 Nonpoint Pollution Event Mean Concentrations

The Watershed Management Model estimates loads from pollutants which are most frequently associated with nonpoint pollution sources, including, but not limited to:

- Oxygen Demand
  - Biochemical Oxygen Demand (BOD_5)
  - Chemical Oxygen Demand (COD)
- Sediment
  - Total Suspended Solids (TSS)
  - Total Dissolved Solids (TDS)
- Nutrients
  - Total Phosphorus (TP)
  - Dissolved Phosphorus (DP)
  - Total Kjeldahl Nitrogen (TKN)
  - Nitrate + Nitrite Nitrogen (NO3 +NO2)
- Heavy Metals
  - Lead (Pb)
  - Copper (Cu)
  - Zinc (Zn)
  - Cadmium (Cd)

Estimates of the annual load of most of these pollutants were also specified as part of the Phase I National Pollutant Discharge Elimination System (NPDES) stormwater permitting program. These pollutants and their impacts on water quality and aquatic habitat are described below.

Oxygen Demand: Biochemical Oxygen Demand (BOD_5) is caused by the decomposition of organic material in storm water which depletes dissolved oxygen (DO) levels in slower moving receiving waters such as lakes and estuaries. Low dissolved oxygen is often the cause of fish kills in streams and reservoirs. The degree of DO depletion is measured by the BOD_5 test that expresses the amount of easily oxidized organic matter present in water.

Sediment: Sediment from nonpoint sources is the most common pollutant of surface waters. Many other toxic contaminants adsorb to sediment particles or solids suspended in the water column. Excessive sediment can lead to the destruction of habitat for fish and aquatic life. Total suspended solids (TSS) is a laboratory measurement of the amount of sediment particles suspended in the water column. Excessive sediment pollution is primarily associated with poor sedimentation controls at construction sites in developing areas or unstable channels throughout river systems.

Nutrients: Nutrients (phosphorus and nitrogen) are essential for plant growth. Within a lake, impoundment, or other slow moving receiving water, high concentrations of nutrients, particularly phosphorus, can result in overproduction of algae and other aquatic vegetation. Excessive levels of algae present in a receiving water is called an algal bloom. Algal blooms typically occur during the summer when sunlight and water temperature are ideal for algal growth. Water quality problems associated with algal blooms range from simple nuisance or unaesthetic conditions, to noxious taste and odor problems, oxygen depletion in the water column, and fish kills. Collectively, the problems associated with excessive levels of nutrients in a receiving water are referred to as eutrophication impacts. Control of nutrients discharged to streams can severely limit algal productivity and minimize the water quality problems associated with eutrophication.

Heavy Metals: Heavy metals are toxic to humans and are subject to State and Federal drinking water quality standards. Heavy metals are also toxic to aquatic life and may bioaccumulate in fish. Lead, copper, zinc and cadmium are heavy metals which typically exhibit higher nonpoint pollutant loadings than other metals found in urban runoff. The presence of these heavy metals in streams and reservoirs in the basin may also be indicative of problems with a wide range of other toxic chemicals, like synthetic organics, that have been identified in previous field monitoring studies of urban runoff pollution (USEPA, 1983b).

Event Mean Concentrations

Over the past 20 years, nonpoint pollution monitoring studies throughout the U.S. have shown that annual "per acre" discharges of urban storm water pollution (e.g., nutrients, metals, BOD_5) are positively related to the amount of imperviousness in the land use (i.e., the more imperviousness the greater the nonpoint pollution load) and that the EMC is fairly consistent for a given land use. The EMC is a flow-weighted average concentration for a storm event and is defined as the sum of individual measurements of storm water pollution loads divided by the storm runoff volume. The EMC is widely used as the primary statistic for evaluations of storm water quality data and as the storm water pollutant loading factor in analyses of pollutant loadings to receiving waters.

Nonpoint pollution loading analyses typically consist of applying land use specific storm water pollution loading factors to land use scenarios in the basin under study. Runoff volumes are computed for each land use category based on the percent impervious of the land use and the annual rainfall. These runoff volumes are multiplied by land use specific mean EMC load factors (mg/L) to obtain nonpoint pollution loads by land use category. This analysis can be performed on a subarea or basin-wide basis, and the results can be used for performing load allocations or analyzing pollution control alternatives, or for input into a riverine water quality model.

Selection of nonpoint pollution loading factors depends upon the availability and accuracy of local monitoring data as well as the effective transfer of literature values for nonpoint pollution loading factors to a particular study area.

EMC monitoring data collected by the USEPA's Nationwide Urban Runoff Program (NURP) and the Federal Highway Administration (FHWA) were determined to be log normally (base e) distributed. The log normal distribution allows the EMC data to be described by two parameters, the mean or median which is a measure of central tendency, and the standard deviation or coefficient of variation (standard deviation divided by the mean) which is a measure of the dispersion or spread of the data. The median value should be used for comparisons between EMCs for individual sites or groups of sites because it is less influenced by a small number of large values which is typical of lognormally distributed data. For computations of annual mass loads, it is more appropriate to use the mean value since large infrequent events can comprise a significant portion of the annual pollutant loads.

To estimate annual pollutant loads discharged to receiving waters from a municipality, median EMCs are converted to mean values (USEPA, 1983b; Novotny, 1992) by the following relationship:

$$M = T * ((1 + CV^2))^{1/2}; \qquad \textit{(Equation 4-2)}$$

where:

M = arithmetic mean;

T = median; and

CV= coefficient of variation = standard deviation/mean.

4.2.4 Nonpoint Pollution Loading Factors

WMM estimates pollutant loadings based upon nonpoint pollution loading factors (expressed as lbs/ac/yr) that vary by land use and the percent imperviousness associated with each land use. The pollution loading factor M_L is computed for each land use L by the following equation:

$$M_L = EMC_L * R_L * K; \qquad \textit{(Equation 4-3)}$$

where:

M_L = loading factor for land use L (lbs/ac/yr);

EMC_L = event mean concentration of runoff from land use L (mg/l); EMC_L varies by land use and by pollutant;

R_L = total average annual surface runoff from land use L computed from Equation 4-1 (in/yr); and

K = 0.2266, a unit conversion constant.

By multiplying the pollutant loading factor by the acreage in each land use and summing for all land uses, the total annual pollution load from a subbasin can be computed. The EMC coverage is typically not changed for various land use scenarios within a given study basin, but any number of land use data sets can be created to examine and compare different land use scenarios (e.g., existing versus future) or land use management scenarios.

BMP Pollutant Removal Efficiencies

The Watershed Management Model applies a constant removal efficiency for each pollutant to all land use types to simulate treatment BMPs. Typical pollutant removal efficiencies for swales, extended dry and wet detention ponds, baffle boxes and retention ponds are shown in **Table 4-1**.

Calculation of Pollutant Loading Reduction from BMPs

The effectiveness of BMPs in reducing nonpoint source loads is computed for each land use in each subbasin. Up to five BMPs per land use can be specified. The percent reduction in nonpoint pollution per pollutant type in each subbasin of the basin is calculated as:

$$P_{L,SB} = (AC_{1,SB}(REM_1) + (AC_{2,SB}(REM_2) + (AC_{3,SB}(REM_3) + (AC_{4,SB}(REM_4) + (AC_{5,SB}(REM_5) \qquad \text{(}\textit{Equation 4-4}\text{)}$$

Table 4-1
Little Wekiva River Watershed Management Plan
Ranges of BMP Removal Efficiencies (%)

Parameter	Dry Detention (1)	Wet Detention (1)	Swale (1)	Baffle Boxes(2)	Retention Ponds(1)
BOD_5	20 - 30	20 - 30	20 - 40	0	90
COD	20 - 30	20 - 30	20 - 40	0	90
TSS	60 - 90	80 - 90	70 - 90	80	90
TDS	0	30 - 40	0 - 10	0	90
Total -P	20 - 30	40 - 65	30 - 50	35	90
Dissolved P	0	60 - 70	0 - 20	0	90
TKN	10 - 20	20 - 30	30 - 50	5	90
NO_2+NO_3	0	30 - 40	30 - 50	0	90
Lead	70 - 80	70 - 80	60 - 90	75	90
Copper	50 - 60	60 - 70	40 - 60	50	90
Zinc	40 - 50	40 - 50	40- 50	35	90
Cadmium	70 - 80	70 - 80	50 - 80	60	90

(1) Watershed Management Model Version 4.0 User's Manual. CDM, 1998.
(2) Big Creek Watershed Study, Fulton County, GA. CDM, 2001.

where:

$P_{L,SB}$ = percent of annual nonpoint pollution load captured in subbasin SB by application of the five BMP types on land use L;

$AC_{1,SB}$; $AC_{2,SB}$; $AC_{3,SB}$; $AC_{4,SB}$; $AC_{5,SB}$ = fractional area coverage of BMP types 1 through 5 on subbasin SB;

REM_1; REM_2 = REM_3; REM_4; REM_5 removal efficiency of BMP types 1 through 5 respectively; REM; varies by pollutant type but not by land use or subbasin.

Equation 4-4 enables the user to examine the effectiveness of various BMPs and the degree of BMP coverage within a basin. Coverage might vary depending upon whether the BMP is applied to new development only, existing plus new development, etc. Also, topography may limit the areal coverage of some BMPs.

The nonpoint pollution load from a basin is thus computed by combining Equations 4-3 and 4-4 and summing over all land uses and all subbasins; i.e.,

$$MASS = \sum_{SB=1}^{N} \sum_{L=1}^{15} M_{L,SB}(1 - P_{L,SB}); \qquad \textit{(Equation 4-5)}$$

where:

MASS = annual nonpoint pollution load washed off the basin in lbs/yr with BMPS taken into account.

The resultant model is a very versatile yet simple algorithm for examining and comparing nonpoint pollution management alternatives for effectiveness in reducing nonpoint pollution.

4.2.5 Failing Septic Tank Impacts

Many of the residential developments within the U.S. rely on household septic tanks and soil absorption fields for wastewater treatment and disposal. The nonpoint pollution loading factors for low density residential areas, which are typically served by septic tank systems, are based on test basin conditions where the septic systems were in good working order and made no significant contribution to the monitored nonpoint pollution loads. In fact, septic tank systems typically have a limited useful life expectancy and failures are known to occur, causing localized water quality impacts. This section presents a method for estimating average annual septic tank failure rates and the additional nonpoint pollution loadings from failing septic systems.

To estimate an average annual failure rate, the time series approach proposed by the 1986 USEPA report Forecasting Onsite Soil Absorption System Failure Rates was used. This approach considers an annual failure rate (percent per year of operation), future population growth estimates, and system replacement rate to forecast future overall failure rates. Annual septic tank failure rates reported for areas across the U.S. range from about 1% to 3%. For average annual conditions, it is conservative to expect that septic tank systems failures would be unnoticed or ignored for five years before repair or replacement occurred. Therefore, during an average year, 5% to 15% of the septic tanks systems in the basin are estimated to be failing.

This is consistent with the results of a survey conducted in Jacksonville, Florida, by the Department of Health and Rehabilitative Services. Of more than 800 site inspections, about 90 violations had been detected. Types of violations detected were typically: (1) drain field located below groundwater table, (2) direct connections between the tile field and a stream, and (3) structural failures. The violation rate of 11% is consistent with the average year septic tank failure rate and period of failure before discovery/remediation. The "impact zone" or the "zone of influence" for failing septic tanks can be estimated to be all residential areas that are not served by public sewer.

Pollutant loading rates for failing septic systems were developed from a review of septic tank leachate monitoring studies. The range of concentrations of total-P and total-N based upon literature values are as follows:

	Total-P	Total-N
Low	1.0 mg/L	7.5 mg/L
Medium	2.0 mg/L	15.0 mg/L
High	4.0 mg/L	30.0 mg/L

Annual "per acre" loading rates for septic tank failures from low density residential land uses were then estimated using 50 gallons per capita per day wastewater flows. The loading rates can be applied to the percentage of all non-sewered residential land uses with failing septic tanks. The septic tank loading factors are included in the runoff pollution loading factors. The range of percent increases in annual per acre loadings attributed to failing septic tanks is:

	Total-P	Total-N
Low	130%-180%	120%-150%
Medium	160%-250%	140%-200%
High	220%-400%	180%-310%

To assess the increase in surface runoff load due to failing septic tanks, WMM considers a multiplication factor. This multiplication factor is applied to the phosphorus (dissolved P, total P) and nitrogen (TKN, NO_2+NO_3-N) parameters.

Consequently, the load from a residential area with failing septic tanks is:

(surface runoff load without failing septic tanks) x

((multiplication factor) x (% of area with failing septic tanks/100%) + (1 - (% of area with failing septic tanks)/100%))

Despite the large increase in annual loading rates, septic tank failures typically have only a limited impact on overall nonpoint pollution discharges. This is because the increased annual loading rates are applied only to the fraction of non-sewered residential development that are predicted to have a failing septic tank system during an average year. Based upon this methodology, failing septic tank systems typically would contribute less than 10% of total nonpoint loadings.

4.2.6 Point Source Loadings

Pollutant loadings from point source discharges such as package wastewater treatment plants (WWTP), regional WWTPs, and industrial sources can also be estimated to determine the relative contributions of point versus other watershed pollution loadings. An inventory of package plants and industrial discharges within each subbasin are typically developed from utility location maps and discharge permit data. Package plants and industrial dischargers usually are assumed to be discharging effluent at their permit limits where compliance monitoring data are not available. Where data on permit limits are not readily available, package plant discharges can be represented by following effluent concentrations which are based on typical effluent limits for secondary WWTPs:

- Total-P 6.0 mg/L
- Total-N 12.0 mg/L
- Lead 0.0 mg/L
- Zinc 0.0 mg/L

If permit data on industrial discharges are not available, then pollutant loads for each point source discharge are estimated for each subbasin by multiplying the discharge flow rate by the effluent concentration.

4.2.7 Model Limitations

The Watershed Management Model was developed to estimate the relative changes in nonpoint source pollutant loads (average annual or seasonal) due to changes in land use or from the cumulative effects of alternative basin management decisions (e.g. treatment BMPs). The models should be applied to appropriate spatial (basin wide) and temporal (average annual or seasonal) scales. It is not appropriate to use these input/output models for analysis of short-term (i.e., daily, weekly) water quality impacts. It is also not appropriate to use WMM to estimate absolute loads for a given outfall system without specific monitoring data for that system.

4.3 WMM Data Analysis

There are eleven major subbasins in the Little Wekiva River Basin as previously shown in Figure 3-2. These subbasins range in size from 585 to 11,858 acres in total area. The following sections describe how land use, BMP, septic tank, point source and other data was obtained and processed to perform the pollution loading analysis.

4.3.1 WMM Model Scenarios

By evaluating the relative changes in nonpoint source pollutant loadings due to changes in land use, septic tank impacts, point sources and existing BMPs within the watershed boundaries, the WMM was used as a screening tool to identify areas suitable for water quality retrofit in order to address areas with higher relative pollutant loads as well as TMDL issues. Based on FDEP's Verified List of Impaired Waters (May 2004) for the Middle St. Johns River Basin, there are 10 water bodies/segments within the Little Wekiva River Basin that are required to have a TMDL developed for them by 2008 with the exception of Lake Lucien which is scheduled for 2011. The impaired water bodies include:

- Bay Lake
- Lake Adelaide
- Lake Florida
- Lake Lawne
- Lake Lucien
- Lake Orienta
- Little Wekiva Canal

- Little Wekiva River
- Silver Lake
- Spring Lake

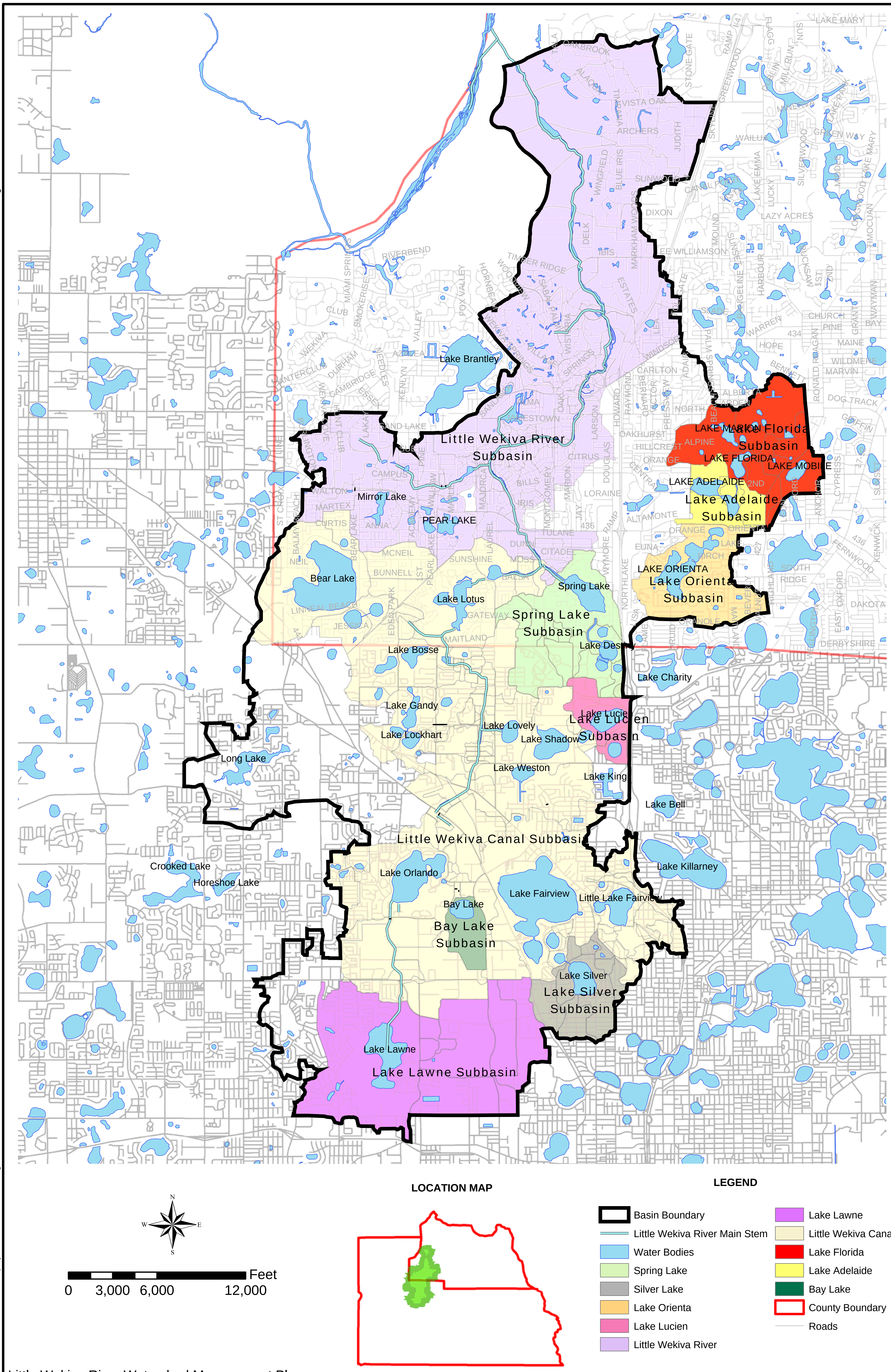
The locations of these water bodies were previously shown on Figure 2-13 and the parameters for which they are listed were shown in Table 2-6. The tributary areas for the TMDL water bodies are shown in **Figure 4-1**. Please note that for the purpose of this effort, the tributary areas for the Little Wekiva River and the Little Wekiva Canal as identified by FDEP do not include the closed basins (i.e., Woodsmere, Long Lake and Cranes Roost) as these areas are not pumped to the river on a continuous basis. They were however, taken into account in the scenario that evaluated all the 11 major subbasins that make up the entire watershed. In addition to these two scenarios, CDM also used the WMM to estimate pollutant loadings for several points of interest along the Little Wekiva River. The purpose of this work was to determine which segments of the river may be receiving greater loads and where planning efforts should be focused to potentially reduce these loads. These points of interest primarily coincide with locations where tributaries discharge into the river as well as at jurisdictional boundaries (i.e., the County line). The locations of these points of interests are shown on **Figure 4-2**.

4.3.2 Land Use

As described in Section 3.2.5.1, the existing and future land use coverages originally obtained from the local municipalities were reviewed and compared against 2000 digital ortho-photo quads (DOQs) and modified where necessary in order to reflect greater accuracy of the land cover. To be consistent with the 1998 Study, FLUCCS codes established by the FDOT were used for the land use categories. Subbasin shape files were then intersected with the land use shape files to determine the land use distribution by subbasin. For simplification, the FLUCCS categories were consolidated into thirteen major categories for the purpose of the WMM, as shown in **Table 4-2**. These thirteen land use categories generally correspond to land use categories that have EMC data available. The existing land use showing the thirteen major categories for the basin is presented in **Figure 4-3**, and the future land use is presented in **Figure 4-4**.

Table 4-3 presents the acreages of each of the thirteen land use categories in the major subbasins for present and future land use conditions.

Runoff coefficients for pervious and impervious areas were obtained from the previous NPDES permit applications for Seminole and Orange Counties. The same is true for the percent DCIA for the land uses with one exception, that for wetlands/waterbodies. Studies done at the University of Florida have indicated that wetlands export about only 25% of the annual rainfall to other wetlands or water bodies due to internal storage within the wetlands. Lakes export a slightly higher



Little Wekiva River Watershed Management Plan

CDM

Figure 4-1
TMDL Tributary Areas

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gebhardtdm

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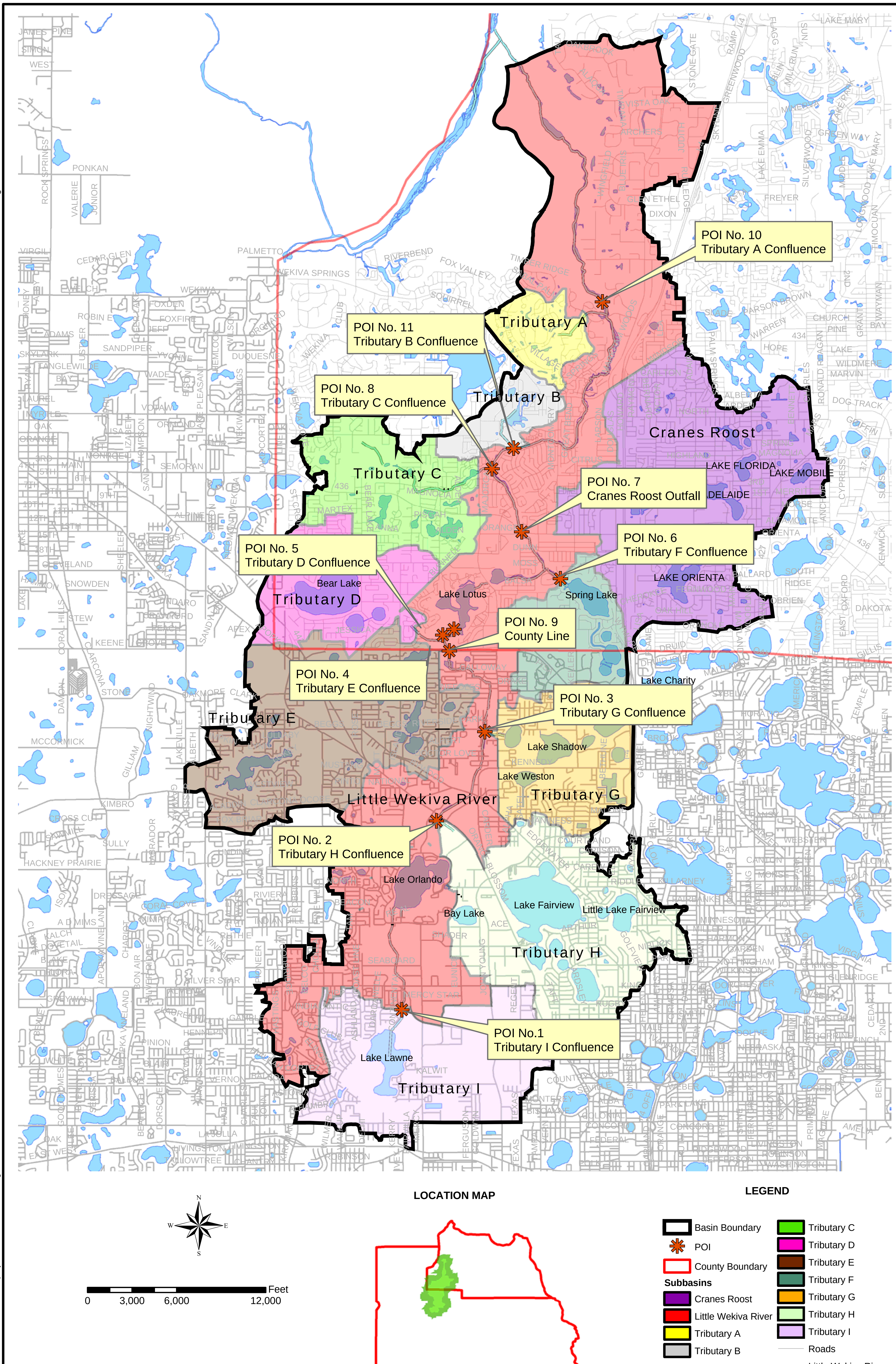


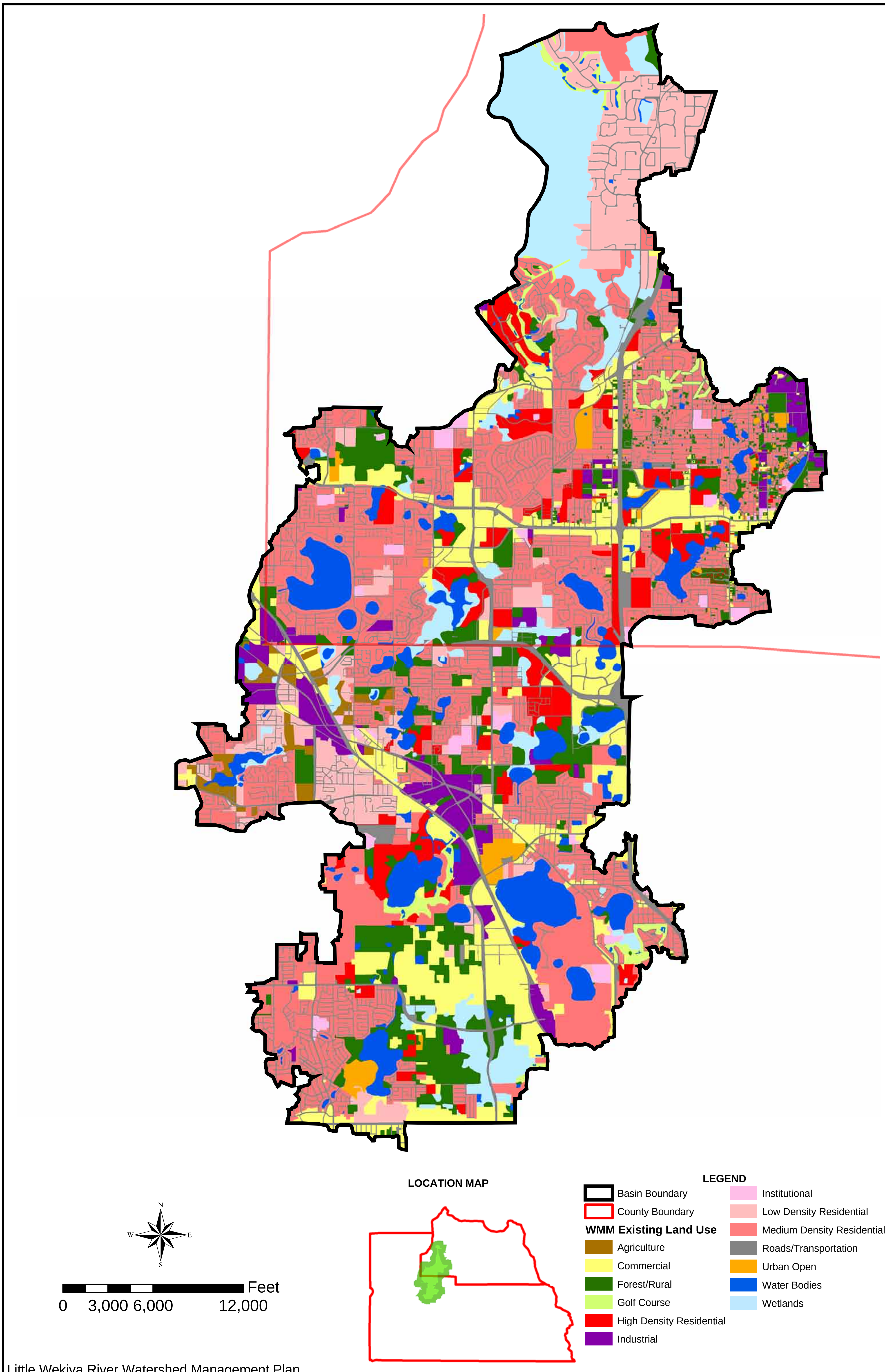
Little Wekiva River Watershed Management Plan

CDM

Figure 4-2
WMM Points of Interest

Table 4-2
Little Wekiva River Watershed Management Plan
WMM Land Use Categories

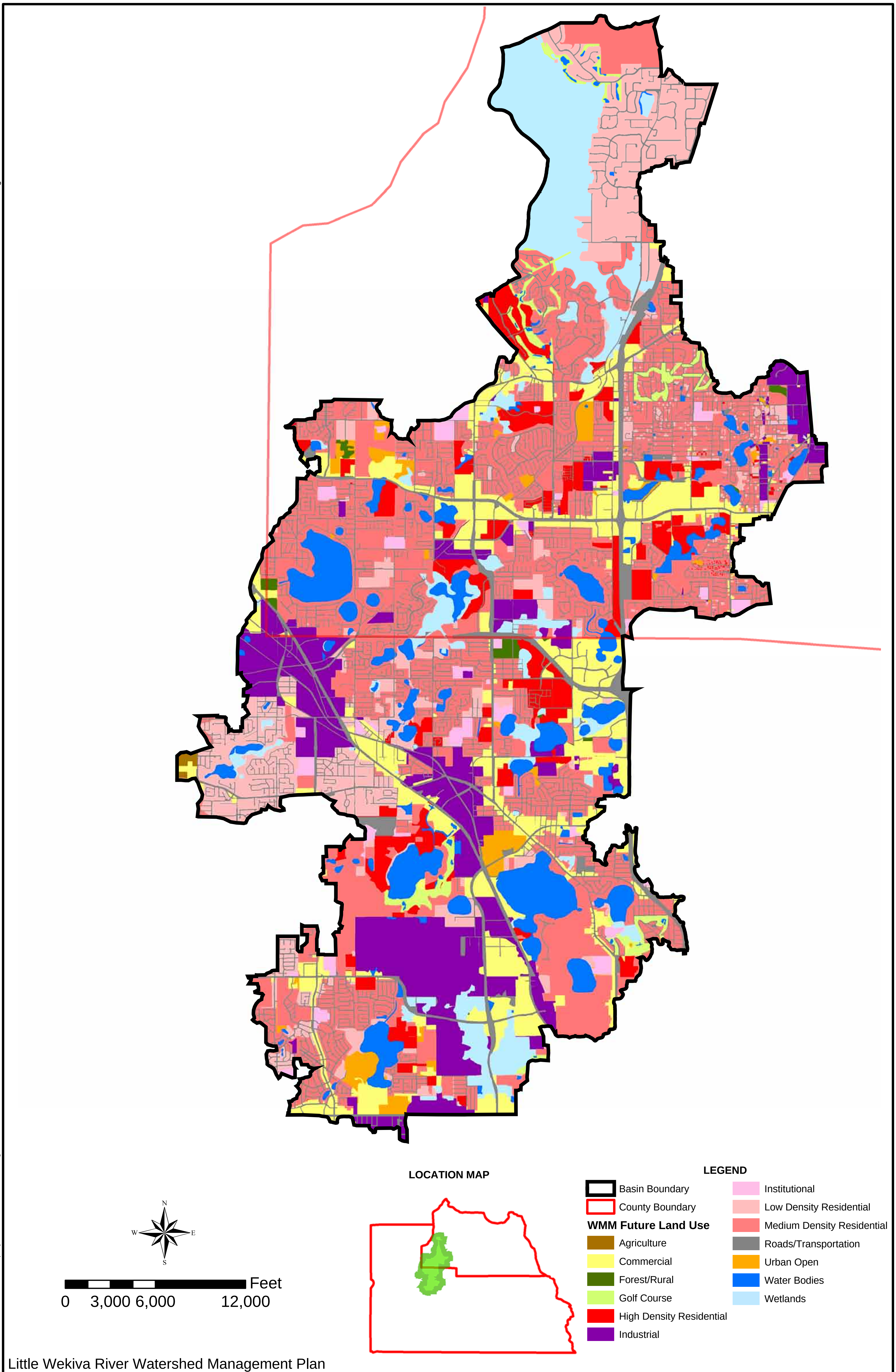
FLUCCS Land Use Category	WMM Land Use
Agricultural	Agricultural
Commercial Professional Services	Commercial
Golf Course	Golf Course
Institutional Religious Educational Facilities Government Building	Institutional
Industrial Utilities	Industrial
Roads and Highways Transportation Railroad	Highways
Low Density Residential	Low Density Residential
Medium Denisty Residential	Medium Denisty Residential
High Density Residential Multiple Dwelling Units	High Density Residential
Forest Open Land Shrub and Brushland	Forest/Rural Open
Cemetery Recreation	Urban Open
Water Body Stormwater Pond	Water
Wetlands	Wetlands



Little Wekiva River Watershed Management Plan

CDM

Figure 4-3
WMM Existing Land Use



Little Wekiva River Watershed Management Plan

Figure 4-4
WMM Future Land Use

Table 4-3
Little Wekiva River Watershed Management Plan
WMM Land Use Acreages

WMM Land Use	Existing Land Use		Future Land Use	
	Acres	%	**Acres**	%
Agricultural	821	2.4%	33	0.1%
Commercial	3,532	10.2%	3,166	9.1%
Golf Course	382	1.1%	384	1.1%
Institutional	476	1.4%	578	1.7%
Industrial	1,531	4.4%	3,728	10.7%
Highways	4,346	12.5%	4,384	12.6%
Low Density Residential	3,137	9.0%	4,873	14.0%
Medium Density Residential	9,477	27.3%	9,834	28.3%
High Density Residential	1,712	4.9%	1,744	5.0%
Forest/Rural Open	3,335	9.6%	106	0.3%
Urban Open	389	1.1%	522	1.5%
Water	2,572	7.4%	2,518	7.3%
Wetlands	3,020	8.7%	2,860	8.2%
TOTAL	34,730	100.0%	34,730	100.0%

Note: The actual total area of the Little Wekiva Basin is 37,445 acres. However, for the purpose of the WMM, the acreages for hydrologic units that are completely closed from the primary system are excluded.

value (approximately 30%). For this study, an average of the two was used for the combined water/wetland land use category.

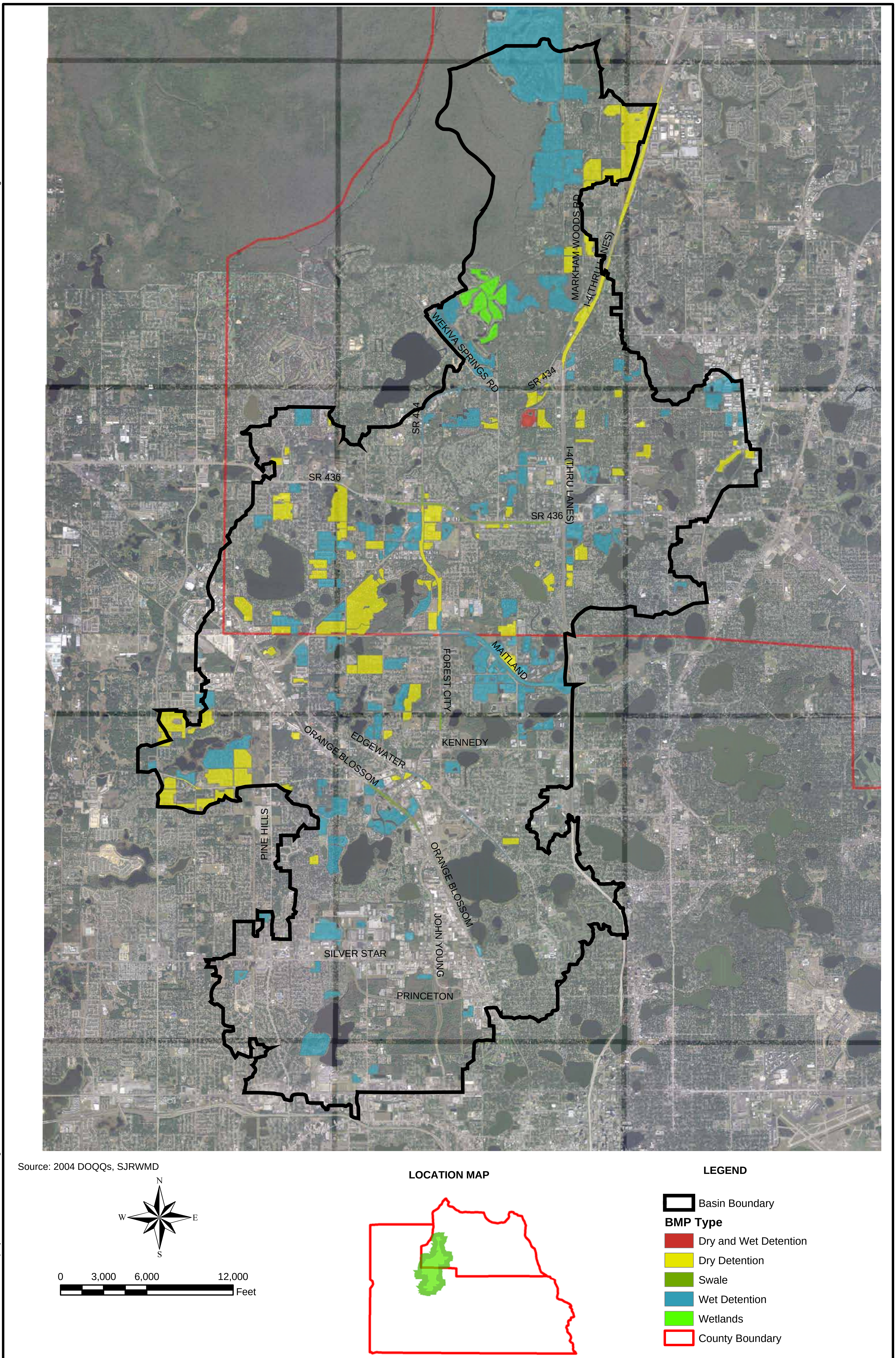
4.3.3 BMP Identification and Pollution Removal Efficiencies

The existing BMPs were identified using existing aerial photography, GIS stormwater structure inventory data available from Seminole County and Altamonte Springs, local knowledge of the area as well as parcel maps. The BMP treatment areas from these data sources were then mapped in ArcView. Approximately 5,360 acres or 8.4 square miles within the Little Wekiva River Basin are served by BMPs as shown in **Figure 4-5**. **Tables 4-4** and **4-5** presents the BMP type and the acreage and percent land use served by each type of BMP under existing and future conditions, respectively.

For future land use conditions, it was expected that all future development (i.e., those lands considered developable based on land use) will have treatment by BMPs based on current regulations (the most likely scenario). This was done to show the pollution reduction benefits of mandating BMPs for all future development. The locations of BMPs under the future land use scenario are shown in **Figure 4-6**.

There are five types of BMPs that were identified in the Little Wekiva River Basin: wet detention, dry detention, wet and dry detention (treatment train) swales and wetlands. The treatment removal efficiencies for wet detention, dry detention and swales were based on published literature values as those shown in Table 4-1. Treatment wetlands are treated as wet detention in the WMM as their abilities in removing pollutants are similar.

Since combination BMPs (i.e., wet and dry detention) are not standard default BMPs included in the WMM, it was necessary to create a new BMP type for wet detention/dry detention from their individual treatment efficiencies. These efficiencies are estimated by calculating the “minimum” and “maximum” efficiency of the two BMPs in question. The minimum efficiency would be the maximum of the two BMPS. As an example, the efficiency for copper for wet detention and dry detention is 60 and 70 percent, respectively. It is safe to assume that at least a 70 percent removal will occur in the dry detention facility. The equation for "maximum efficiency" assumes that each BMP in series has the same efficiency it would have if it was the only BMP. For example, a wet detention BMP was assumed to have a BMP efficiency of 60 percent for copper, and a dry detention pond was assumed to have 70 percent removal efficiency for copper. Under the "maximum efficiency" calculation, wet detention would remove 60 percent (e.g., of a 100-pound load, 60 lb would be removed and 40 lb would be discharged) and the second BMP (dry detention) would remove 70 percent of the copper discharged by the first BMP (in the example, 40 lb is discharged by the first BMP into the second BMP and of that 40 lb, 28 lb (70%) is removed and 12 lb (30%) is discharged). The maximum efficiency would be 88% (100 lb into the BMP series, 88 lb removed and 12 lb discharged).



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Little Wekiva River Watershed Management Plan

CDM

Figure 4-5
Existing BMP Tributary Areas

Table 4-4
Little Wekiva River Watershed Management Plan
Existing Land Use BMP Treatment Data

	Cranes Roost						LWR							
	Swales		Wet Detention		Dry Detention		Swales		Wet Detention		Dry Detention		Dry/Wet Detention	
Land Use	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served
Agricultural	0.0	0.0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Commercial	0.2	0.1%	71.4	16%	8.3	2%	0.1	0%	88.2	10%	111.6	12%	0.0	0%
Golf Course	0.0	0.0%	0.0	0%	0.0	0%	0.0	0%	23.1	14%	0.0	0%	0.0	0%
Institutional	0.0	0.0%	0.0	0%	5.6	7%	0.0	0%	1.0	2%	0.3	0%	0.0	0%
Industrial	0.0	0.0%	52.9	22%	8.9	4%	0.0	0%	22.1	7%	13.7	4%	0.0	0%
Highways	9.0	1.6%	19.4	3%	23.8	4%	27.4	2%	131.6	10%	178.5	14%	0.0	0%
Low Density Residential	0.0	0.0%	0.0	0%	0.0	0%	0.0	0%	443.7	28%	227.3	14%	0.0	0%
Medium Density Residential	0.0	0.0%	14.1	2%	25.6	3%	0.0	0%	372.3	12%	136.2	4%	0.1	0%
High Density Residential	0.0	0.0%	92.7	29%	33.4	10%	0.3	0%	127.6	23%	48.0	9%	0.0	0%
Forest/Rural Open	0.0	0.0%	31.6	8%	14.6	4%	0.0	0%	34.4	4%	1.1	0%	0.0	0%
Urban Open	0.0	0.0%	0.1	0%	0.4	1%	0.0	0%	0.0	0%	0.0	0%	24.7	31%
Water	0.0	0.0%	0.8	0%	0.0	0%	0.0	0%	6.4	2%	0.0	0%	0.0	0%
Wetlands	0.0	0.0%	0.0	0%	0.0	0%	0.0	0%	50.982	2%	4.677	0%	0.0	0%

	TRIBA		TRIBB		TRIBC						TRIBD			
	Wet Detention		Wet Detention		Swales		Wet Detention		Dry Detention		Wet Detention		Dry Detention	
Land Use	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served
Agricultural	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Commercial	12.0	63%	17.0	12%	0.0	0%	55.6	21%	13.5	5%	0.4	1%	0.0	0%
Golf Course	8.8	10%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Institutional	0.0	0%	0.0	0%	0.0	0%	0.2	1%	11.6	47%	12.4	43%	1.2	4%
Industrial	0.04	1%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	1.7	2%	3.4	5%
Highways	29.6	38%	22.6	29%	6.1	2%	11.1	4%	7.5	3%	12.0	6%	38.9	19%
Low Density Residential	1.0	6%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	18.4	31%	2.1	4%
Medium Density Residential	85.3	45%	1.7	1%	0.0	0%	70.3	9%	37.2	5%	97.0	11%	151.1	17%
High Density Residential	105.8	64%	32.7	46%	0.0	0%	14.4	11%	51.3	40%	0.0	0%	0.0	0%
Forest/Rural Open	1.7	6%	0.0	0%	0.0	0%	3.6	1%	1.9	1%	1.8	4%	0.5	1%
Urban Open	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	1%	0.0	0%
Water	3.7	20%	0.6	6%	0.0	0%	0.9	1%	2.0	2%	0.0	0%	0.0	0%
Wetlands	0.03	0.1%	1.365	2%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%

	TRIBE				TRIBF				TRIBG					
	Wet Detention		Dry Detention		Wet Detention		Dry Detention		Swales		Wet Detention		Dry Detention	
Land Use	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served
Agricultural	15.3	2%	1.9	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Commercial	9.4	4%	8.5	4%	67.2	36%	18.1	10%	0.0	0%	47.2	28%	2.3	1%
Golf Course	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Institutional	39.2	41%	18.6	19%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Industrial	60.8	10%	6.7	1%	10.1	13%	20.1	26%	0.0	0%	0.0	0%	0.0	0%
Highways	59.3	8%	114.0	15%	57.3	31%	4.4	2%	2.6	1%	43.5	19%	0.0	0%
Low Density Residential	17.5	2%	51.1	4%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Medium Density Residential	235.5	20%	384.9	32%	23.8	7%	12.7	4%	0.0	0%	1.1	0.3%	0.0	0%
High Density Residential	20.7	56%	0.0	0%	61.7	48%	0.2	0.1%	0.0	0%	85.8	45%	0.0	0%
Forest/Rural Open	1.0	0%	17.6	2%	5.0	7%	2.0	3%	0.0	0%	14.5	6%	0.0	0%
Urban Open	0.0	0%	0.0	0%	0.0	0%	0.1	84%	0.0	0%	0.0	0%	0.0	0%
Water	1.2	0%	1.2	0.4%	0.0	0%	0.0	0%	0.0	0%	0.1	0.05%	0.0	0%
Wetlands	1.35	1%	0.272	0.1%	2.4	2%	0.856	1%	0.0	0%	5.1	5%	0.0	0%

	TRIBH						TRIBI	
	Swales		Wet Detention		Dry Detention		Wet Detention	
Land Use	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served
Agricultural	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Commercial	0.0	0%	29.5	5%	0.0	0%	9.1	2%
Golf Course	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Institutional	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Industrial	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Highways	5.3	1%	11.1	3%	2.4	1%	2.3	1%
Low Density Residential	0.0	0%	0.0	0%	0.0	0%	6.3	6%
Medium Density Residential	0.0	0%	0.2	0%	9.7	1%	8.1	1%
High Density Residential	0.0	0%	10.0	18%	0.0	0%	0.0	0%
Forest/Rural Open	0.0	0%	2.9	2%	0.0	0%	9.6	2%
Urban Open	0.0	0%	0.0	0%	0.0	0%	65.0	65%
Water	0.0	0%	3.8	1%	0.0	0%	0.1	0%
Wetlands	0.0	0%	0.0	0%	0.3	1%	0.1	0%

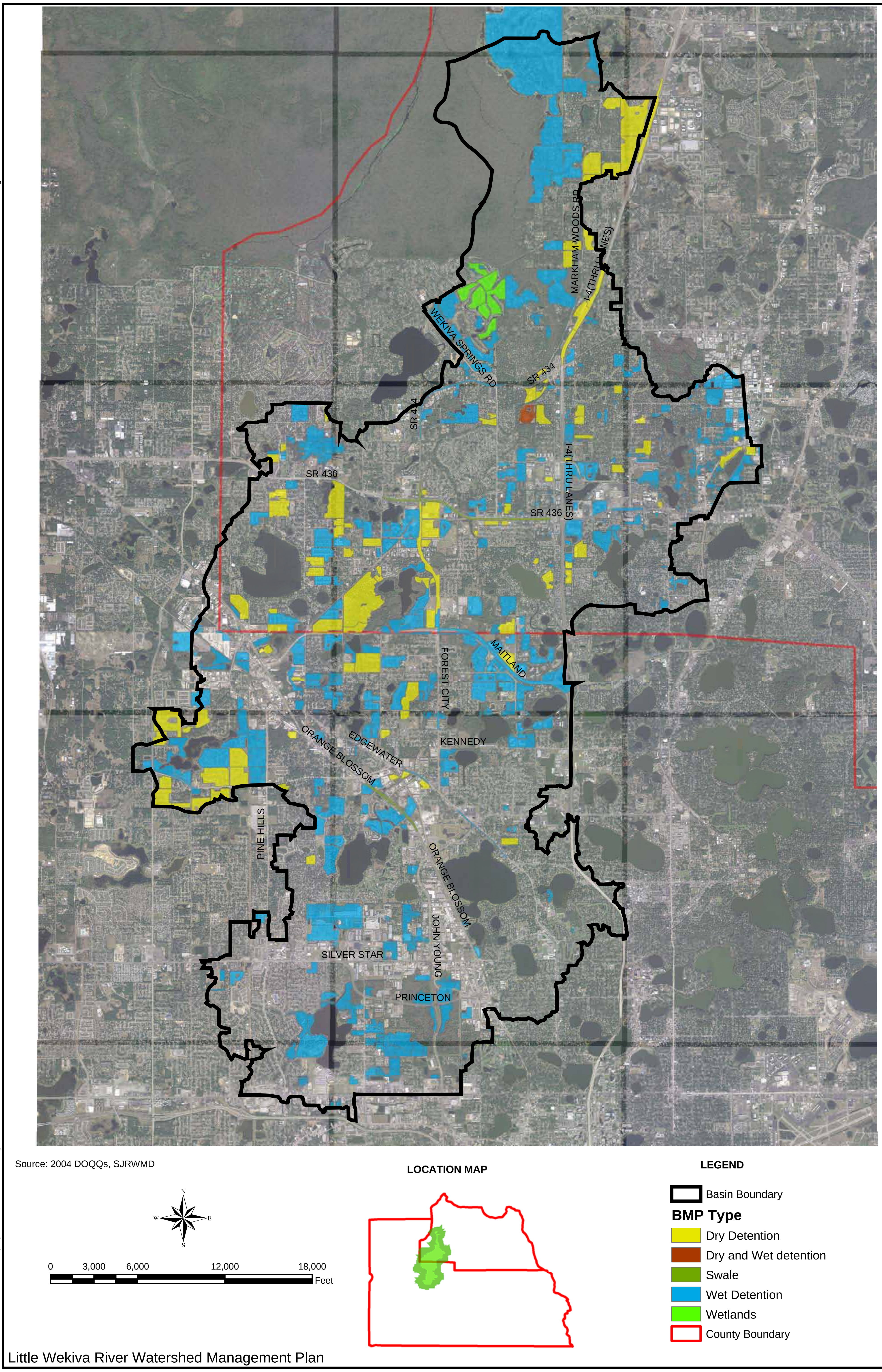
Table 4-5
Little Wekiva River Watershed Management Plan
Future Land Use BMP Treatment Data

	Cranes Roost						LWR							
	Swales		Wet Detention		Dry Detention		Swales		Wet Detention		Dry Detention		Dry/Wet Detention	
Land Use	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served
Agricultural	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Commercial	0.2	0%	77.0	15%	8.3	2%	0.1	0%	36.0	7%	106.0	20%	0.0	0%
Golf Course	0.0	0%	0.0	0%	0.0	0%	0.0	0%	21.1	13%	0.0	0%	0.0	0%
Institutional	0.0	0%	0.0	0%	5.6	9%	0.0	0%	3.3	3%	0.3	0%	0.0	0%
Industrial	0.0	0%	96.4	28%	14.3	4%	0.0	0%	243.7	20%	14.6	1%	0.0	0%
Highways	9.0	2%	19.5	3%	23.8	4%	26.3	2%	132.7	10%	178.4	14%	0.004	0%
Low Density Residential	0.0	0%	77.7	60%	1.5	1%	0.0	0%	494.8	27%	227.2	13%	0.0	0%
Medium Density Residential	0.0	0%	161.5	17%	32.1	3%	0.0	0%	545.2	17%	143.6	5%	0.0	0%
High Density Residential	0.0	0%	93.3	30%	33.4	11%	0.2	0%	132.4	25%	46.5	9%	0.0	0%
Forest/Rural Open	0.0	0%	12.3	84%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Urban Open	0.0	0%	7.3	25%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	24.8	25%
Water	0.0	0%	0.9	0%	0.0	0%	0.01	0%	6.4	2%	0.0	0%	0.0	0%
Wetlands	0.0	0%	0	0%	0.0	0%	0.0	0%	27.4	1%	4.7	0%	0.0	0%

	TRIBA		TRIBB		TRIBC						TRIBD			
	Wet Detention		Wet Detention		Swales		Wet Detention		Dry Detention		Wet Detention		Dry Detention	
Land Use	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served
Agricultural	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Commercial	12.6	64%	28.4	18%	0.0	0%	38.6	18%	12.6	6%	0.0	0%	0.0	0%
Golf Course	8.8	10%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Institutional	0.0	0%	0.0	0%	0.0	0%	0.2	1%	15.4	49%	14.4	57%	1.2	5%
Industrial	0.0	1%	0.0	0%	0.0	0%	15.3	81%	0.0	0%	1.7	2%	3.4	4%
Highways	29.6	38%	22.6	29%	6.1	2%	11.1	4%	7.5	3%	12.4	6%	38.9	19%
Low Density Residential	0.0	0%	1.2	90%	0.0	0%	5.0	8%	1.8	3%	18.9	27%	2.2	3%
Medium Density Residential	110.8	47%	1.4	1%	0.0	0%	172.9	19%	34.5	4%	101.3	12%	151.5	17%
High Density Residential	106.7	63%	32.4	47%	0.0	0%	14.4	10%	51.3	36%	0.0	0%	0.0	0%
Forest/Rural Open	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Urban Open	0.0	0%	1.7	38%	0.0	0%	29.7	30%	0.0	0%	0.0	0%	0.0	0%
Water	2.2	13%	0.6	6%	0.0	0%	0.1	0%	2.0	2%	0.0	0%	0.0	0%
Wetlands	0.0	0%	1.4	2%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%

	TRIBE				TRIBF				TRIBG					
	Wet Detention		Dry Detention		Wet Detention		Dry Detention		Swales		Wet Detention		Dry Detention	
Land Use	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served
Agricultural	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Commercial	39.7	22%	0.0	0%	71.8	37%	18.1	9%	0.0	0%	122.7	41%	2.3	1%
Golf Course	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Institutional	71.7	50%	18.6	13%	2.8	100%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Industrial	252.4	23%	15.2	1%	31.8	30%	20.2	19%	0.0	0%	0.0	0%	0.0	0%
Highways	73.9	10%	109.3	14%	57.3	31%	4.4	2%	0.0	0%	46.1	20%	0.004	0%
Low Density Residential	1006.1	40%	271.0	11%	8.4	15%	0.4	1%	0.0	0%	0.0	0%	0.0	0%
Medium Density Residential	330.4	33%	184.6	18%	29.2	8%	12.7	4%	0.0	0%	8.0	2%	0.0	0%
High Density Residential	20.7	57%	0.0	0%	61.7	45%	0.0	0%	0.0	0%	95.7	48%	0.0	0%
Forest/Rural Open	0.0	0%	0.0	0%	0.2	2%	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Urban Open	0.0	0%	0.0	0%	0.0	0%	0.0	0%	0.0	0%	3.1	25%	0.0	0%
Water	1.2	0%	1.0	0%	0.0	0%	0.0	0%	0.0	0%	0.1	0%	0.0	0%
Wetlands	0.7	1%	0.3	0%	5.5	5%	0.9	1%	0.0	0%	5.1	5%	0.0	0%

	TRIBH						TRIBI	
	Swales		Wet Detention		Dry Detention		Wet Detention	
Land Use	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served	Acres	% Land Use Served
Agricultural	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Commercial	0.0	0%	32.1	6%	0.0	0%	96.7	20%
Golf Course	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Institutional	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Industrial	0.0	0%	50.7	14%	0.0	0%	112.1	24%
Highways	5.3	1%	11.1	3%	2.4	1%	12.6	4%
Low Density Residential	0.0	0%	20.6	16%	0.0	0%	75.6	86%
Medium Density Residential	0.0	0%	5.2	0%	9.7	1%	97.5	15%
High Density Residential	0.0	0%	10.6	18%	0.0	0%	18.6	20%
Forest/Rural Open	0.0	0%	0.0	0%	0.0	0%	0.0	0%
Urban Open	0.0	0%	1.7	1%	0.0	0%	78.5	50%
Water	0.0	0%	3.2	0%	0.0	0%	0.1	0%
Wetlands	0.0	0%	0.0	0%	0.3	1%	0.1	0%



Little Wekiva River Watershed Management Plan

CDM

Figure 4-6
BMP Tributary Areas - Future Conditions

The equation below performs the calculations described above:

$$\text{Maximum Efficiency} = 100 - \frac{[(100 - \text{BMP1 efficiency})(100 - \text{BMP2 efficiency})]}{100}$$

where:

The BMP efficiencies are in percent removal (e.g., use "50" in the equation for 50% removal).

The final removal efficiency of the two BMPs in series is an average of the minimum and maximum efficiencies. The treatment removal efficiencies used in the Little Wekiva River Basin WMM are presented in **Table 4-6**.

4.3.4 Event Mean Concentration Values

For this study, the EMC values were obtained from the NPDES Permit Applications for Orange and Seminole Counties. As these values differed significantly for some parameters, both sets of EMCs were used in the WMM and run for all model scenarios. The EMC values for the thirteen land use categories are presented in **Table 4-7**.

4.3.5 Rainfall Data

Rainfall data for the Little Wekiva River Basin were obtained for the Sanford station which has a period of record from 1973 to the present. The data showed an annual rainfall of 51 inches. The wet season (June to September) had an average of 27.2 inches of rainfall, or 53% of the annual total. The dry season (October to May) had 23.8 inches of rain, or 47% of the annual total.

4.3.6 Septic Tank Usage

Septic tanks are still used in many areas of the Little Wekiva River Basin for sewage disposal, primarily in older residential areas. To identify those areas where septic tanks are used, a variety of sources were consulted. Seminole County and the City of Orlando provided a septic tank coverage in GIS format. The majority of the City of Altamonte Springs is served by sanitary sewer based on the wastewater GIS coverage provided by the City. Septic tank information for Orange County was obtained from the Orange County Utility Master Plan (PBS&J, 2001). In this study, it was presumed that all areas currently not served by sanitary sewer are served by septic tanks. The GIS coverage reflecting this was obtained and used as part of the WMM analysis.

Upon inspection of the GIS data obtained, specifically for Seminole County, there were many subdivisions in the County where only some parcels within the subdivision were shown to be on septic systems. However, these subdivisions were also not served by sanitary sewer based on the GIS coverage provided by the County. CDM reviewed these areas along with the 1990 census data and evaluated the entire subdivision as served by septic systems if no sanitary sewer lines were shown serving the area. The 1990 census data were used because this type of information was not surveyed for the 2000 census. The 1990 census long form inquired if homes were

Table 4-6
Little Wekiva River Watershed Management Plan
BMP Removal Efficiencies (%) Used In WMM

Parameter	Dry Detention (1)	Wet Detention (1)	Swale (1)	Wet Detention and Dry Detention (2)
BOD	30	30	30	40
COD	30	30	30	40
TSS	90	90	80	94
TDS	0	40	10	40
Total -P	30	50	40	57
Dissolved P	0	70	10	70
TKN	20	30	40	37
NO2+NO3	0	30	40	30
Lead	80	80	75	88
Copper	60	70	50	79
Zinc	50	50	50	60
Cadmium	80	80	65	88

(1) Watershed Management Model Version 4.0 User's Manual. CDM, 1998.
(2) Estimated from efficiencies for a combination of wet detention and dry detention.

Table 4-7
Little Wekiva River Watershed Management Plan
WMM Land Use EMC Values

	BOD mg/l	COD mg/l	TSS mg/l	TDS mg/l	TP mg/l	DP mg/l	TKN mg/l	NO2/NO3 mg/l	Pb mg/l	Cu mg/l	Zn mg/l	Cd mg/l
Agricultural												
Orange County	13.2	70.0	50.0	113.0	0.14	0.12	0.87	1.15	0.005	0.004	0.023	0.000
Seminole County	3.8	51.0	55.3	100.0	0.34	0.23	1.74	0.58	0.000	0.000	0.000	0.000
Golf Course												
Orange County	1.45	55.0	11.1	174.0	0.53	0.00	1.250	0.188	0.025	0.015	0.006	0.005
Seminole County	3.80	51.0	55.3	100.0	0.34	0.23	1.740	0.580	0.000	0.000	0.000	0.000
Commercial												
Orange County	12.7	55.0	87.7	174.0	0.29	0.18	1.14	0.201	0.180	0.107	0.141	0.033
Seminole County	7.8	53.0	42.5	141.0	0.20	0.09	1.03	0.670	0.011	0.022	0.065	0.001
Industrial												
Orange County	9.6	55.0	93.9	174.0	0.310	0.131	1.79	0.27	0.202	0.120	0.122	0.037
Seminole County	14.0	83.0	77.0	130.0	0.280	0.200	1.47	0.40	0.023	0.024	0.132	0.001
Institutional												
Orange County	6.6	45.0	54.0	57.5	0.14	0.06	0.83	1.24	0.010	0.008	0.046	0.001
Seminole County	7.3	49.9	41.2	114.1	0.15	0.08	1.24	1.05	0.012	0.018	0.079	0.001
Forest/Open												
Orange County	1.5	55.0	11.1	174.0	0.53	0.004	1.25	0.188	0.025	0.015	0.006	0.005
Seminole County	1.5	51.0	11.0	100.0	0.05	0.004	0.94	0.310	0.000	0.000	0.000	0.000
Low Density Residential												
Orange County	5.6	41.3	29.3	136.5	0.635	0.298	1.33	0.236	0.060	0.036	0.036	0.011
Seminole County	15.1	70.8	26.6	286.0	0.440	0.330	1.34	0.630	0.002	0.009	0.051	0.002
Medium Density Residential												
Orange County	7.45	55.0	39.0	177.0	0.843	0.397	1.78	0.314	0.080	0.048	0.048	0.015
Seminole County	9.20	64.6	58.8	58.8	0.450	0.270	1.77	0.270	0.013	0.007	0.057	0.001
High Density Residential												
Orange County	9.3	68.8	48.8	217.5	1.050	0.496	2.22	0.392	0.100	0.059	0.060	0.018
Seminole County	7.8	53.0	42.5	141.0	0.200	0.090	1.03	0.670	0.011	0.022	0.065	0.001
Highways												
Orange County	9.04	55.0	79.1	174	0.489	0.178	1.75	0.303	0.153	0.090	0.098	0.028
Seminole County	14.0	83.0	77.0	130	0.280	0.200	1.47	0.400	0.023	0.024	0.132	0.001
Water												
Orange County	3.1	22.0	5.0	100.0	0.090	0.020	1.1000	1.3000	0.010	0.000	0.005	0.00000
Seminole County	3.2	16.8	6.2	100.0	0.170	0.090	0.6004	0.1896	0.006	0.045	0.146	0.00083
Wetlands												
Orange County	1.45	55.0	11.1	174.0	0.53	0.004	1.2500	0.1880	0.025	0.015	0.006	0.00500
Seminole County	3.20	16.8	6.2	100.0	0.17	0.090	0.6004	0.1896	0.006	0.045	0.146	0.00083

served by septic tanks or sanitary sewer systems. These data are available by census tract and block group at the U.S. Census web page. By making the determinations previously described, the resulting changes reflected something closer to the values reported in the census data. The estimated percentage of each major subbasin served by septic tanks is presented in **Table 4-8**. In total, approximately 11,801 acres or 32 percent of the basin area was identified as using septic systems. The resulting septic tank coverage with the assumptions incorporated is shown in **Figure 4-7**.

The WMM assesses the impact of failing septic tank by applying a multiplication factor to the surface runoff load. This multiplication factor was applied only to the phosphorus (dissolved P, total P) and nitrogen (TKN, NO_2+NO_3) parameters. The factor used for the phosphorus parameters was 2.1 and 2.0 was used for the nitrogen parameters (i.e., nitrogen load for a residential area with failing septic tanks is estimated to be 2.0 times the load from a residential area without failing septic tanks).

To assess the increase in surface runoff load due to failing septic tanks, WMM considers the multiplication factor (discussed above), the percent septic tank coverage, and the percent failure rate. The percent failure rate used for this study was 10%. Although lower failure rates have been reported for many municipalities in general, a conservative estimate was used to account for those septic tanks not permitted and registered with the State.

Consequently, the maximum increase in nitrogen loading from a residential area with 100% septic tank coverage and a 10% failure rate is 10% over the base load:

(2.0 x 10%/100% + (1 - 10%/100%) = 0.2 + 0.9 = 1.1, or 10% increase over the case without septic tanks)

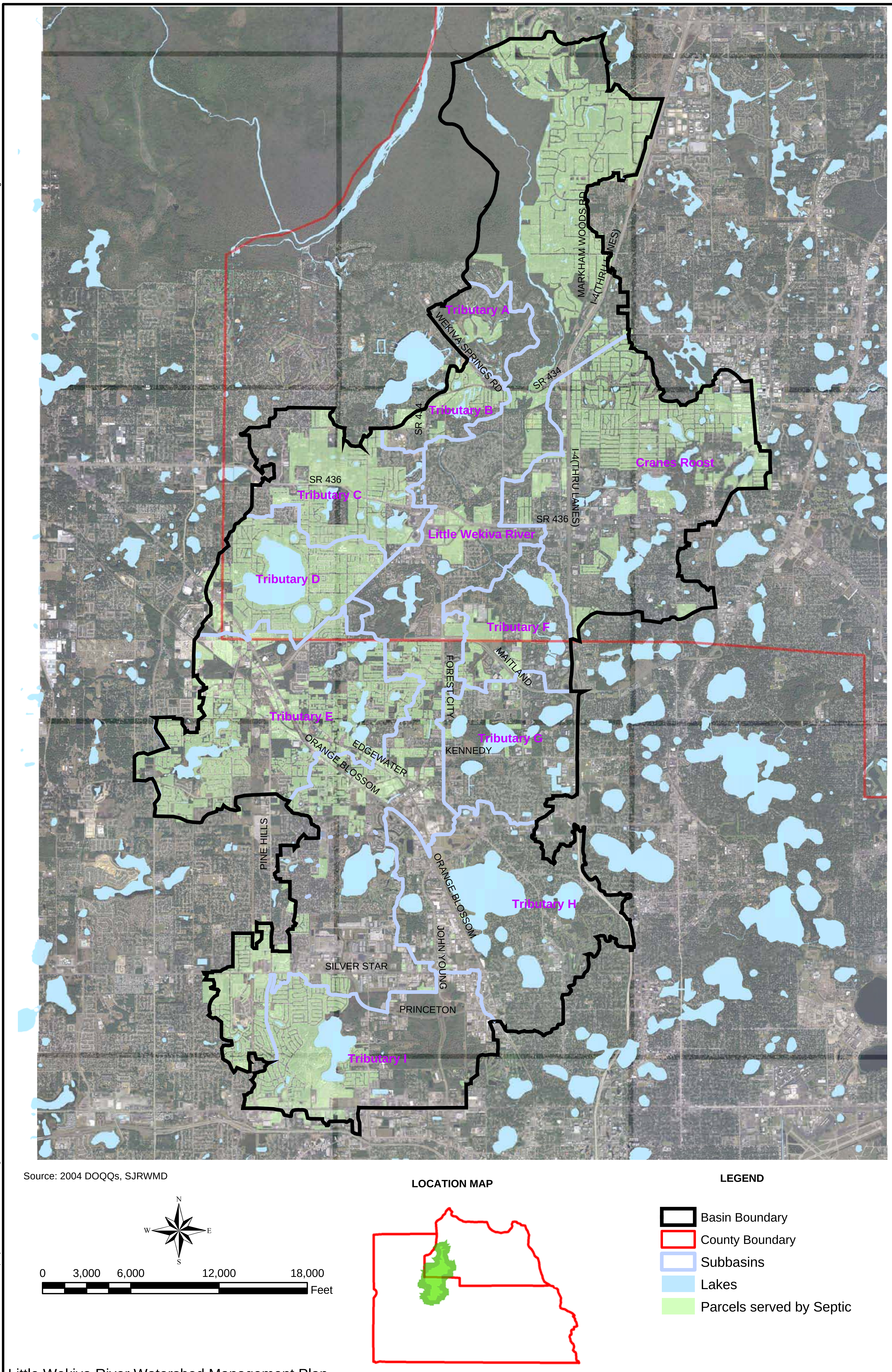
Based on the information obtained from both Orange and Seminole Counties, approximately 19 percent of the area served by septic tanks was identified as non-residential (i.e., commercial, industrial and institutional). Little to no data were available regarding the use of septic tanks for non-residential areas. Since these land uses typically have greater disposal rates than those of residential, the higher end of the range of percent increases in annual per acre loadings was used to account for the higher volume.

Septic tanks may also be a significant source for fecal coliform and other bacteria, and may affect fishable and public health parameters, which were not analyzed in this plan. Therefore, it is recommended that the local municipalities consider implementation of a septic tank management plan. This would consist of the following:

- Public education program,
- Routine inspection/maintenance program for septic tanks; and
- Septic tank phase-out program in areas where it is feasible to access the public system.

Table 4-8
Little Wekiva River Watershed Management Plan
Septic Tank Usage By Major Basin

Basin	Area Currently Served By Septic Tanks (%)
LWR	31.4%
CR	32.8%
TRIBA	12.2%
TRIBB	41.2%
TRIBC	52.6%
TRIBD	60.8%
TRIBE	45.7%
TRIBF	19.1%
TRIBG	5.3%
TRIBH	0.5%
TRIBI	31.1%
TOTAL:	31.5%



Little Wekiva River Watershed Management Plan

CDM

Figure 4-7
Parcels Served by Septic Tanks

4.3.7 Point Source Discharges

One point source discharge exists along the main stem of the Little Wekiva River and is associated with the Swofford WWTP and water reclamation facility operated by the City of Altamonte Springs. The outfall from this plant located just upstream of this confluence of the Little Wekiva River and tributary from Spring Lake. Monthly discharge monitoring reports (DMRs) from February, 1997 through December, 2003 were obtained from the WWTP. Discharge data were available for flow and concentrations of BOD, TP and TSS. Overall, the average values for the period of record are included below in **Table 4-9**.

Table 4-9
Little Wekiva River Watershed Management Plan
Average Discharge Monitoring Data from the Swofford WWTP

	Flow (mgd)	CBOD5 (mg/L)	TSS (mg/L)	Phosphorus, Total as P (mg/L as P)
Annual Flow	0.85	1.25	0.58	1.38
Wet Season Flow	1.03	1.20	0.56	1.49
Dry Season Flow	0.76	1.27	0.58	1.33

4.4 WMM Results

The WMM was used to evaluate 3 scenarios for each major subbasin for existing and future land use and the EMCs for Orange and Seminole Counties. This resulted in 36 runs using rainfall data for annual, wet and dry seasons and all included septic tank impacts and point source discharges. The summary of all the scenarios evaluated are listed as follows:

- Existing Land Use – Annual – 11 Major Subbasins
- Existing Land Use – Dry Season – 11 Major Subbasins
- Existing Land Use – Wet Season – 11 Major Subbasins
- Existing Land Use – Annual – TMDL Subbasins
- Existing Land Use – Dry Season – TMDL Subbasins
- Existing Land Use – Wet Season – TMDL Subbasins
- Existing Land Use – Annual – Points of Interest
- Existing Land Use – Dry Season – Points of Interest
- Existing Land Use – Wet Season – Points of Interest
- Future Land Use – Annual – 11 Major Subbasins

- Future Land Use – Dry Season – 11 Major Subbasins
- Future Land Use – Wet Season – 11 Major Subbasins
- Future Land Use – Annual – TMDL Subbasins
- Future Land Use – Dry Season – TMDL Subbasins
- Future Land Use – Wet Season – TMDL Subbasins
- Future Land Use – Annual – Points of Interest
- Future Land Use – Dry Season – Points of Interest
- Future Land Use – Wet Season – Points of Interest

The results of the WMM analysis for both existing and future land use conditions for the three scenarios (i.e., entire watershed, TMDL subbasins and points of interest) with BMPs considered under annual rainfall have been graphed and are shown in **Figures 4-8**, **4-9** and **4-10**, respectively. These specifically show the relative change in annual loadings between existing and future land use conditions. The results for all the model runs have been tabulated and are included in **Appendix K**.

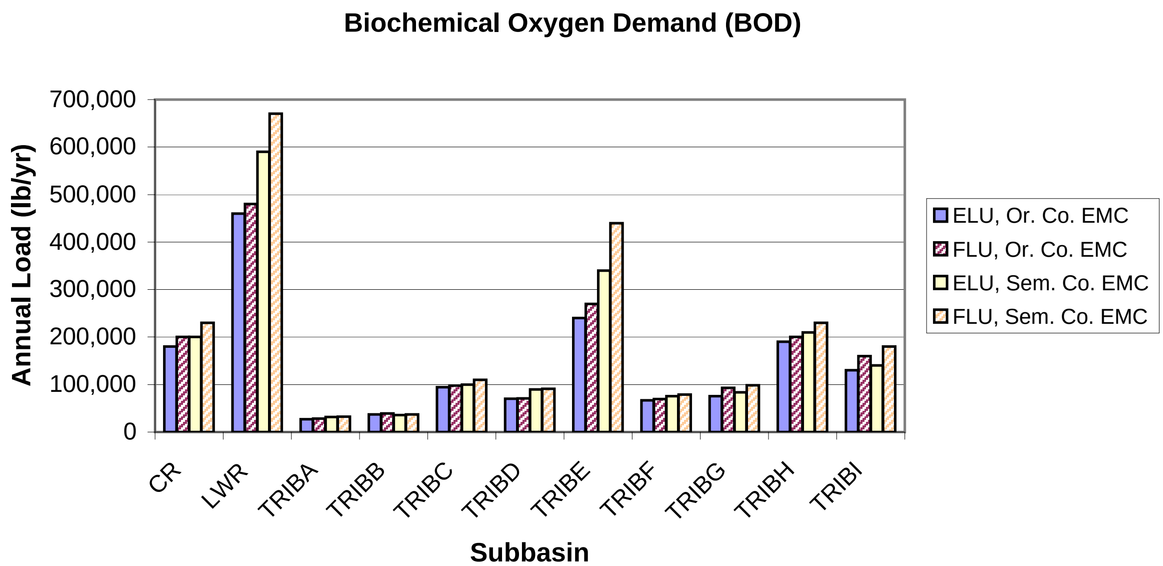
4.4.1 Existing Land Use

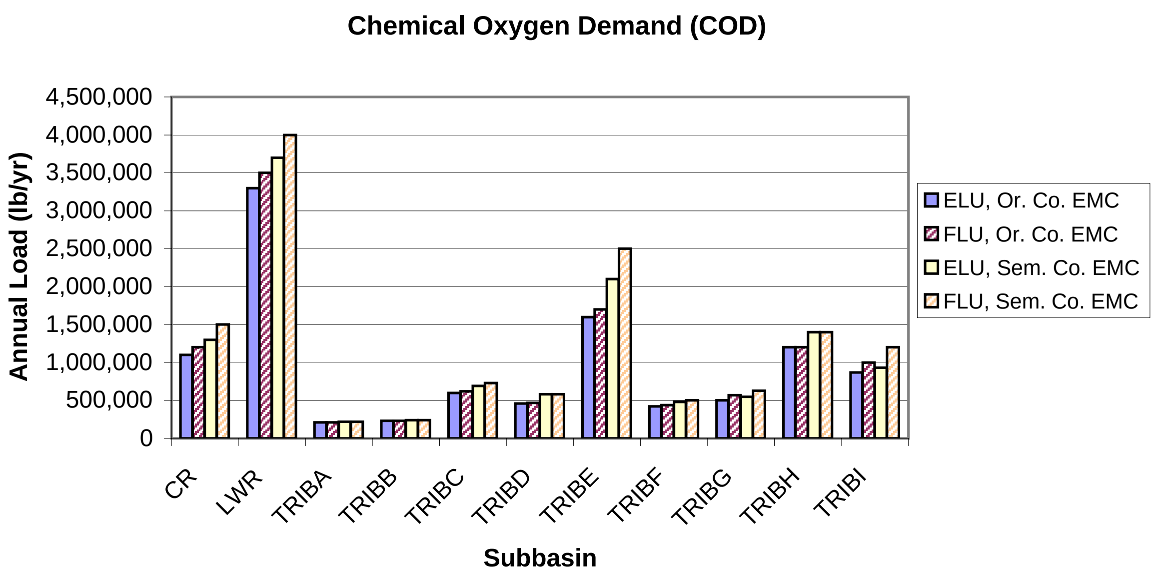
There are approximately 37,445 acres of land in the Little Wekiva River basin, with 10,405 acres in the "medium density residential" category and the remaining 27,040 acres in the other twelve WMM land use categories. Under existing land use conditions, developed land (e.g., residential, commercial, industrial/utility, institutional, major roads) accounts for 26,450 acres, which is approximately 71% of the total basin area. The existing BMPs serve 19.4 percent of the developed area and remove approximately 7 percent of the pollutants generated. TDS, TSS, and COD comprise the vast majority (about 95 percent) of the pollutants generated. The Little Wekiva River major subbasin (LWR) generates the most pollutants, because it is the largest subbasin in the watershed, and approximately 69 percent of the subbasin consists of developed land uses. The Tributary A major subbasin generates the least amount of pollutants as it is the smallest of the eleven subbasins. Developed area accounts for about 72 percent of the subbasins land use under existing conditions.

Seasonal Impacts

The dry season runs from October to May and produces about 23.8 inches of rainfall. The wet season runs from June to September and produces about 27.2 inches of rainfall. During the four month wet season, about 53% of the NPDES pollutants will be generated, and the remaining 47% will be generated during the eight month dry season based on the rainfall variation using a constant EMC throughout the year.

Figure 4-8
Little Wekiva River Watershed Management Plan
WMM Results - Annual Rainfall - Major Subbasins





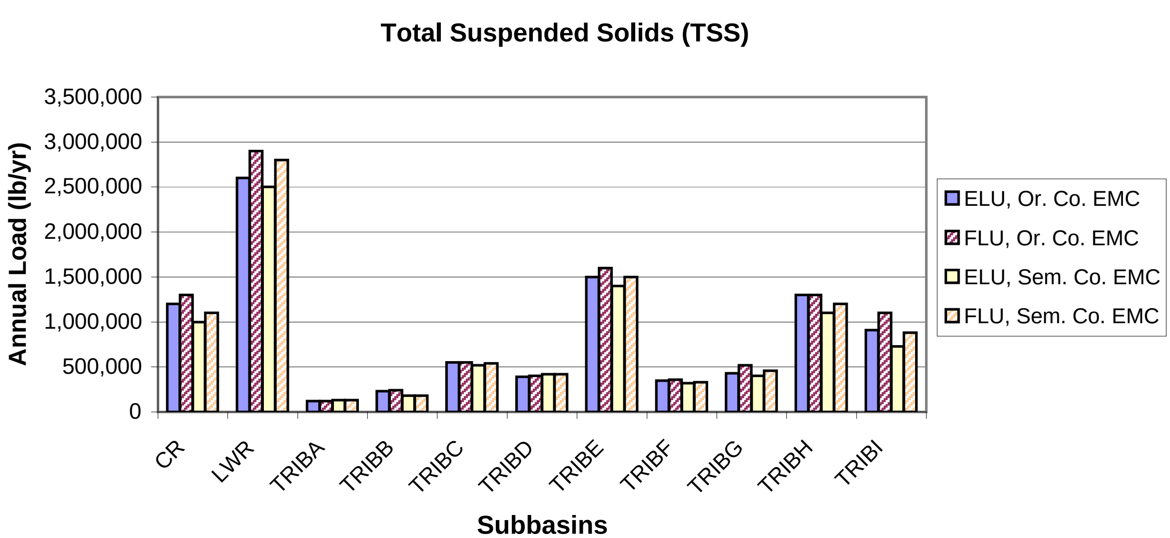
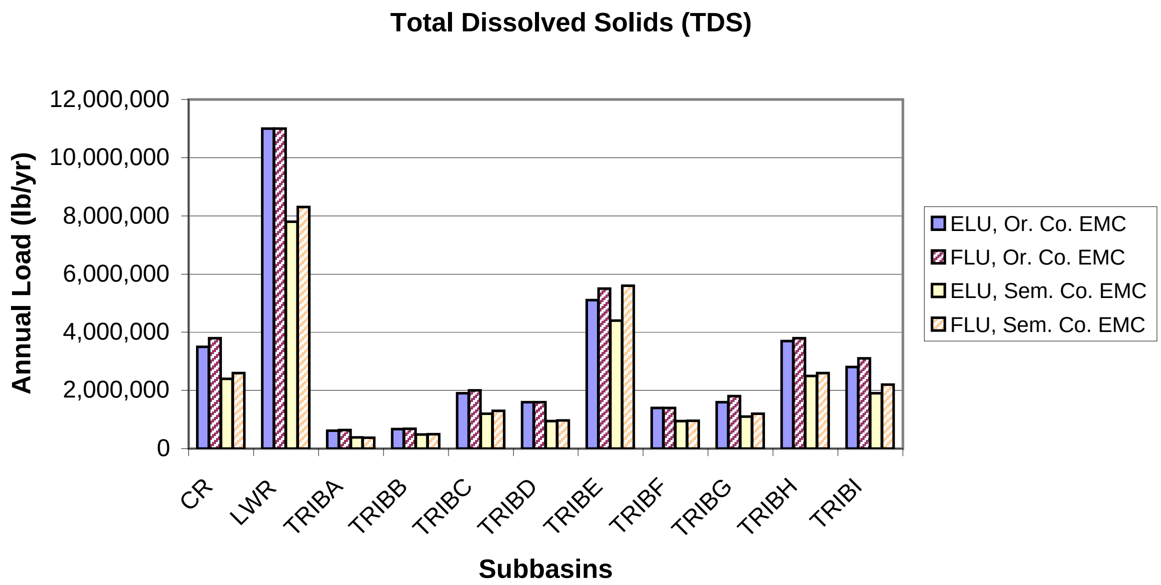
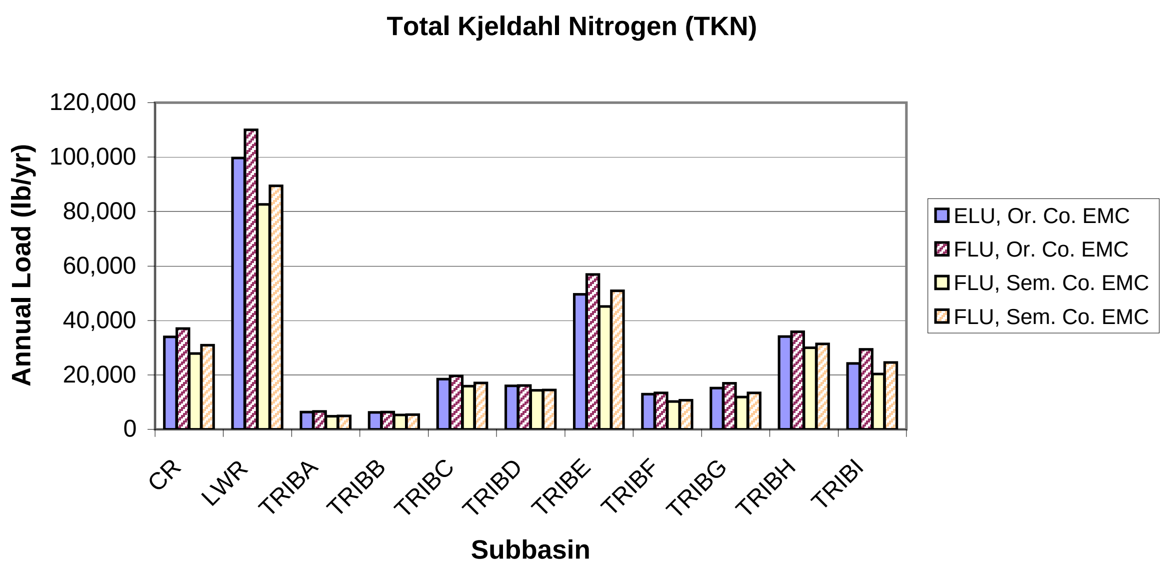


Figure 4-8
Little Wekiva River Watershed Management Plan
WMM Results - Annual Rainfall - Major Subbasins





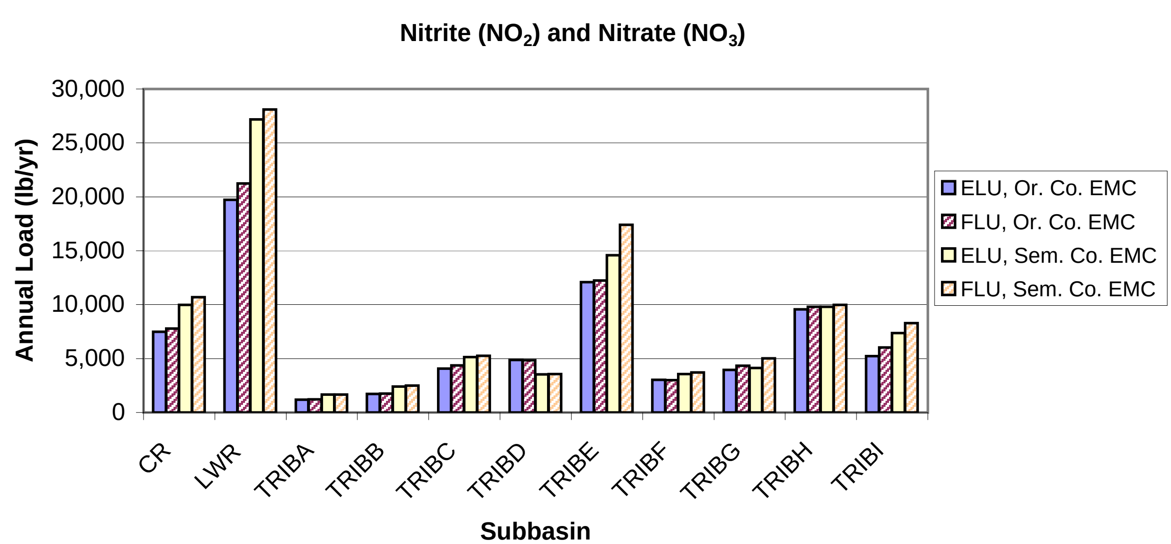
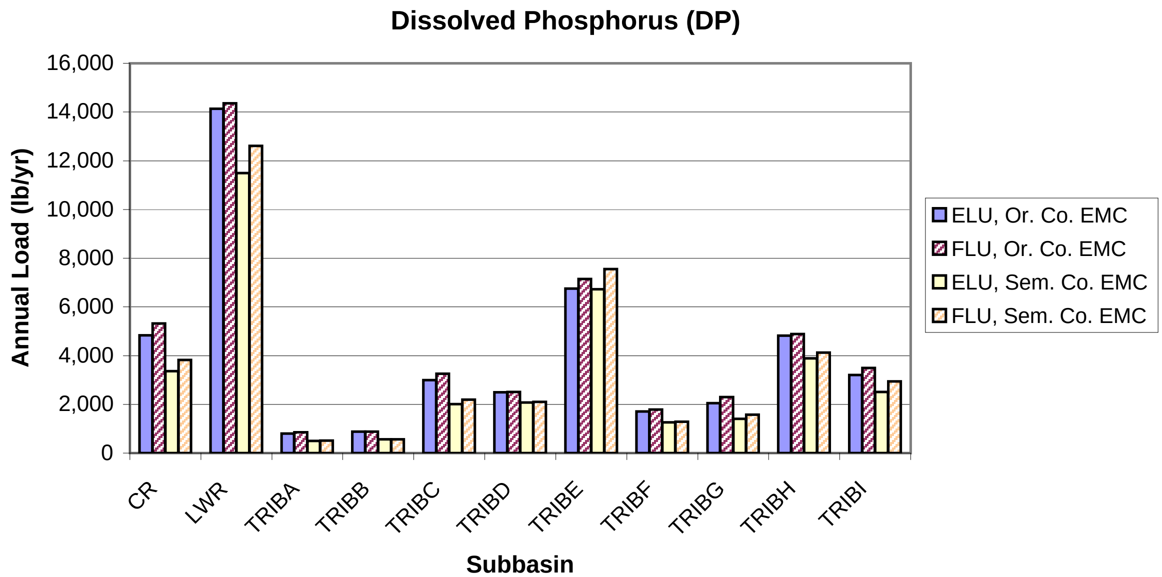
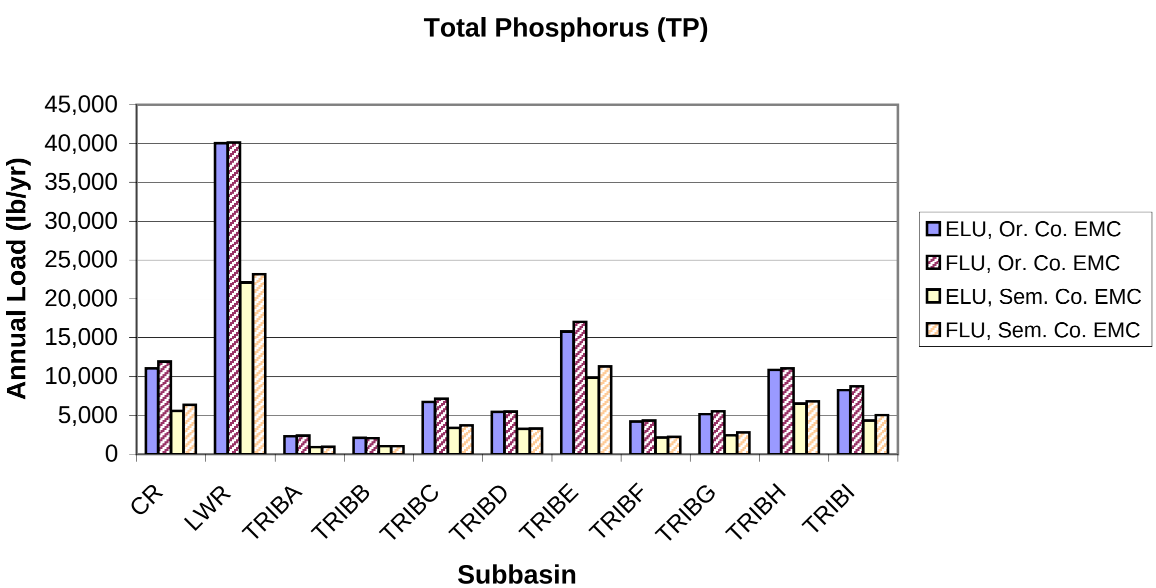


Figure 4-8
Little Wekiva River Watershed Management Plan
WMM Results - Annual Rainfall - Major Subbasins





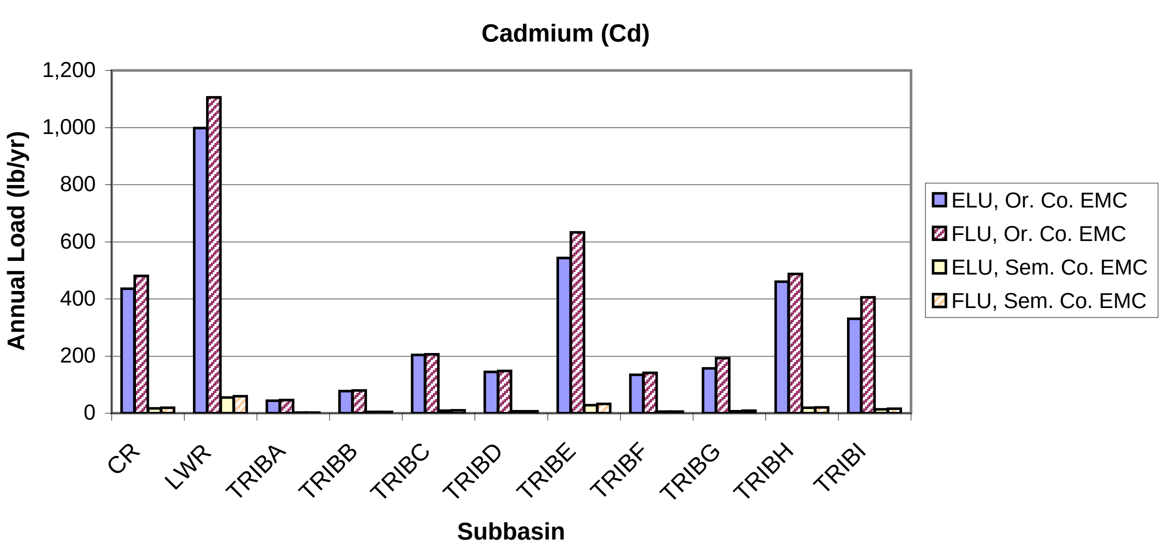
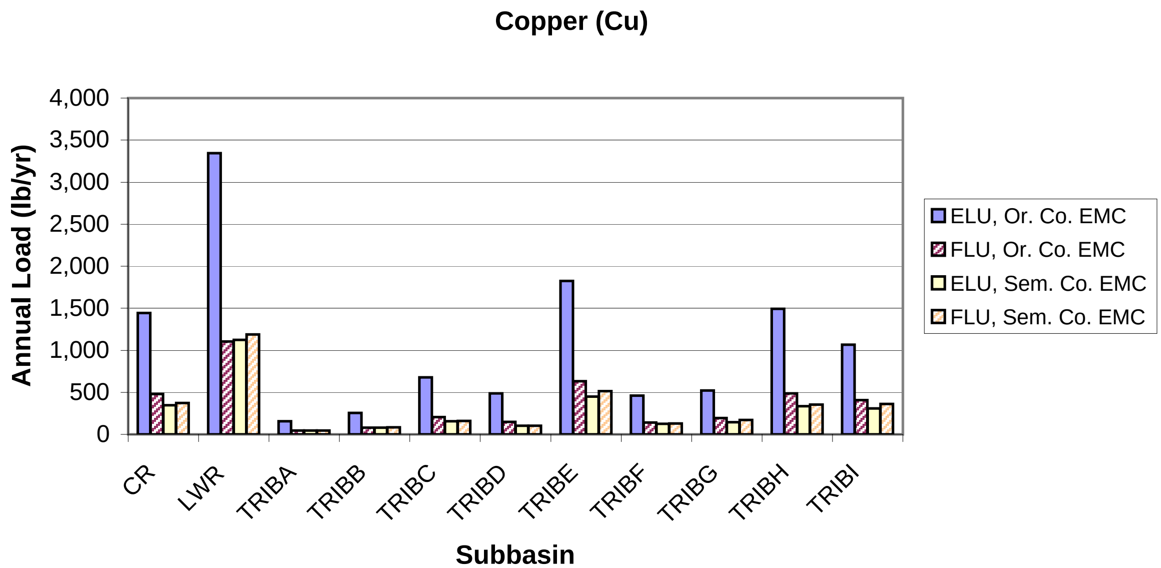
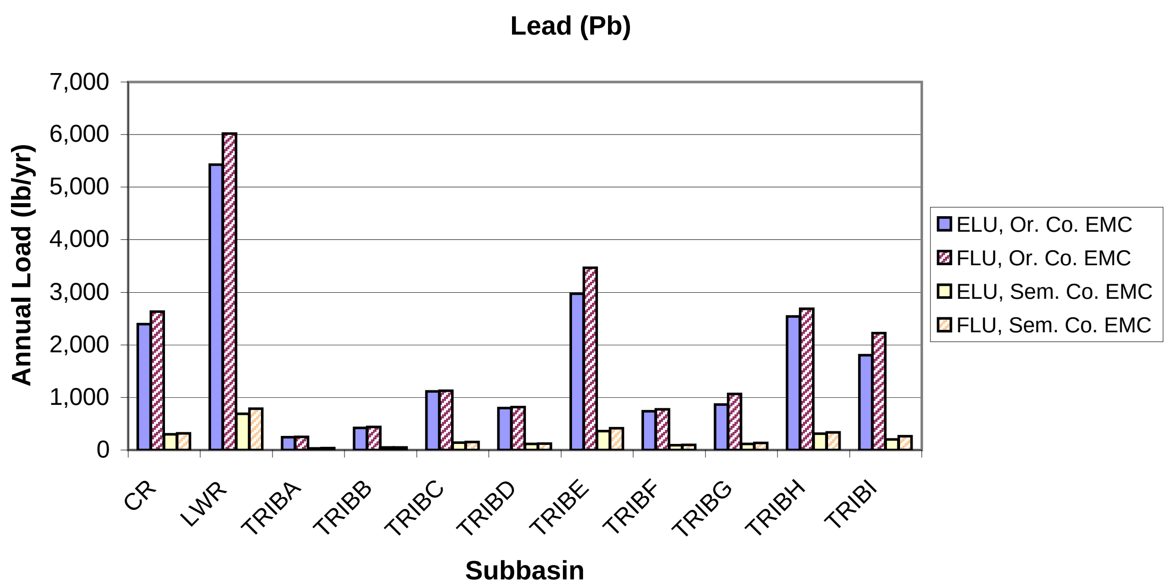


Figure 4-8
Little Wekiva River Watershed Management Plan
WMM Results - Annual Rainfall - Major Subbasins





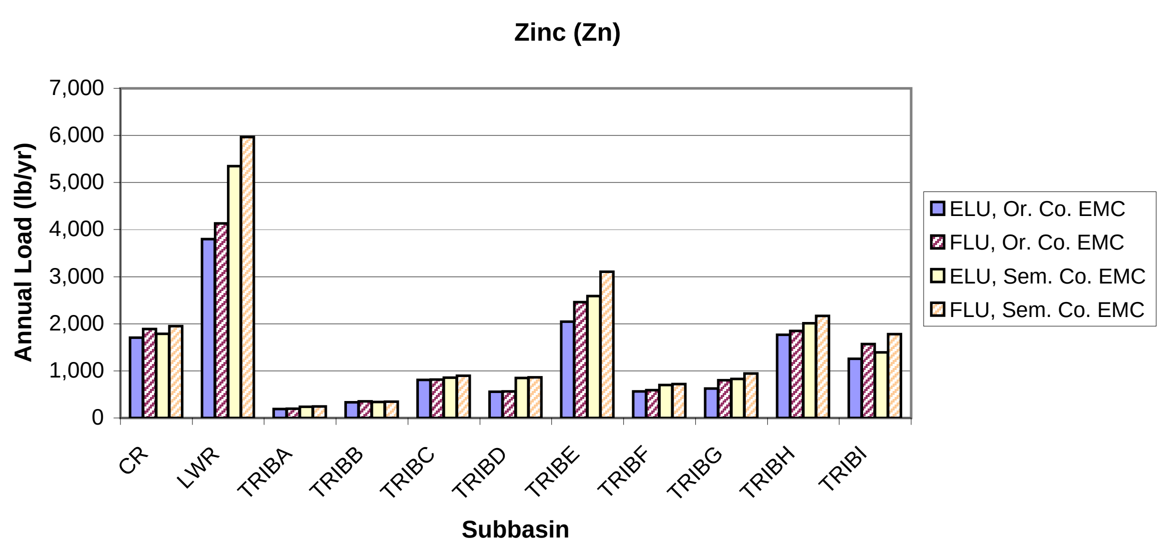
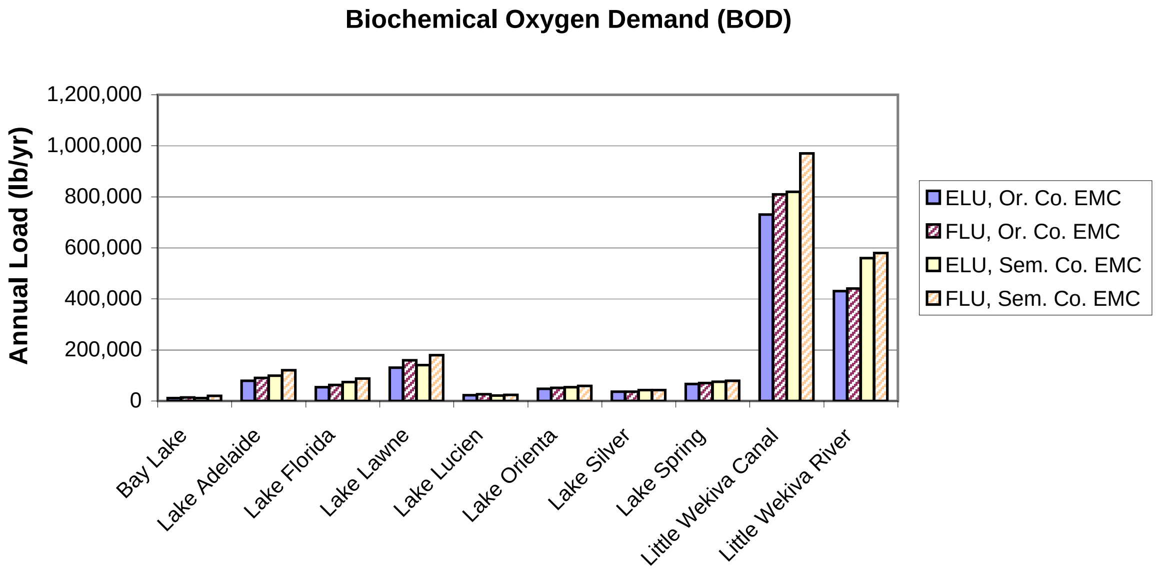
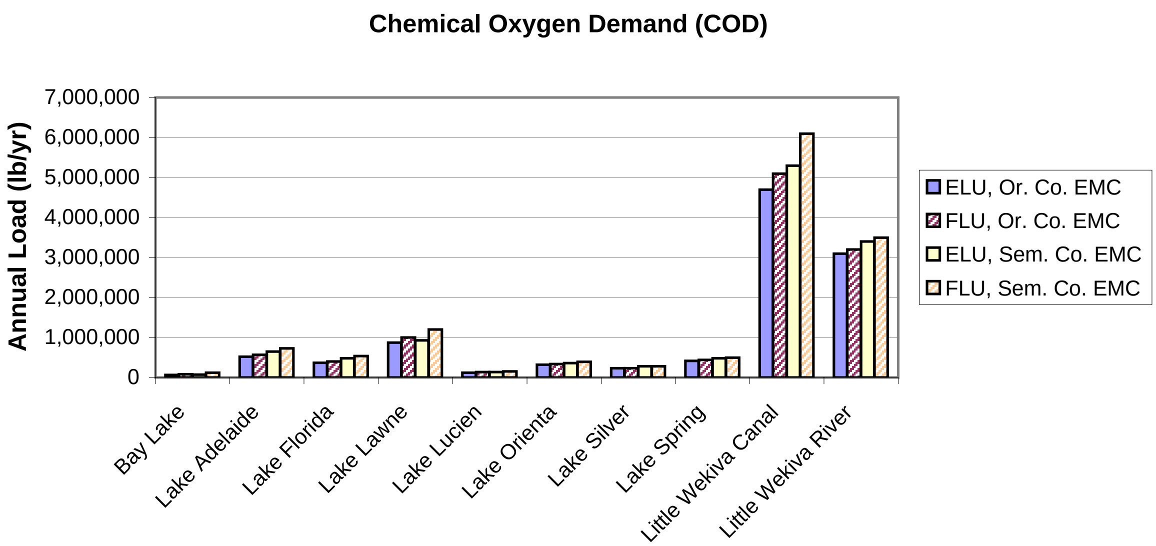


Figure 4-9
Little Wekiva River Watershed Management Plan
WMM Results - TMDL Subbasins Annual





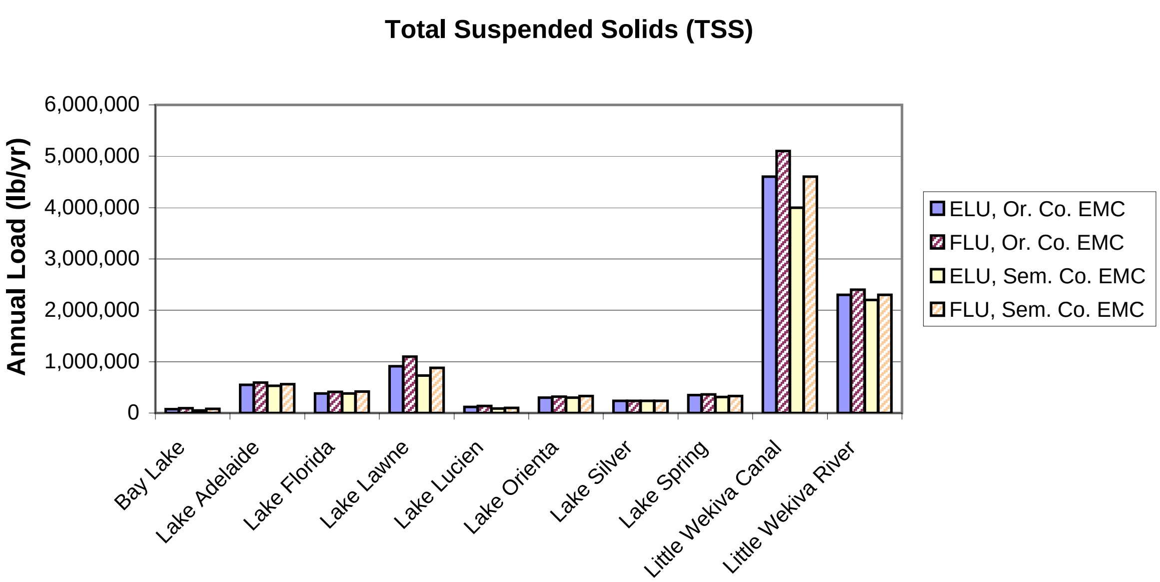
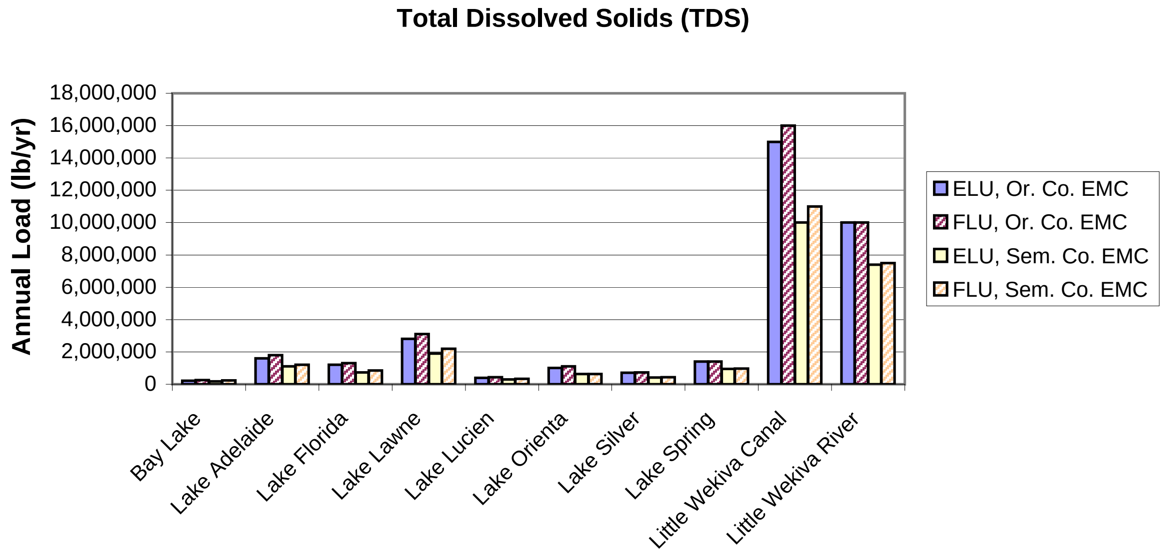
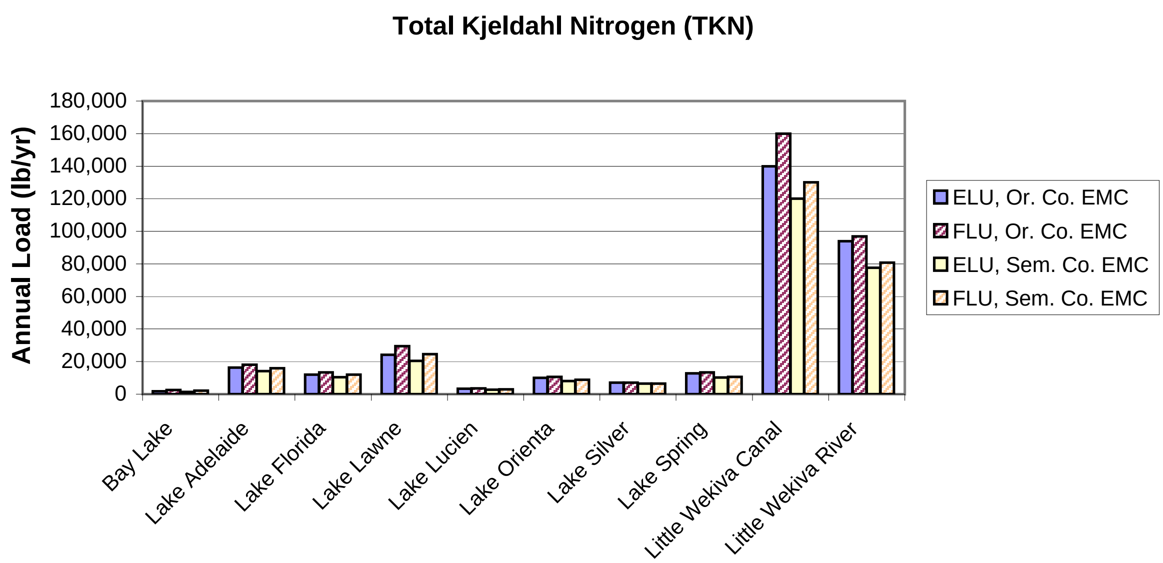


Figure 4-9
Little Wekiva River Watershed Management Plan
WMM Results - TMDL Subbasins Annual





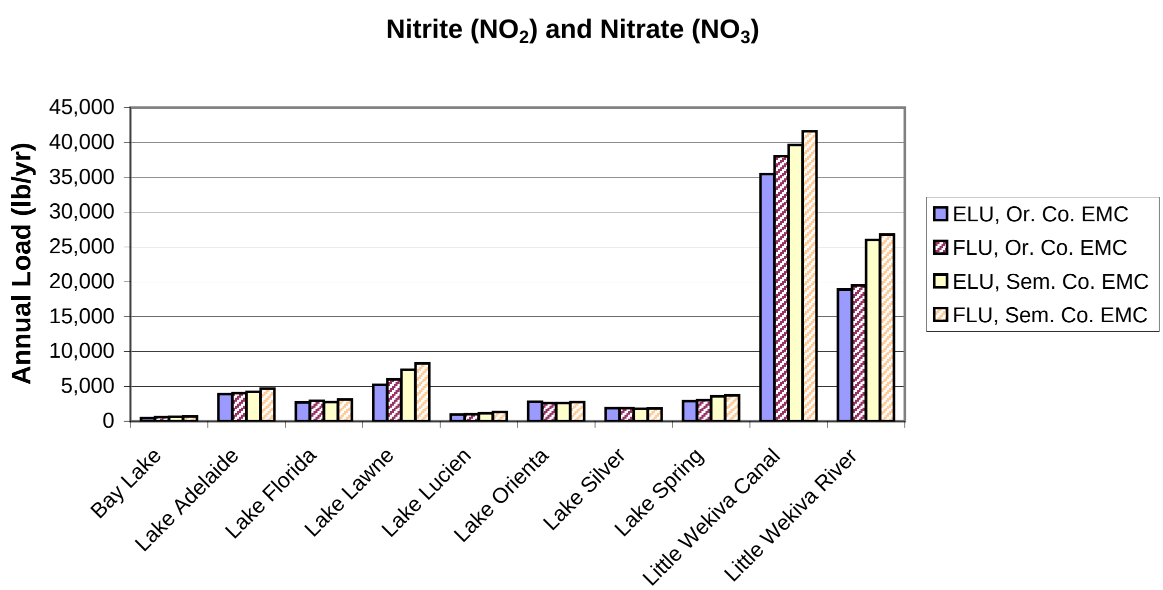
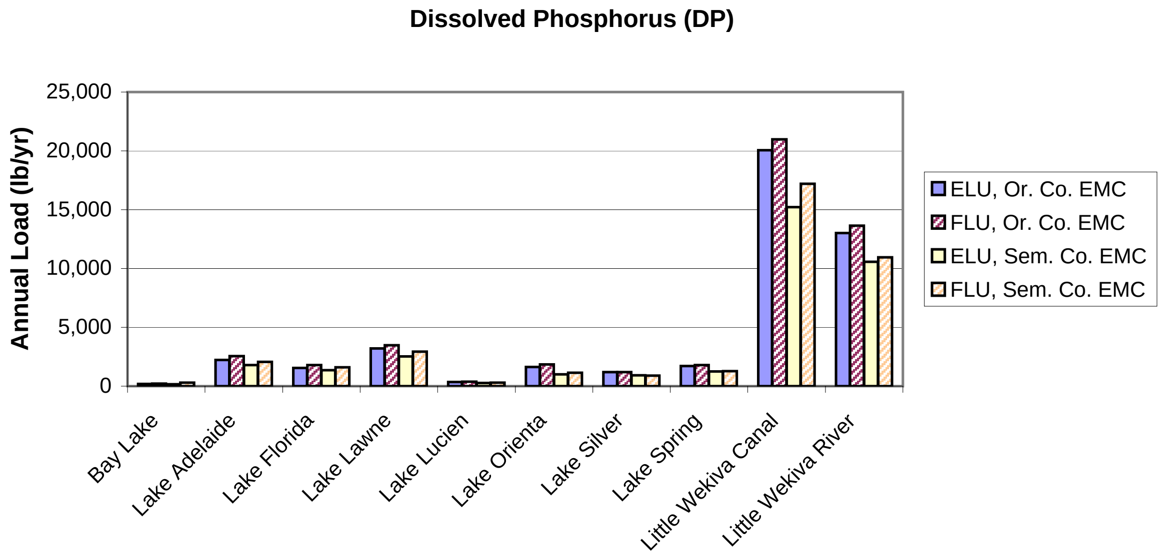
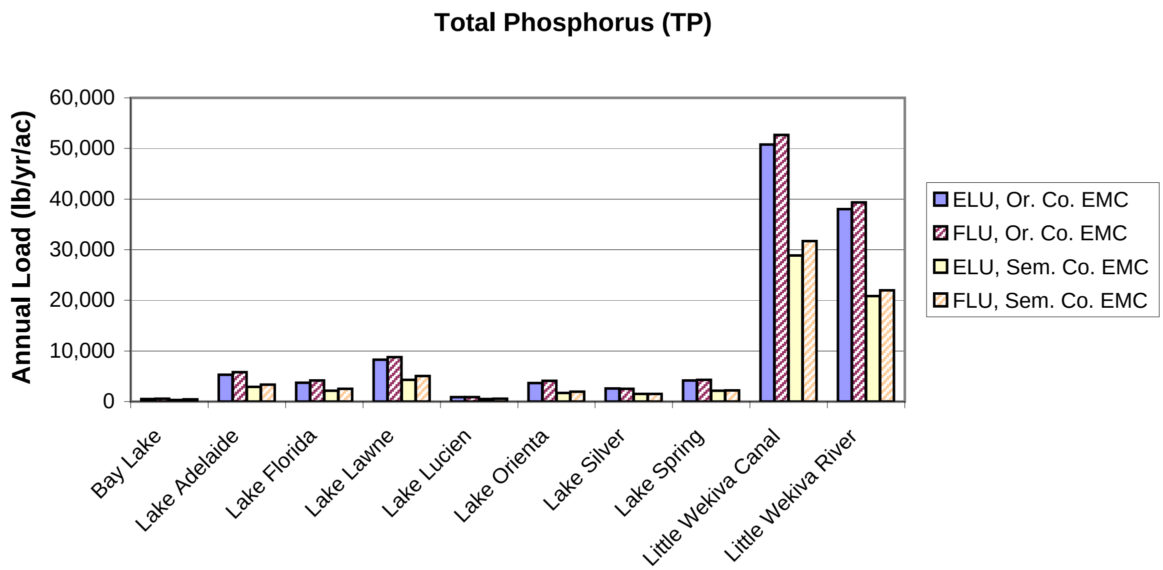


Figure 4-9
Little Wekiva River Watershed Management Plan
WMM Results - TMDL Subbasins Annual





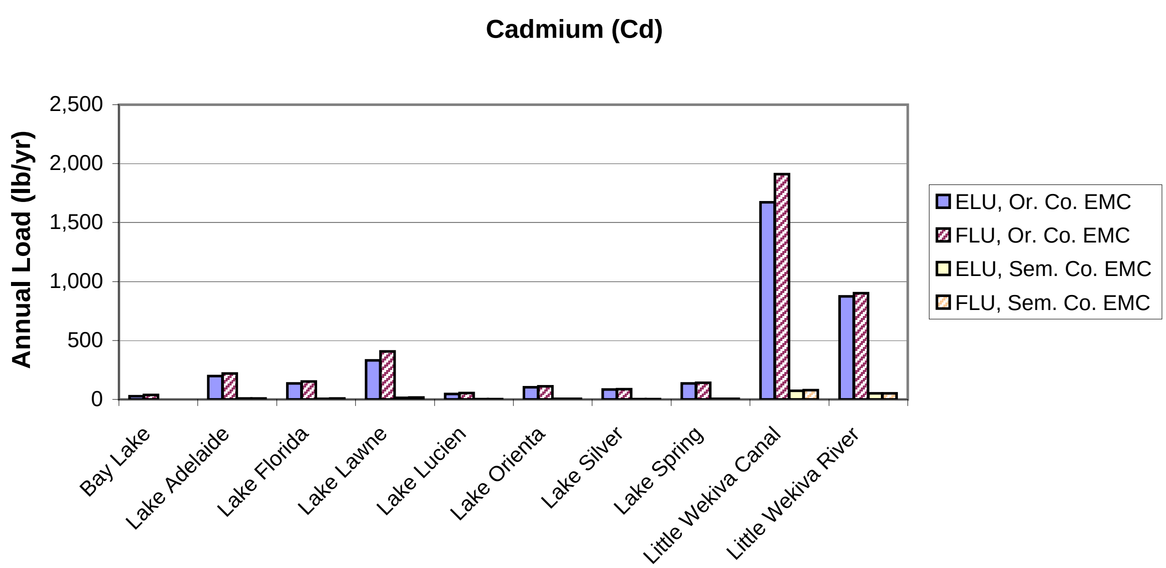
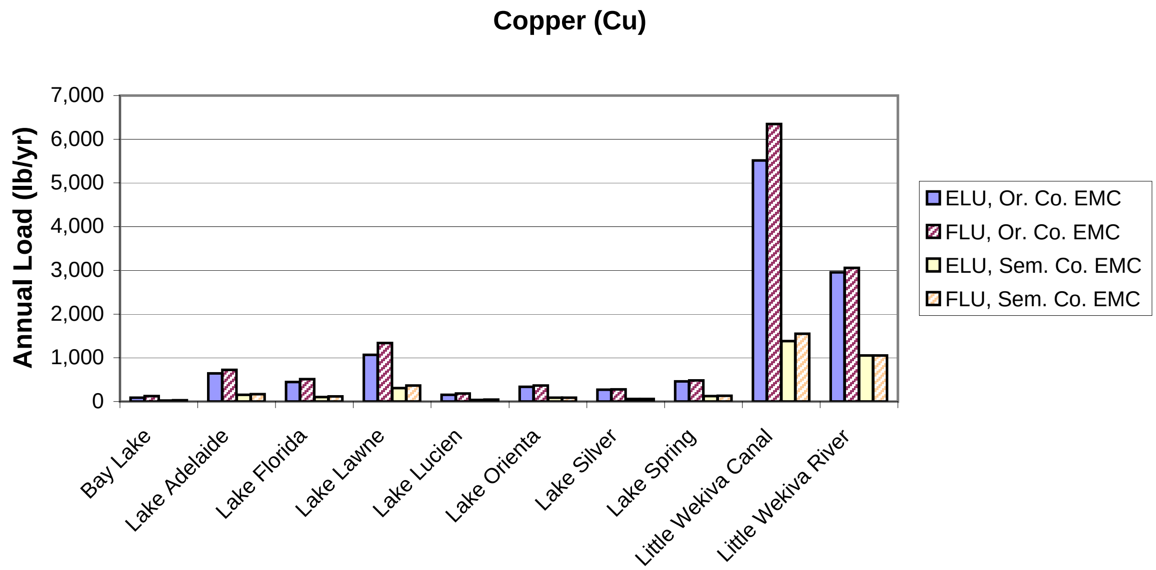
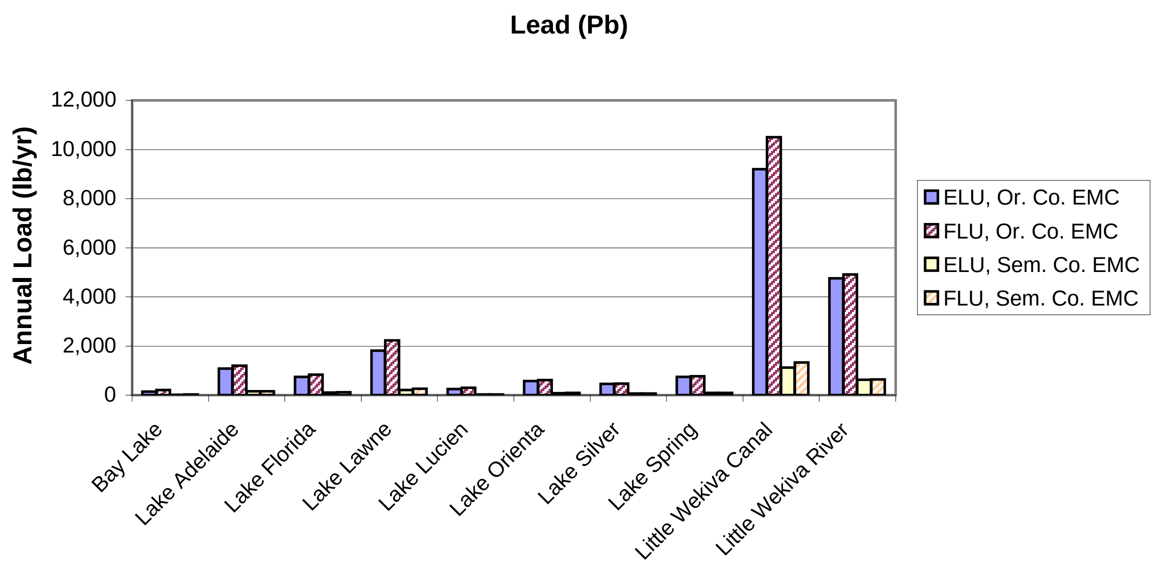


Figure 4-9
Little Wekiva River Watershed Management Plan
WMM Results - TMDL Subbasins Annual





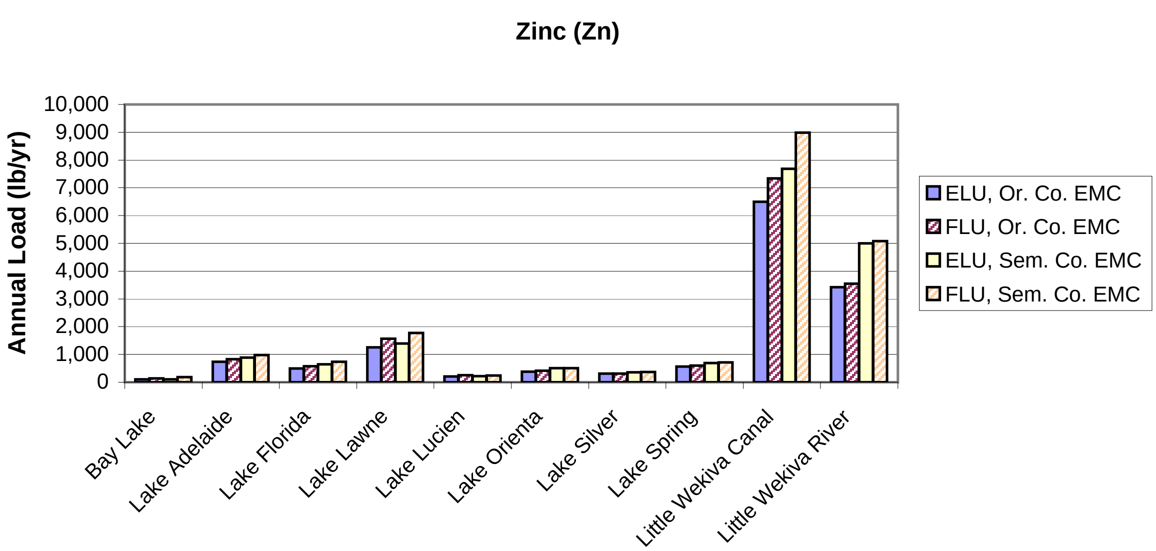
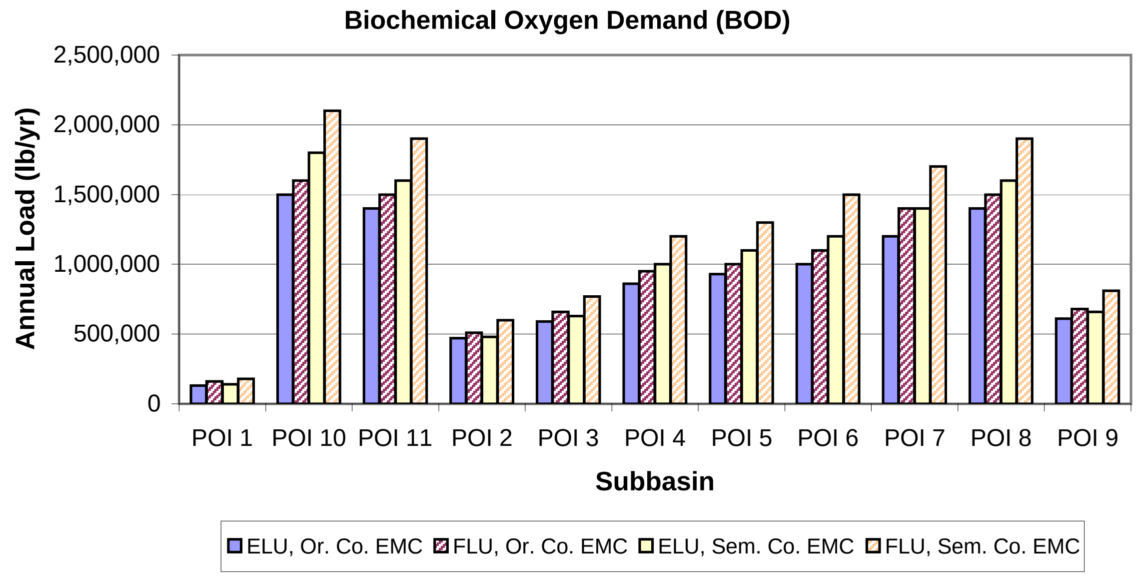
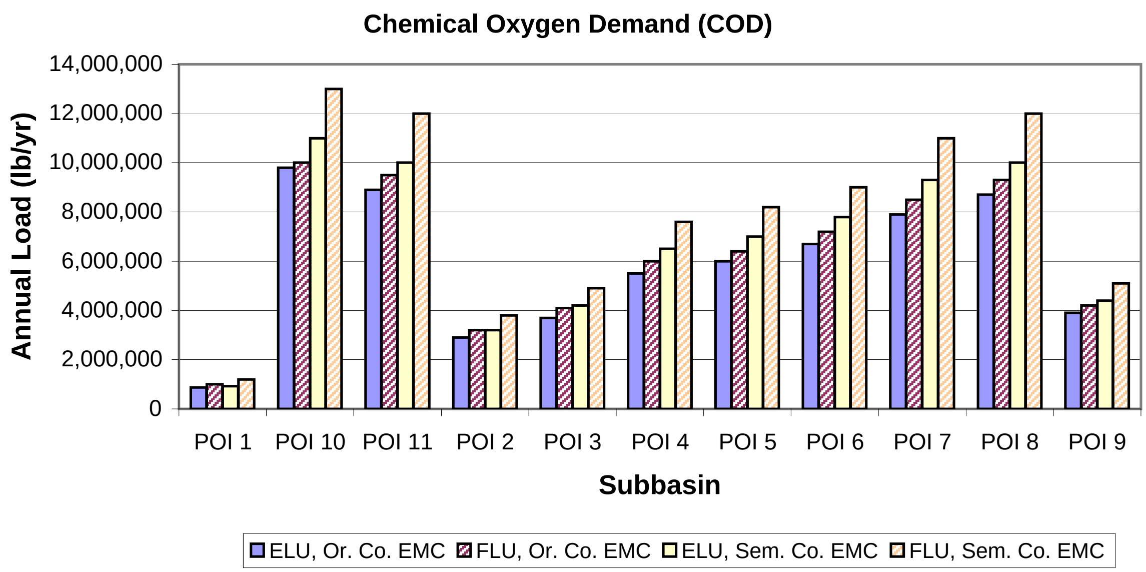


Figure 4-10
Little Wekiva River Watershed Management Plan
WMM Results - Point of Interest Annual





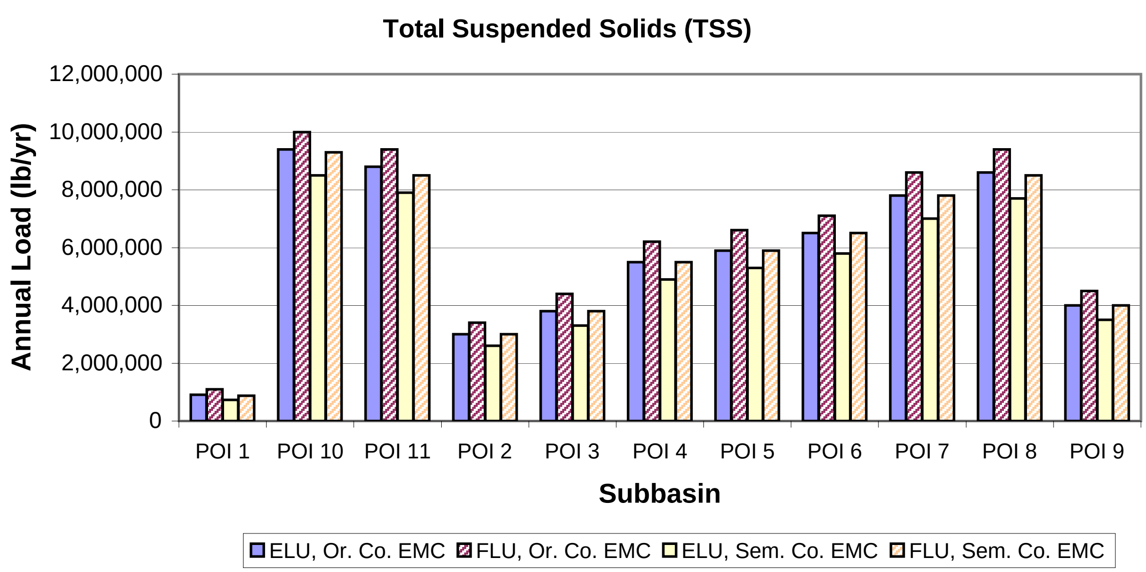
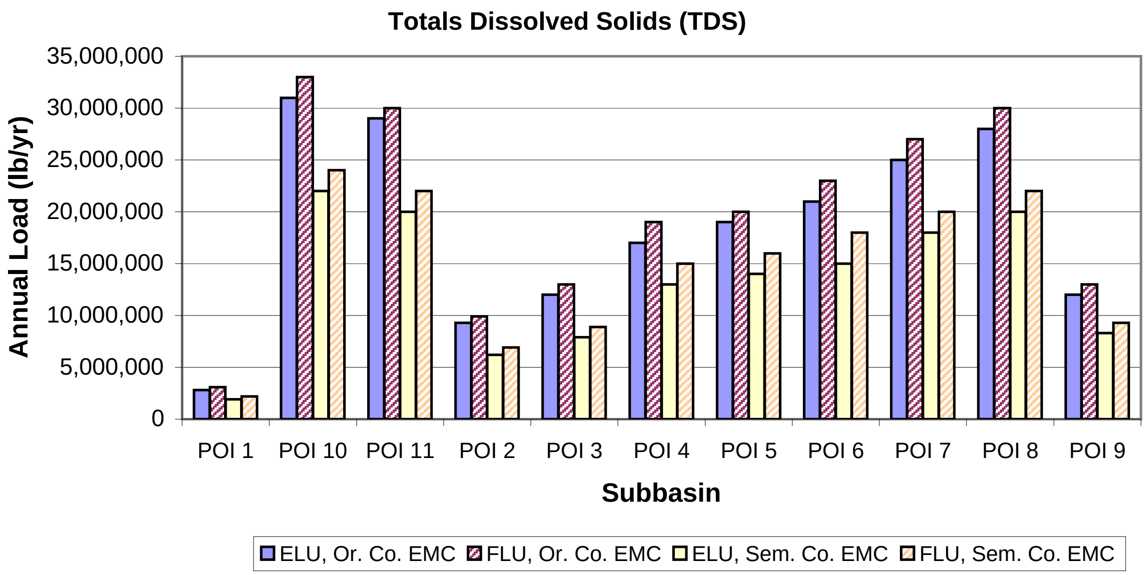
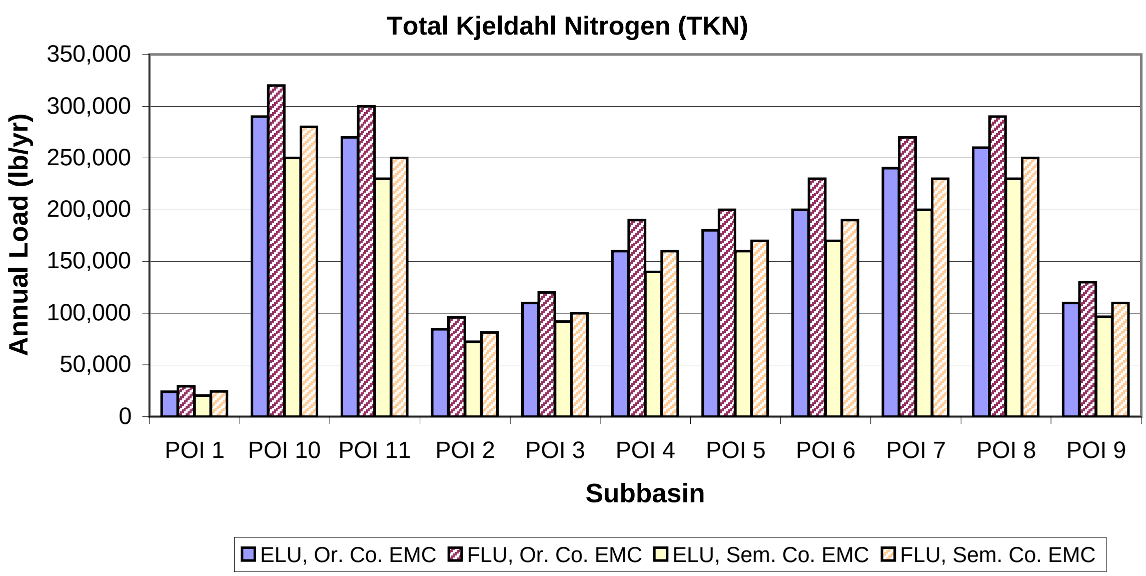


Figure 4-10
Little Wekiva River Watershed Management Plan
WMM Results - Point of Interest Annual





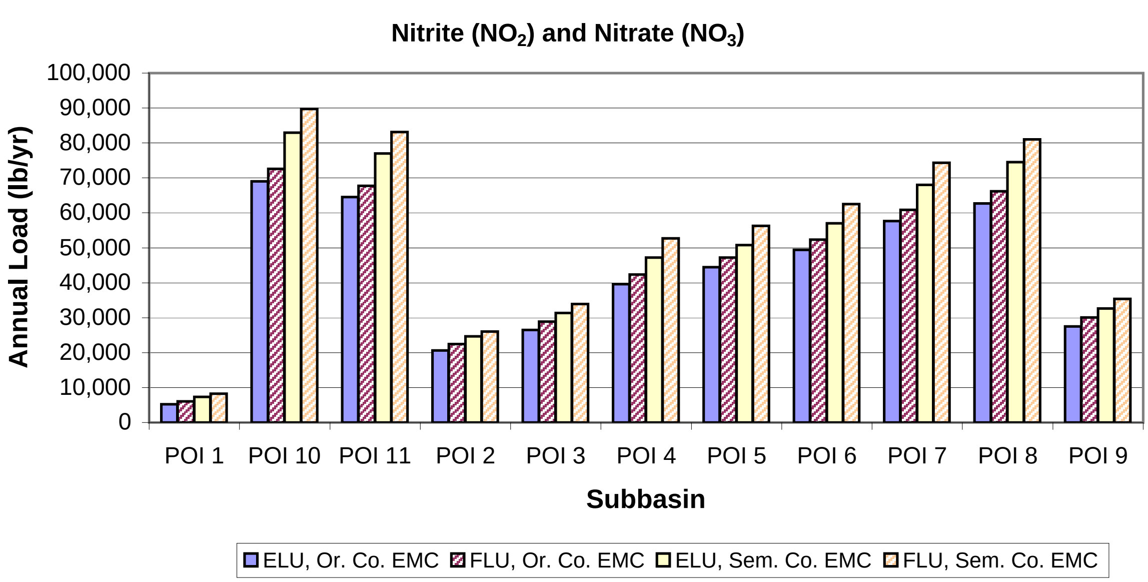
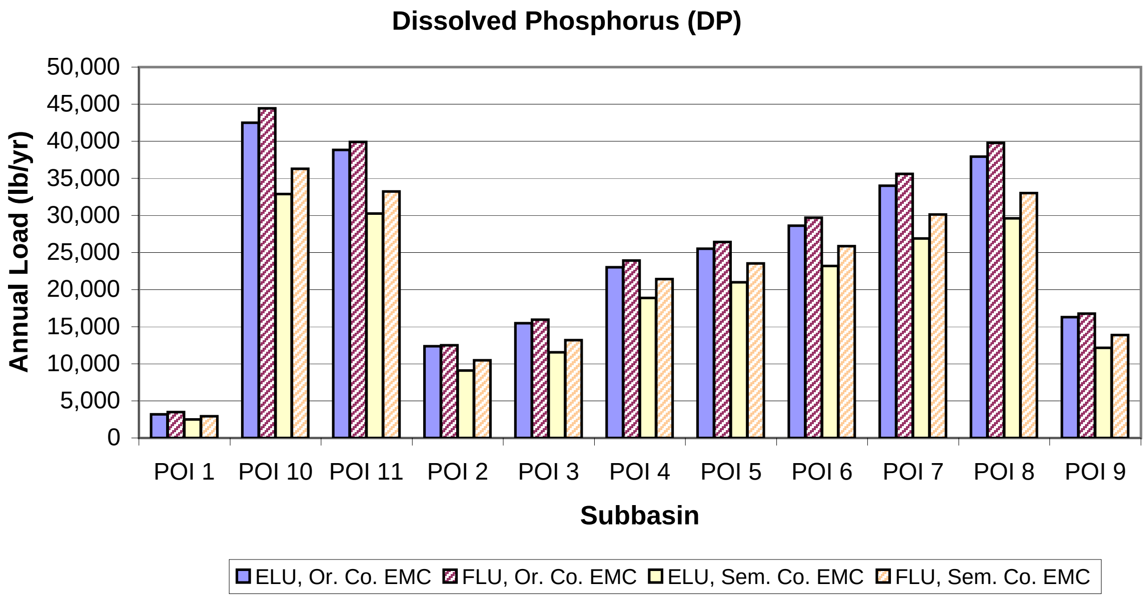
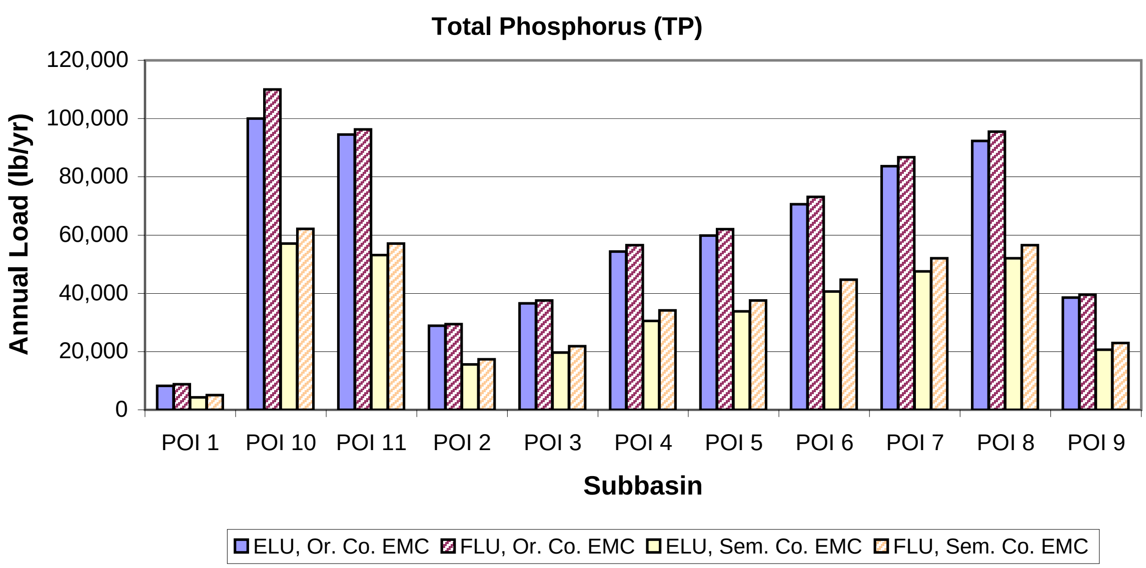


Figure 4-10
Little Wekiva River Watershed Management Plan
WMM Results - Point of Interest Annual





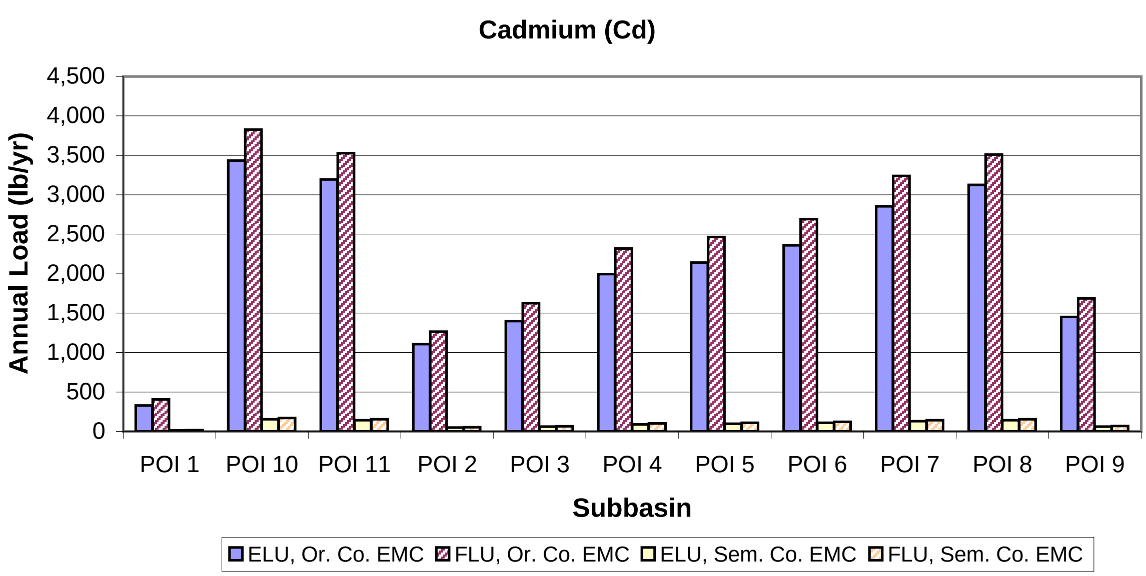
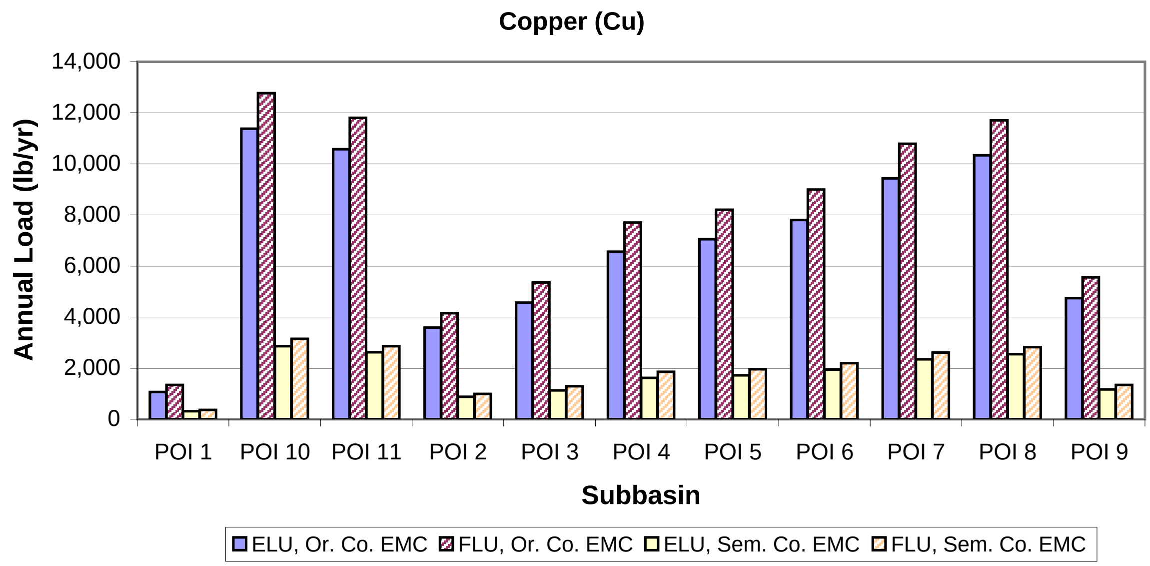
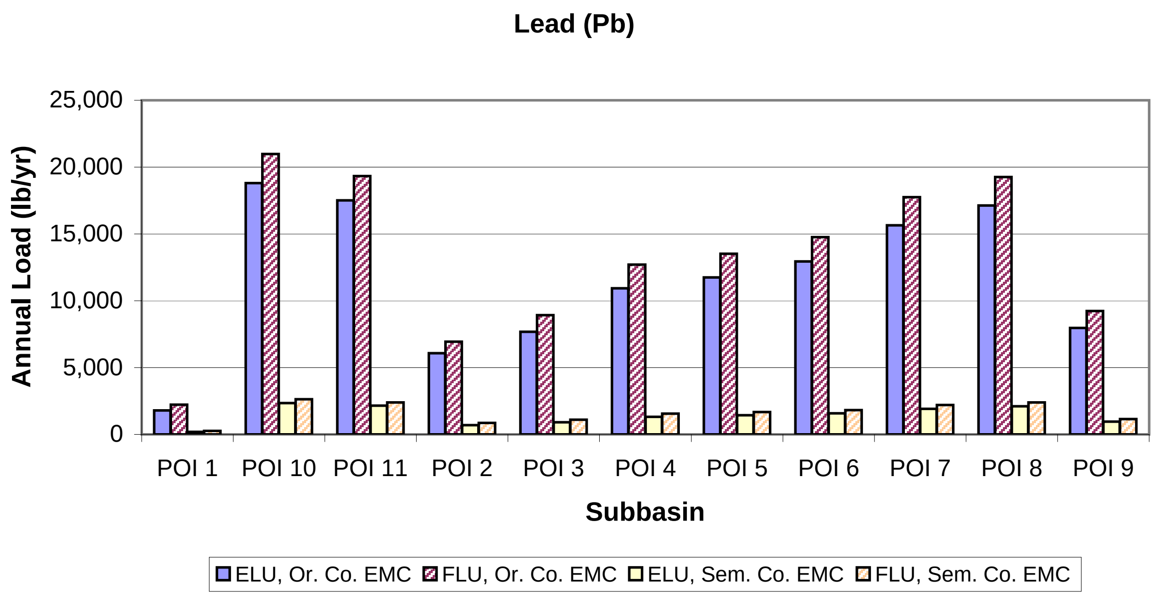
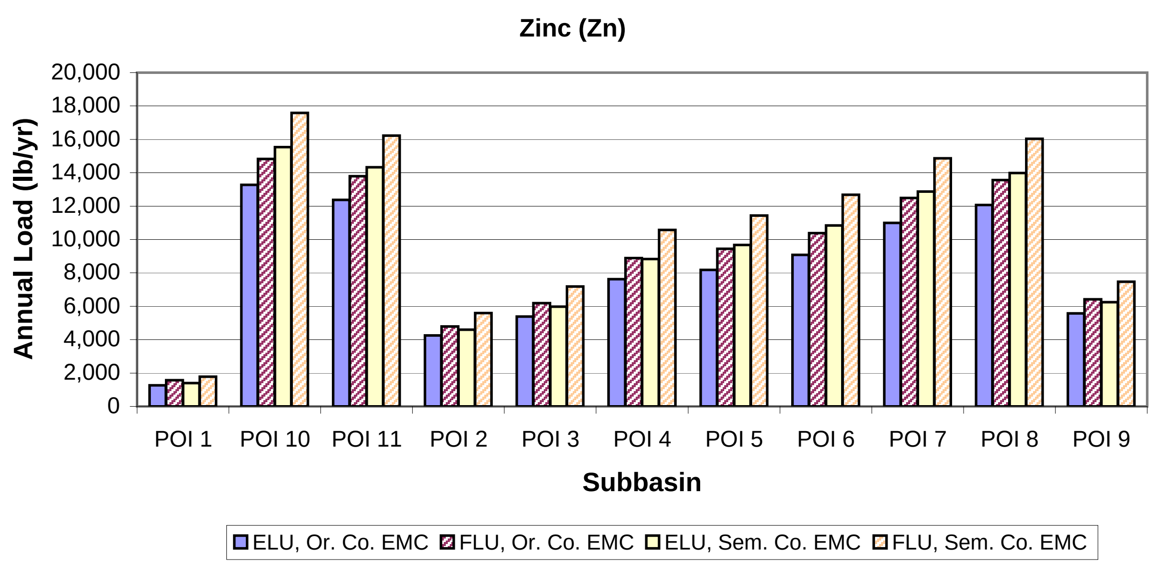


Figure 4-10
Little Wekiva River Watershed Management Plan
WMM Results - Point of Interest Annual







4.4.2 Future Land Use

Under future land use conditions, developed land (e.g., residential, commercial, industrial, institutional, major roads) accounts for 28,307 acres, which is approximately 81 percent of the total basin area.

For the entire watershed, the estimated annual surface runoff load of all twelve NPDES pollutants is estimated to increase by approximately 12 percent from existing land use conditions.

If all new development were treated by wet detention BMPs (as would be required by permitting agencies), approximately 21 percent of the total basin area and 28 percent of developed lands would be served by BMPs. The BMPs would remove a little over 10 percent of the total pollutant load, and the total amount of pollutants reaching the Little Wekiva River would be approximately 8 percent higher than the existing load. The Tributary "E", "G" and "I" subbasin had the largest percent increase of pollutant loads compared to existing land use conditions while the Tributary "D" subbasin showed the least amount of change. The comparisons are shown in Figure 4-6.

4.4.3 Lake/Reservoir Water Quality (LAKE) Module

An earlier version of WMM (version 3.3) contains a module that is used to predict the chlorophyll-a and TSI values for lakes based on nonpoint source pollutant loadings. This module was used separately from the WMM analysis (version 4.17) described earlier that predicts loadings from nonpoint source pollution. The lakes in the Little Wekiva River Basin identified on the FDEP's verified list that require the development of a TMDL were analyzed using the WMM Lake module. These lakes include Lake Lawne, Lake Silver, Bay Lake, Spring Lake, Lake Orienta, Lake Florida and Lake Adelaide.

In order to simulate the effects in downstream lakes or reservoirs of land use changes within the watershed or of water quality improvements resulting from the application of BMPs, lake simulation algorithms are included in the model. These algorithms are used to estimate in-lake concentrations of nutrients, chlorophyll-a, metals, and oxygen demand and sediments. The Carlson Florida Trophic State Index (TSI) procedure is also included in the spreadsheet model. Nutrient concentrations derived from the loading model are used in the lake algorithms to predict in-lake concentrations which are then used to calculate a nutrient TSI value. The TSI procedure is an effective method of classifying lakes into good, fair, or poor water quality categories.

Eutrophication Analysis

Models developed by Reckhow for lakes in the United States (1988, 1992) and by Walker (1985a) are employed in the LAKE Module for evaluations of eutrophication impacts. These input-output models are improved versions of the classic Vollenweider-type eutrophication models (Vollenweider, 1975). The models relate phosphorus and nitrogen loadings predicted by the previously described nonpoint source model to in-lake phosphorus and nitrogen concentrations based on lake characteristics. The Reckhow model was formulated and tested using a robust non-linear regression analysis on multi-lake data sets of U.S. lakes.

The nutrient models assume that lakes and reservoirs are well mixed. This condition is generally met for many lakes. Assuming that the lake inflow is equal to the outflow and including such parameters as mean depth, hydraulic detention time, and average inflow, the final in-lake nutrient concentration can be expressed as:

$$C = \frac{C_{in}}{(1 + k * T_w)} * 10^a \qquad (Equation\ 4-6)$$

where:

C = mean in-lake nutrient concentration (mg/L) of either total-P or total-N;

C_{in} = mean inflow nutrient concentration (mg/L)
= annual nutrient load/annual inflow;

K = nutrient trapping coefficient (1/yr);

T_w = average hydraulic residence time (yr)
=lake volume (cu ft)/average inflow (cu ft/yr);

a_p = phosphorus exponent; and

a_n = nitrogen exponent.

Separate values for "k" are calculated for total-P and total-N.

The nutrient concentrations projected with Equation 4-6 are used in the prediction of mean chlorophyll-a levels in the lake in conjunction with other parameters such as average hydraulic residence time in the lake during the summer months (the period of greatest algal activity) and the mean depth of the mixed layer in the lake. Region-specific models developed by Reckhow may be used in the WMM to predict in-lake water quality with less error than would be attainable with a single national model. Mean concentrations of total-P, total-N, chlorophyll-a, and secchi disk depth in lakes and reservoirs may be predicted for seven regions covering 41 states using equations and coefficients specific to those regions. For the purpose of this analysis, equations and coefficients specific to Florida were used.

Secchi Disk Depth

Secchi depth is probably the most frequently used parameter in limnology. The Secchi disk is a 20 cm plastic or metal disk that is most often divided into alternating painted black and white quadrants. This disk is lowered into the water until the observer can no longer see the disk. The depth is recorded and is referred to as the Secchi transparency, or Secchi depth, of the lake (EPA, 1988).

The Secchi disk transparency is essentially a function of the reflection of light from its surface, and is therefore influenced by both the absorption characteristics of the water and of its dissolved and particulate matter (Wetzel, 1975). Relationships between the Secchi depth and the amount of algal biomass as expressed as chlorophyll-a have been developed for a large number of lakes. Secchi disk relationships have been incorporated into the LAKE module of the WMM.

Trophic State Index Procedure

The Trophic State Index (TSI) procedure provides an effective method of classifying lakes based on the lake's chlorophyll, Secchi depth, and phosphorus concentrations. The index is based on a trophic classification scheme developed in 1977 by R.E. Carlson. He relied on three trophic indicators to describe the trophic status of a lake. His goal was to have each indicator related to algal biomass such that a 10 unit change in the index would represent a doubling or halving of algal biomass. Carlson developed indices based on Secchi disc transparency, chlorophyll concentration and total phosphorus concentration. Region specific TSI criteria for Florida lakes were used for this analysis. The following ranges of TSI are indicators of the water quality condition:

TSI Range	Condition
70-100	Poor
60-69	Fair
0-59	Good

The following paragraphs discuss the results of the LAKE module for each of the impaired lakes in the Little Wekiva River basin. Along with these results, CDM also estimated what the reduction in pollutant loads would have to be in order to for each lake to meet a TSI<60.

4.4.3.1 Lake Lawne

Lake Lawne is located in the southern part of the Little Wekiva River basin and is considered to be the headwaters of the Little Wekiva River. It is within both Orange County and the City of Orlando jurisdictions. The lake itself is comprised of 156 acres and is surrounded primarily by residential and commercial areas. The physical characteristics of the lake are provided below in **Table 4-10**.

Table 4-10
Little Wekiva River Watershed Management Plan
Lake Lawne Physical Characteristics

Surface Area (acres)	Volume (ac-ft)	Mean Depth (feet)	Maximum Depth (feet)	Shoreline Length (feet)
156	299	6.33	24.8	16,020

Using these characteristics and the estimated pollutant loads from the WMM analysis for existing conditions, the LAKE Module was used to predict the chlorophyll-a, secchi disk depth and the Florida TSI. The results are summarized below in **Table 4-11.**

Table 4-11
Little Wekiva River Watershed Management Plan
Lake Lawne LAKE Module Results

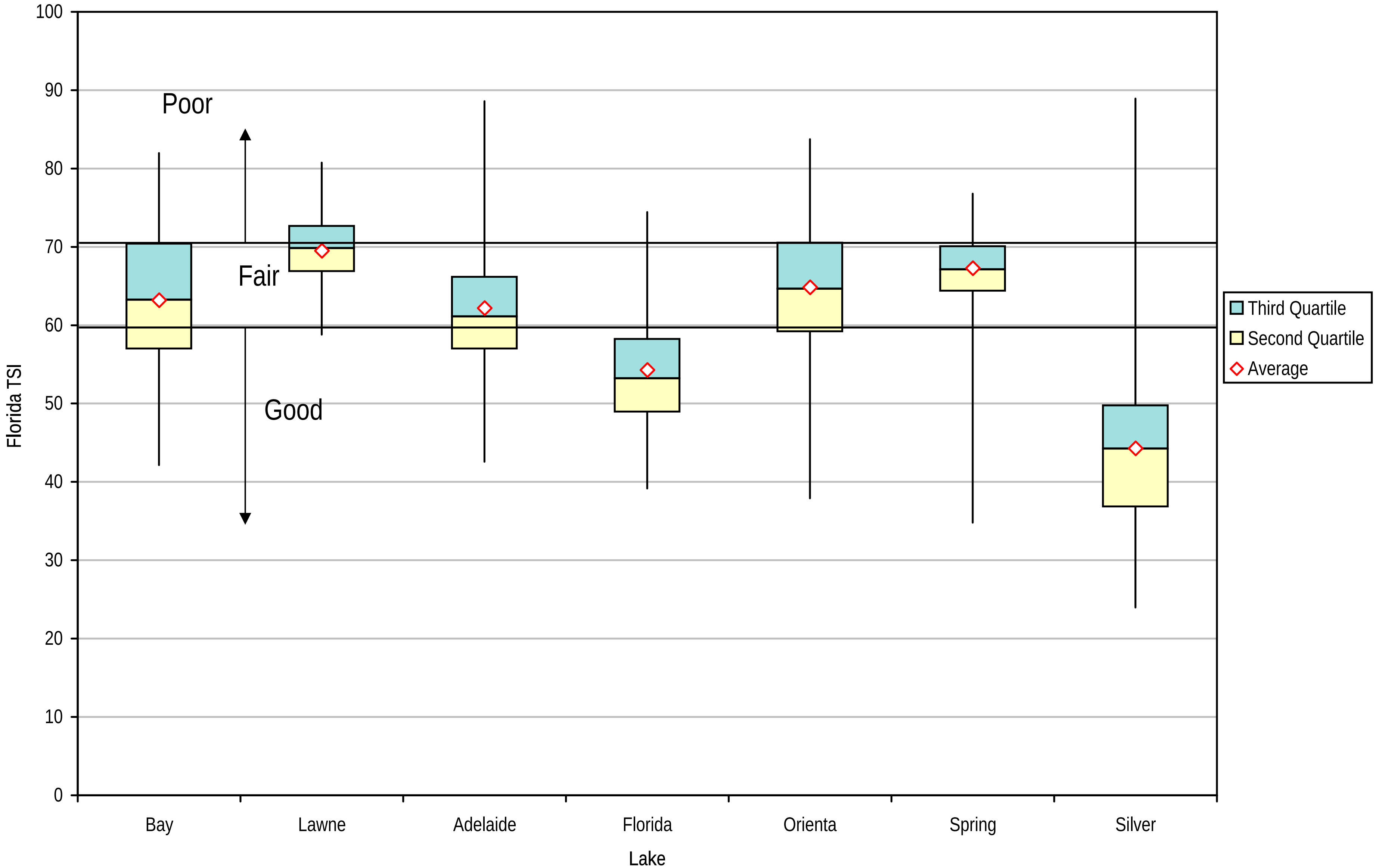
Surface Area (acres)	In Lake Total Nitrogen Concentration (mg/l)	In Lake Total Phosphorus Concentration (mg/l)	Chlorophyll a (ug/l)	Secchi Disk Depth (m)	Florida TSI
Existing Conditions without BMPs	1.28	0.18	50.5	0.57	70
Existing Conditions with BMPs	1.28	0.18	50.2	0.57	70

There is little difference in the predicted values between the two existing land use scenarios. This is attributed to the fact that less than 4 percent of the Lake Lawne subbasin (TRIBI) is equipped with some type of treatment BMP. A study entitled *Diagnostic/Feasibility Study for the Restoration of Lake Lawne* (FDEP, 1993) cited that monitored inflows from four stormwater canals discharging into the lake during three storm events indicated the majority of the nutrients, metals and suspended solid loadings originate from the eastern part of the subbasin.

The predicted values derived from the LAKE module were compared with historical sampling data obtained from the City of Orlando. The median TSI value from the sampling data is 69.8 (fair to poor). A box and whisker plot was created from the historical sampling data and is shown in **Figure 4-11.**

Box and whisker plots are created using statistical methods and provide a visual representation of the dispersion of data sets. The methodology provides a graphical summary of a set of data based on the quartiles of a particular data set. Quartiles are used to split the data into four groups, each containing 25 percent of the measurements. Box plots are summary plots based on the median of the data set and interquartile range which contains 50 percent of the values. Whiskers extend from the box to the highest and lowest values, excluding outliers. A box and whisker plot was used as part of this exercise to determine where the predicted TSI fell in relationship to the sampled TSI in order to gain a level of confidence in the modeling results. In the case of Lake Lawne, the predicted TSI was almost identical to the median value of the sampled data.

Figure 4-11
TSI Box and Whisker Plots
Historical Lake Sampling



Historical sampling data for Lake Lawne suggests that the algal production in the lake is co-limited by both nitrogen and phosphorus. The *Diagnostic/Feasibility Study for the Restoration of Lake Lawne* (FDEP, 1993) also cited that there is evidence from N:P ratios and modeling that co-limitation of both these nutrients may exist. Using the LAKE module results, CDM then estimated how much of a reduction in nonpoint source pollutant loads would be required to achieve a TSI of less than 60, which would be deemed as good water quality. The loadings for nitrogen and phosphorus predicted by the WMM were reduced until a TSI value of 59 was achieved. For this to occur, it is estimated that total phosphorus (TP) and total nitrogen (TN) would have to be reduced by 55 and 50 percent respectively from nonpoint source loadings.

In addition to stormwater runoff, it is important to note that lake systems typically have other loadings that are both external and internal. Loadings other than surface runoff include atmospheric deposition, bank seepage, artesian input, direct rainfall on the lake surface and nutrient release from lake sediment. These other loadings can be significant and were not examined as a part of this analysis. Therefore, it is important to keep in mind that the estimated reductions in TP and TN are based on stormwater inputs only and that that the recommended strategy for lake restoration is to limit both external and stormwater inputs and the internal nutrient contribution from the sediments. In the case of Lake Lawne, evidence suggested sediment internal loadings within the lake have proven to be a significant source of phosphorus. The best estimate for internal loading from lake sediments is that 1.5 times more phosphorus is released from sediments than enters the lake externally from stormwater drainage, rainfall directly onto the lake and septic tank leachate (FDEP 1993).

4.4.3.2 Bay Lake

Bay Lake is located partially within the Orlando city limits and is comprised of approximately 36 acres. The lake is surrounded primarily by residential, commercial and forested areas. The physical characteristics of the lake are provided below in **Table 4-12**.

Table 4-12
Little Wekiva River Watershed Management Plan
Bay Lake Physical Characteristics

Surface Area (acres)	Volume (ac-ft)	Mean Depth (feet)	Maximum Depth (feet)	Shoreline Length (feet)
36	92	8.3	N/A	4,778

N/A – Not Available

Using these characteristics and the estimated pollutant loads from the WMM analysis for existing conditions, the LAKE Module was used to predict the chlorophyll-a, secchi disk depth and the Florida TSI. The results are summarized below in **Table 4-13.**

Table 4-13
Little Wekiva River Watershed Management Plan
Bay Lake LAKE Module Results

Surface Area (acres)	In Lake Total Nitrogen Concentration (mg/l)	In Lake Total Phosphorus Concentration (mg/l)	Chlorop hyll a (ug/l)	Secchi Disk Depth (m)	Florida TSI
Existing Conditions without BMPs	1.70	0.39	31.3	0.82	63
Existing Conditions with BMPs	1.68	0.39	30.7	0.82	63

Again, there is a slight difference in the predicted values between the two existing land use scenarios. Less than 3 percent of the Bay Lake tributary area is currently treated by BMPs. The predicted values derived from the LAKE module were compared with historical sampling data obtained from the City of Orlando. The median TSI value from the sampling data is 63.3 (fair to good). A box and whisker plot was created from the historical sampling data and is shown in Figure 4-11. The predicted TSI was almost identical to the median value of the sampled data for Bay Lake.

FDEP identified algal production in Bay Lake to be co-limited by both nitrogen and phosphorus based on sampling data. The LAKE module was then used to estimate the nonpoint source pollutant load reduction, namely TN and TP, required in order to achieve a TSI of less than 60. TN and TP would have to be reduced by approximately 20 and 30 percent, respectively to achieve a TSI of 59. Please note that the estimated reductions in TP and TN are based on stormwater inputs only and that that the recommended strategy for lake restoration is to limit both external and stormwater inputs and the internal nutrient contribution from the sediments.

4.4.3.3 Lake Silver

Lake Silver, located entirely within the Orlando city limits, is comprised of approximately 70 acres. It has a tributary area of approximately 723 acres which consists mostly of medium density residential land use. The physical characteristics of the lake are provided below in **Table 4-14**.

Table 4-14
Little Wekiva River Watershed Management Plan
Lake Silver Physical Characteristics

Surface Area (acres)	Volume (ac-ft)	Mean Depth (feet)	Maximum Depth (feet)	Shoreline Length (feet)
70	359	15.8	N/A	6,997

N/A – Not Available

Using these characteristics and the estimated pollutant loads from the WMM analysis for existing conditions, the LAKE Module was used to predict the chlorophyll-a, secchi disk depth and the Florida TSI. The results are summarized below in **Table 4-15.**

Table 4-15
Little Wekiva River Watershed Management Plan
Lake Silver LAKE Module Results

Surface Area (acres)	In Lake Total Nitrogen Concentration (mg/l)	In Lake Total Phosphorus Concentration (mg/l)	Chlorophyll a (ug/l)	Secchi Disk Depth (m)	Florida TSI
Existing Conditions without BMPs	2.02	0.58	32.9	0.95	64
Existing Conditions with BMPs	2.02	0.58	32.9	0.95	64

There is no difference in the predicted values for the parameters in Table 4-15 due to the lack of stormwater treatment BMPs within the tributary area. The predicted values derived from the LAKE module were compared with historical sampling data obtained from the City of Orlando. The median TSI value from the sampling data is 44.3 which differs significantly from the predicted value of 64 (fair). The range of historical sampling data is from 24 to 90, indicating a wide spread of data over time. A box and whisker plot was created from the historical sampling data and is shown in Figure 4-11**.** The predicted TSI of 64 falls within the fourth quartile of the sampling data. The upper twenty five percent of the sampling values are within this fourth quartile, represented as the whisker on Figure 4-11, and range from 50 to 89. This wide variability in sampling data indicates that other inputs other than stormwater may have greater influence on algal production in the lake.

Algal production in Lake Silver is co-limited by both nitrogen and phosphorus based on FDEP's verified list of impaired water bodies. The LAKE module was used to estimate the nonpoint source pollutant load reduction, namely TN and TP, required in order to achieve a TSI of less than 60. It is estimated that TN and TP would have to be reduced by approximately 30 and 35 percent, respectively to achieve a TSI of 59. Please note that the estimated reductions in TP and TN are based on stormwater inputs only and that that the recommended strategy for lake restoration is to limit both external and stormwater inputs and the internal nutrient contribution from the sediments.

4.4.3.4 Spring Lake

The tributary area of Spring Lake is located within unincorporated Seminole County and the City of Altamonte Springs. The lake itself is comprised of approximately 88 acres is surrounded primarily by areas classified as medium density residential land use. The physical characteristics of the lake are provided below in **Table 4-16**.

Table 4-16
Little Wekiva River Watershed Management Plan
Spring Lake Physical Characteristics

Surface Area (acres)	Volume (ac-ft)	Mean Depth (feet)	Maximum Depth (feet)	Shoreline Length (feet)
88	167	6.0	19.0	N/A

N/A – Not Available

Using these characteristics and the estimated pollutant loads from the WMM analysis for existing conditions, the LAKE Module was used to predict the chlorophyll-a, secchi disk depth and the Florida TSI. The results are summarized below in **Table 4-17.**

Table 4-17
Little Wekiva River Watershed Management Plan
Spring Lake LAKE Module Results

Surface Area (acres)	In Lake Total Nitrogen Concentration (mg/l)	In Lake Total Phosphorus Concentration (mg/l)	Chlorop hyll a (ug/l)	Secchi Disk Depth (m)	Florida TSI
Existing Conditions without BMPs	1.73	0.28	37.1	0.66	69
Existing Conditions with BMPs	1.59	0.25	32.5	0.69	67

Approximately 22 percent of the tributary is treated with stormwater BMPs which accounts for the differences in the predicted values shown in Table 4-17 for the two existing land use scenarios. The predicted values derived from the LAKE module were compared with historical sampling data obtained from the Seminole County Watershed Atlas. The median TSI value from the historical sampling data is 67 (fair to poor). A box and whisker plot was created from the historical sampling data and is shown in Figure 4-11. The predicted TSI using the LAKE module is identical to the median value of the sampled data for Spring Lake.

FDEP identified algal production in Spring Lake to be limited by phosphorus based on sampling data. The LAKE module estimated that TP would have to be reduced by approximately 67 percent to achieve a TSI of 59. Please note that the estimated reductions in TP and TN are based on stormwater inputs only and that that the recommended strategy for lake restoration is to limit both external and stormwater inputs and the internal nutrient contribution from the sediments.

4.4.3.5 Lake Orienta

Lake Orienta is approximately 142 acres in size and is located within the City of Altamonte Springs. Its tributary area is primarily made up of medium and high density residential land use. The physical characteristics of the lake are provided below in **Table 4-18**.

Table 4-18
Little Wekiva River Watershed Management Plan
Lake Orienta Physical Characteristics

Surface Area (acres)	Volume (ac-ft)	Mean Depth (feet)	Maximum Depth (feet)	Shoreline Length (feet)
142	272	6.0	24.0	N/A

N/A – Not Available

Using these characteristics and the estimated pollutant loads from the WMM analysis for existing conditions, the LAKE Module was used to predict the chlorophyll-a, secchi disk depth and the Florida TSI. The results are summarized below in **Table 4-19.**

Table 4-19
Little Wekiva River Watershed Management Plan
Lake Orienta LAKE Module Results

Surface Area (acres)	In Lake Total Nitrogen Concentration (mg/l)	In Lake Total Phosphorus Concentration (mg/l)	Chlorophyll a (ug/l)	Secchi Disk Depth (m)	Florida TSI
Existing Conditions without BMPs	1.78	0.29	33.4	0.75	67
Existing Conditions with BMPs	1.77	0.29	33.0	0.76	67

Only 2.6 percent of the Lake Orienta tributary area is treated with stormwater BMPs which is reflected in Table 4-17 for the two existing land use scenarios. The predicted values derived from the LAKE module were compared with historical sampling data obtained from the Seminole County Watershed Atlas. The median TSI value from the historical sampling data is 65 (fair). A box and whisker plot was created from the historical sampling data and is shown in Figure 4-11. The predicted TSI using the LAKE module is comparable to the median value of the sampled data for Lake Orienta.

FDEP identified algal production in Lake Orienta to be limited by both phosphorus and nitrogen based on sampling data. The LAKE module estimated that TP and TN would both have to be reduced by approximately 30 percent to achieve a TSI of 59. Please note that the estimated reductions in TP and TN are based on stormwater inputs only and that that the recommended strategy for lake restoration is to limit both external and stormwater inputs and the internal nutrient contribution from the sediments.

4.4.3.6 Lake Florida

The tributary area for Lake Florida is approximately 1,202 acres and is located within both unincorporated Seminole County and the City of Altamonte Springs. The lake itself is 25 acres in size and it is surrounded primarily by medium density residential land uses. The physical characteristics of the lake are provided below in **Table 4-20**.

Table 4-20
Little Wekiva River Watershed Management Plan
Lake Florida Physical Characteristics

Surface Area (acres)	Volume (ac-ft)	Mean Depth (feet)	Maximum Depth (feet)	Shoreline Length (feet)
25	58	7.0	21.0	N/A

N/A – Not Available

Using these characteristics and the estimated pollutant loads from the WMM analysis for existing conditions, the LAKE Module was used to predict the chlorophyll-a, secchi disk depth and the Florida TSI. The results are summarized below in **Table 4-21.**

Table 4-21
Little Wekiva River Watershed Management Plan
Lake Florida LAKE Module Results

Surface Area (acres)	In Lake Total Nitrogen Concentration (mg/l)	In Lake Total Phosphorus Concentration (mg/l)	Chlorop hyll a (ug/l)	Secchi Disk Depth (m)	Florida TSI
Existing Conditions without BMPs	1.89	0.31	46.3	0.59	72
Existing Conditions with BMPs	1.83	0.30	43.9	0.6	71

Stormwater runoff from approximately 12 percent of the Lake Florida tributary area is treated by stormwater BMPs as shown in Table 4-21 for the two existing land use scenarios. The predicted values derived from the LAKE module were compared with historical sampling data obtained from the Seminole County Watershed Atlas. The median TSI value from the historical sampling data is 53 (good). A box and whisker plot was created from the historical sampling data and is shown in Figure 4-11. The median TSI value from the sampling data differs significantly from the predicted value of 71. The historical sampling data ranges from a TSI of 39 to 74, indicating a wide spread of data over time. The predicted TSI of 71 falls within the fourth quartile of the sampling data. The upper twenty five percent of the sampling values are within this fourth quartile, represented as the top whisker on Figure 4-11, and range from 58 to 74. This wide variability in sampling data may indicate that inputs other than stormwater may have a more pronounced influence on algal production in the lake over time.

FDEP identified algal production in Lake Florida as co-limiting (i.e., production is limited by both phosphorus and nitrogen) based on sampling data. The LAKE module estimated that TP and TN would have to be reduced by approximately 50 and 47 percent to achieve a TSI of 59. Please note that the estimated reductions in TP and TN are based on stormwater inputs only and that that the recommended strategy for lake restoration is to limit both external and stormwater inputs and the internal nutrient contribution from the sediments.

4.4.3.7 Lake Adelaide

Lake Adelaide has a surface area of 21 acres and its tributary area is approximately 1,620 acres and is located within both unincorporated Seminole County and the City of Altamonte Springs. The tributary area surrounding the lake is dominated by residential land uses. The physical characteristics of the lake are provided below in **Table 4-22**.

Table 4-22
Little Wekiva River Watershed Management Plan
Lake Adelaide Physical Characteristics

Surface Area (acres)	Volume (ac-ft)	Mean Depth (feet)	Maximum Depth (feet)	Shoreline Length (feet)
21	54	7.0	12.0	N/A

N/A – Not Available

Using these characteristics and the estimated pollutant loads from the WMM analysis for existing conditions, the LAKE Module was used to predict the chlorophyll-a, secchi disk depth and the Florida TSI. The results are summarized below in **Table 4-23.**

Table 4-23
Little Wekiva River Watershed Management Plan
Lake Adelaide LAKE Module Results

Surface Area (acres)	In Lake Total Nitrogen Concentration (mg/l)	In Lake Total Phosphorus Concentration (mg/l)	Chlorophyll a (ug/l)	Secchi Disk Depth (m)	Florida TSI
Existing Conditions without BMPs	1.87	0.30	46.4	0.58	72
Existing Conditions with BMPs	1.78	0.28	42.9	0.59	71

Stormwater runoff from approximately 10 percent of the tributary area is treated by stormwater BMPs. The predicted values derived from the LAKE module were compared with historical sampling data obtained from the Seminole County Watershed Atlas. The median TSI value from the historical sampling data is 61 (fair). A box and whisker plot was created from the historical sampling data and is shown in Figure 4-11. The median TSI value from the sampling data differs somewhat from the predicted value of 71. The historical sampling data ranges from a TSI of 43 to 89, again indicating a wide spread of data over time. The predicted TSI of 71 falls within the fourth quartile of the sampling data or the upper twenty five percent of the sampling values represented as the top whisker on Figure 4-11. This quartile ranges from 66 to 89. The wide variability in sampling data may indicate that inputs other than stormwater may have a more pronounced influence on algal production in the lake over time.

FDEP identified algal production in Lake Adelaide to be limited by both phosphorus and nitrogen based on sampling data. Using the LAKE module, it is estimated that both TP and TN would have to be reduced by approximately 50 percent to achieve a TSI of 59. Please note that the estimated reductions in TP and TN are based on stormwater inputs only and that that the recommended strategy for lake restoration is to limit both external and stormwater inputs and the internal nutrient contribution from the sediments.

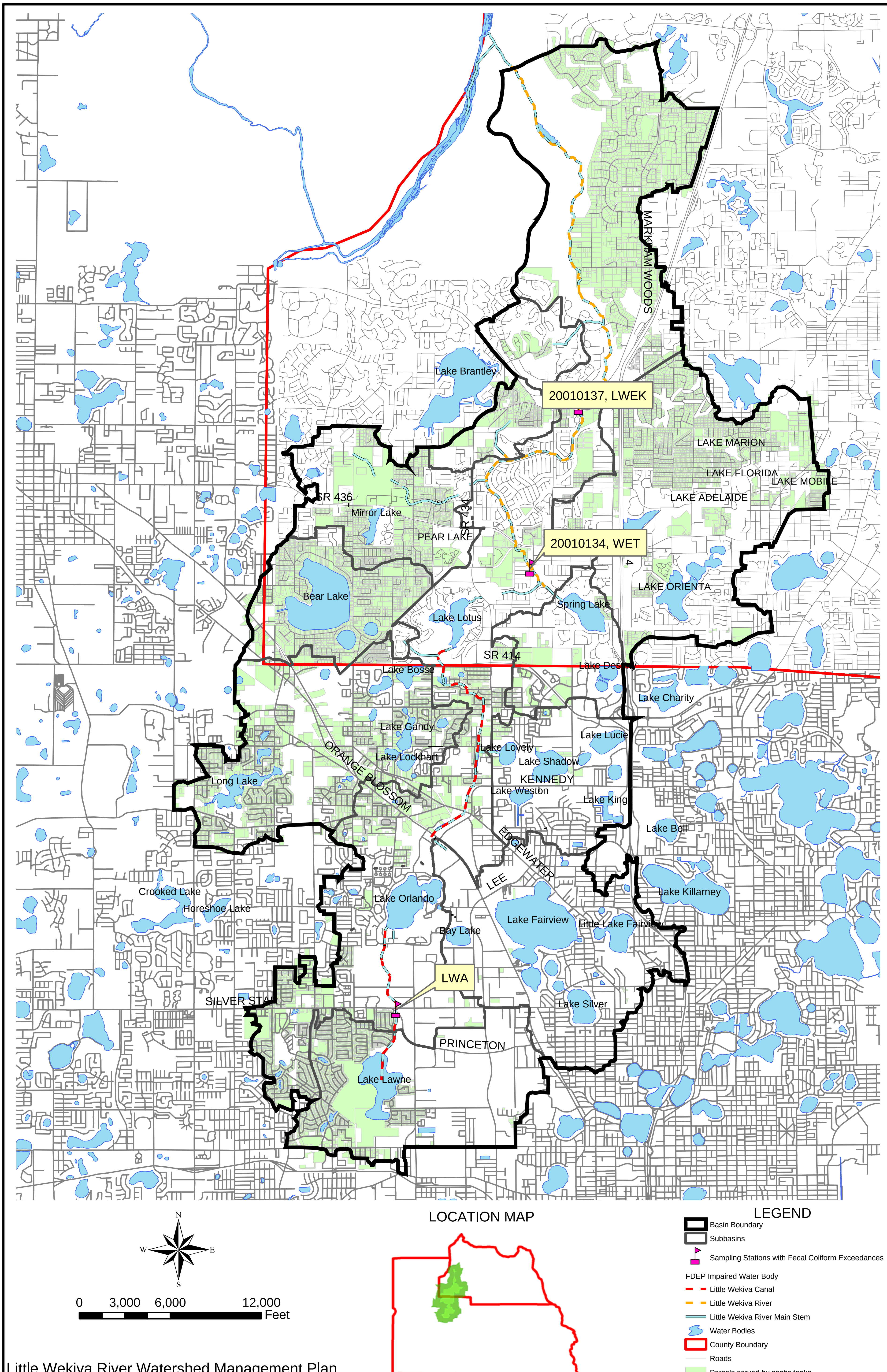
4.5 Septic Tank Analysis

The section of the Little Wekiva River within Orange County is identified as the Little Wekiva Canal by FDEP for the purposes of tracking impaired water body segments. This segment is currently listed as impaired for fecal coliform bacteria according to FDEP's verified list of impaired water bodies while the Little Wekiva River (Seminole County) segment is currently listed for both fecal and total coliform bacteria. The locations of these impaired water bodies were previously shown on Figure 2-13. The State's water quality standard is currently 400 and 2,400 colonies/100ml for fecal and total coliform bacteria, respectively. Although septic tank impacts were incorporated into the WMM (which account for an increase in nitrogen and phosphorus loadings), CDM reviewed available water quality sampling data for fecal coliform bacteria to determine if a relationship may exist between the presence of septic tanks and the elevated levels of fecal coliforms in the river. The density of septic tanks and their proximity to the impaired water body were taken into account when determining if there might be a relationship. The following paragraphs discuss the findings of this exercise.

4.5.1 Little Wekiva Canal

There is one sampling location (LWA) along the Little Wekiva Canal where results for fecal coliform levels were available. This location, shown on **Figure 4-12**, is at the river's crossing with Silver Star Road and review of the sampling data at this location showed several exceedances of the water quality standard for fecal coliform. Review of the septic tank data coverage in this area, shown in Figure 4-12, shows that there is a high density of septic tanks along the west side of the river upstream of the sampling station at Silver Star Road. This may indicate that there is a possible relationship between the presence of septic tanks and elevated fecal coliform levels in the river. However in order to determine if this relationship exists, it is necessary to characterize the source of fecal coliform (i.e., whether it is human or environmental related (such as animals). While characterizing the source of fecal coliform is beyond the scope of this study, there have been several methods documented to identify sanitary discharge sources (CDM, 2001; Pitt 2001; Burkhardt, 1999) using tracers of contamination by sanitary sewage. Potential indicators of human waste include:

- Certain molecular markers, specifically fecal sterols, such as coprostanol and epicoprostanol, although these compounds are also discharged by other carnivores, especially dogs;



CDM

Figure 4-12
Fecal Coliform Exceedances

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- Antibiotic resistance analysis;
- Male bacteriopliage;
- Chemical compounds including saturated hydrocarbons with 16 – 18 carbons and saturated hydrocarbons with 16-21 carbons in addition to coprostanol;
- Pharmaceutical substances, aspirin, caffeine and ibuprofen; and,
- DNA profiling as patterns in fecal coliform vary among birds and animals.

4.5.2 Little Wekiva River

Two sampling stations (FDEP 20010134 and WET) located just downstream from the river's confluence with Spring Lake have shown elevated levels of fecal coliforms in the Little Wekiva River based on water quality sampling data available from the Seminole County Watershed Atlas. The locations of these sampling stations along with the septic tanks are also shown on Figure 4-12. The Swofford Treatment plant is located just upstream of this confluence. However, upon review of seven years of discharge monitoring reports from the plant, the historical average for fecal coliform bacteria (#/100 ml) from the plant's discharge to the river was 11.02. Upon review of the septic tank GIS coverage, there are a minimal number of septic tanks that are located within the tributary area to these sampling points. Further downstream, there are two sampling stations (FDEP site 20010137 and Seminole County sampling site LWEK), both located at SR 434 where results shown levels of fecal coliform that exceed the State's water quality criteria of 400 counts/100ml. Upon review of the septic tank GIS coverage, there are several subdivisions (i.e., Kensington Park, Sanlando Estates and Sanlando Springs) immediately upstream of these sampling sites that are served by septic systems. This may indicate that there is a possible relationship between the presence of septic tanks and elevated fecal coliform levels in the river. Again, in order to determine if this relationship exists, it is necessary to characterize the source of fecal coliform using the methods described in Section 4.5.1.

4.5.3 Wekiva Study Area Onsite Sewage Treatment and Disposal System Study

As part of the WPPA, the Florida Department of Health (DOH) was tasked with studying the efficacy and applicability of onsite disposal system standards needed to achieve nitrogen reductions protective of groundwater quality within the Wekiva Study Area including publicly owned lands and report to the Governor and the Department of Community Affairs no later than December 1, 2004. Based on the December 2004 report, the Department of Health shall, if appropriate, by March 1, 2005, initiate rulemaking to achieve nitrogen reductions protective of water quality or recommend legislation for any additional statutory authority needed to implement the report recommendations. This study prepared by the Florida DOH, entitled *Wekiva Basin Onsite Sewage Treatment and Disposal System Study* (2004), recommends that the highest priority for sewering should be given to areas with high densities of systems within the Wekiva Aquifer Vulnerability Assessment (WAVA) Most Vulnerable and Vulnerable Zones.

WAVA defines three major protection zones in the WSA that are based on soil permeability, buffered effective karst features, thickness of the intermediate confining unit and the head difference between the surficial and Florida aquifer systems. The protection zones are defined as the following:

- Most Vulnerable – those areas expected to most directly (time of travel and reduced natural attenuation) affect the resulting water quality at the springs in the WSA.

- Vulnerable – those areas that still contribute water to the springs, but over a longer period of time and allowing somewhat greater natural attenuation of nitrogen.

- Less Vulnerable – those areas where flow to the springs is thought to be minimal or non-existent.

For septic tanks, the DOH study recommended the following: 1) a discharge limit of 10 mg/l of total nitrogen for new systems, systems being modified, and for existing systems within the WAVA Most Vulnerable and Vulnerable Zones; 2) state and local planning agencies evaluate the economic feasibility of sewering versus nutrient removal upgrades to existing onsite sewage treatment and disposal systems (OSTDSs) (areas with high densities of development will be better suited to central sewering and lower density areas more suitable for nitrogen-removing OSTDSs); 3) failed or modified systems within the WSA be upgraded to meet new system standards; and 4) new regional wastewater management entities be established or that existing ones be modified to oversee the maintenance of all wastewater discharged from OSTDSs in the WSA.

4.6 Proposed Water Quality Retrofit Projects

The Little Wekiva River Basin is highly urbanized with developed land (e.g., residential, commercial, industrial/utility, institutional, major roads) accounting for 26,450 acres, which is approximately 71% of the total basin area. BMPs serve about 14 percent of the land area and are estimated to remove approximately 7 percent of the pollutants generated. Based on these statistics as well as the presence of 10 verified impaired water bodies in the basin, one of the objectives of this WMP was to identify potential sites for water quality retrofit projects. The following paragraphs describe the methodology used to screen potential sites and the resulting projects.

4.6.1 Methodology

CDM reviewed the pollutant load analysis results as well as the impairments for the listed verified water bodies to determine where the higher priority would be for water quality retrofit projects. Due to the highly urbanized nature of the basin, it was necessary to identify vacant or undeveloped lands that would be suitable for retrofit projects. The initial identification of these lands were based on review of the 2000

DOQs along with the existing land use coverage. It is important to note that during the last phase of the development of this WMP, 2004 DOQs became available from the SJRWMD. Therefore the vacant lands were updated using this information and the resulting GIS polygon coverage is shown in **Figure 4-13**. In addition to vacant lands, it was also important to map the existing wetlands so that impacts to sensitive lands and special habitat areas could be minimized during the project site selection process. The NWI GIS coverage is also shown in Figure 4-13.

Based on these data, CDM identified 21 potential water quality retrofit project sites, which are listed in **Table 4-24** and shown in **Figure 4-14**. The projects in this table are grouped by the water body or tributary of concern. Also listed is the specific problem, the project location and description as well as any concerns or issues regarding a project at this location. Once these potential sites were identified, CDM met with the SJRWMD and the Participants to review each project as well as to receive feedback on the selected sites. CDM then developed a ranking matrix in order to prioritize the projects. The results of the ranking would then be used to identify the top ten projects that would receive the highest priority for implementation. The ranking matrix was completed as a cooperative effort with feedback from the SJRWMD and the Participants.

Several categories were selected to establish the ranking, which were refined with input from the SJRWMD and the Participants and assigned a value from 1 to 10 in order to establish prioritization. These categories along with how the ranking was defined for each are described as follows:

- Impaired water body - 10 being the most impaired (i.e., TMDL water body, large pollutant loads generated in tributary area));
- Ease of acquisition - 10 being the easiest to acquire (e.g., the land is already owned by the municipality);
- Age of development - 10 being the oldest development (i.e., area was constructed before the SJRWMD's stormwater management rules went into effect);
- Usable (access) - 10 being the most accessible;
- Proximity to PSMS - 10 being the closest to the water body in question;
- Magnitude of pollutant load - 10 being the largest pollutant load;
- General cost (construction) - 10 having the least expensive construction costs;
- Operation and maintenance - 10 requiring the least O&M throughout its lifetime;
- Water quality treatment potential - 10 having the greatest treatment efficiency for the pollutant in question;

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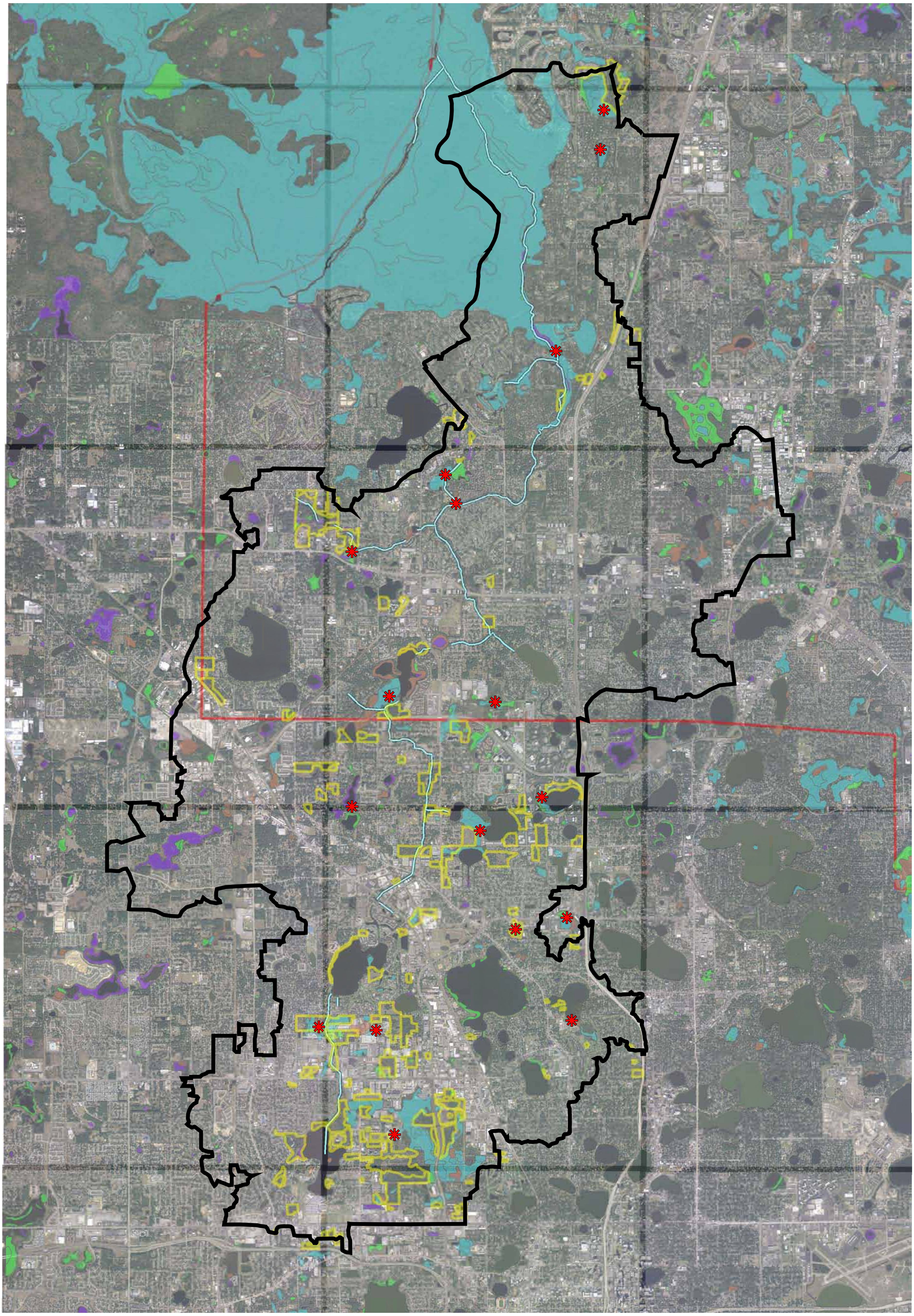
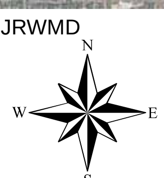


Source: 2004 DOQQs, SJRWMD



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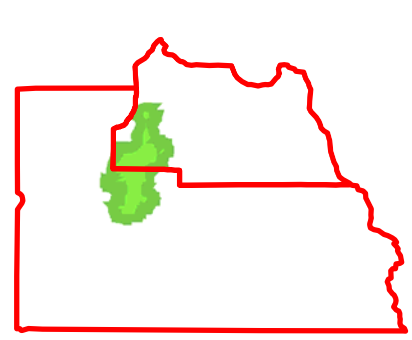

LEGEND

- Basin Boundary
- Verified Wetlands
- Little Wekiva River Main Stem

National Wetlands Inventory

- Aquatic Bed
- Emergent
- Forested
- Scrub-Shrub
- Undeveloped Land
- County Boundary

Little Wekiva River Watershed Management Plan

CDM

Figure 4-13
Undeveloped Lands and Wetlands

Table 4-24
Little Wekiva River Watershed Management Plan
Potential Water Quality Retrofit Project Sites

Site(s)	Water Body	Problem	Project Location/Description	Concerns/Issues
1, 2, 3,4, 5, & 6	Little Wekiva Canal	Nutrients (chla), DO, BOD, Fecal Coliform Bacteria - Due to slower moving nature of this segment of the river, nutrients entering the river may be converted into algal biomass; rarely happens in streams unless slow moving.	Vacant areas adjacent to the river between lake Lawne and Lake Orlando for wet detention with or without chemical treatment. Off-line system in each location - river diverted through weir structure; or linear detention adjacent to the river. (Site 8 owned by Orange Co. BCC)	Design so that no impact to MFLs for the river system; need to determine if exceedances of 20 ug/l occur in slow moving conditions/base flow. Land acquisition, O&M.
7 & 8	Lake Lawne (Tributary I)	Nutrients (TSI) - Older development (pre-1985) surrounding lake on north, west and southeast sides (Pine Hill Sub., Evans Village, Silver Pines, San Jose Shores, Normandy Shores, Riviera Shores, Lake Lawne Shores, Colony Cove) - close to 650 acres of untreated residential areas surrounding the lake. Most of it is direct discharge to the lake based on review of OUSWMM. Also area to the west appears to be heavily concentrated with septic tanks (Utility Master Plan for Orange County, PBS&J). High relative pollutant loads based on WMM results.	Focus on retrofitting older developments before discharge reaches lake. Route systems through potential wet detention pond sites adjacent to lake. Both sites owned by Orange Co. BCC.	Land acquisition, O&M
9	Lake Fairview System (Tributary H)	High relative pollutant loads based on WMM results; little to no treatment in tributary area.	Small vacant parcel to the west of John Young Parkway, adjacent to outfall pipe from Lake Fairview; can provide some treatment before discharge to the river; can also capture some of Bay Lake overflow.	Discharge from Lake Fairview system already routed through several on-line detention ponds (OUSWMM) upstream of Rosewood before converging with the river.
10 & 11	Bay Lake	Nutrients (TSI); little to no stormwater treatment in tributary area.	Undeveloped parcels to the south and west of Bay Lake. Could be ideal for pre-treatment before water is discharged to the lake.	Land acquisition, O&M
12	Lake Silver	Nutrients (TSI); little to no stormwater treatment in tributary area.	No undeveloped/vacant land tributary to lake; remaining alternatives include swirl concentrators, baffle boxes, end-of-pipe treatments, alum injection, drain wells after treatment.	High O&M
13	Spring Lake	Nutrients (TSI)	Little to no available undeveloped/vacant land tributary to lake feasible for water quality retrofit ; remaining alternatives include swirl concentrators, baffle boxes, end-of-pipe treatments, alum injection.	High O&M
14	Little Wekiva River	Fecal & Total Coliform Bacteria; High relative pollutant loads based on WMM results; little treatment in tributary area.	Undeveloped parcels directly adjacent to the river, downstream of the confluence with Spring Lake, currently owned by Spring Knoll Stables. Could provide potential off-line wet detention for residential and commercial areas south of SR 436, much of which is currently untreated.	Land acquisition, O&M
15 & 16	Lake Florida	Nutrients (TSI); High relative pollutant loads based on WMM results; little treatment in tributary area.	2 undeveloped parcels to the southeast of the lake as possible wet detention alternatives.	Land acquisition, O&M
17	Lake Florida	Nutrients (TSI); High relative pollutant loads based on WMM results; little treatment in tributary area.	If vacant land not available, remaining alternatives include swirl concentrators, baffle boxes, end-of-pipe treatments, alum injection.	High O&M
18	Lake Adelaide	Nutrients (TSI); High relative pollutant loads based on WMM results; little treatment in tributary area.	5 undeveloped parcels to north of lake; potential site for water quality retrofit to treat adjacent areas.	Land acquisition, O&M
19	Lake Adelaide	Nutrients (TSI); High relative pollutant loads based on WMM results; little treatment in tributary area.	If vacant land not available, remaining alternatives include swirl concentrators, baffle boxes, end-of-pipe treatments, alum injection.	High O&M
20	Lake Orienta	Nutrients (TSI); High relative pollutant loads based on WMM results; little treatment in tributary area.	Little to no available undeveloped/vacant land tributary to lake feasible for water quality retrofit ; remaining alternatives include swirl concentrators, baffle boxes, end-of-pipe treatments, alum injection.	High O&M
21	Little Wekiva River	Fecal & Total Coliform Bacteria; High relative pollutant loadings based on WMM results	2 undeveloped parcels (~18 acres) to the west of river; possibility for off-line treatment (A & D soils) - wet or dry detention.	Design so that no impact to MFLs for the river system; Land acquisition, O&M

Other Notable Areas:
1) Tributary E had relatively higher loadings, however, projects in this subbasin were not thought to be of high priority as it is pumped some of the time.
Although this subbasin does potentially generate large amounts of pollutants, it's impacts to the Little Wekiva River are not as great due to the way it is operated.

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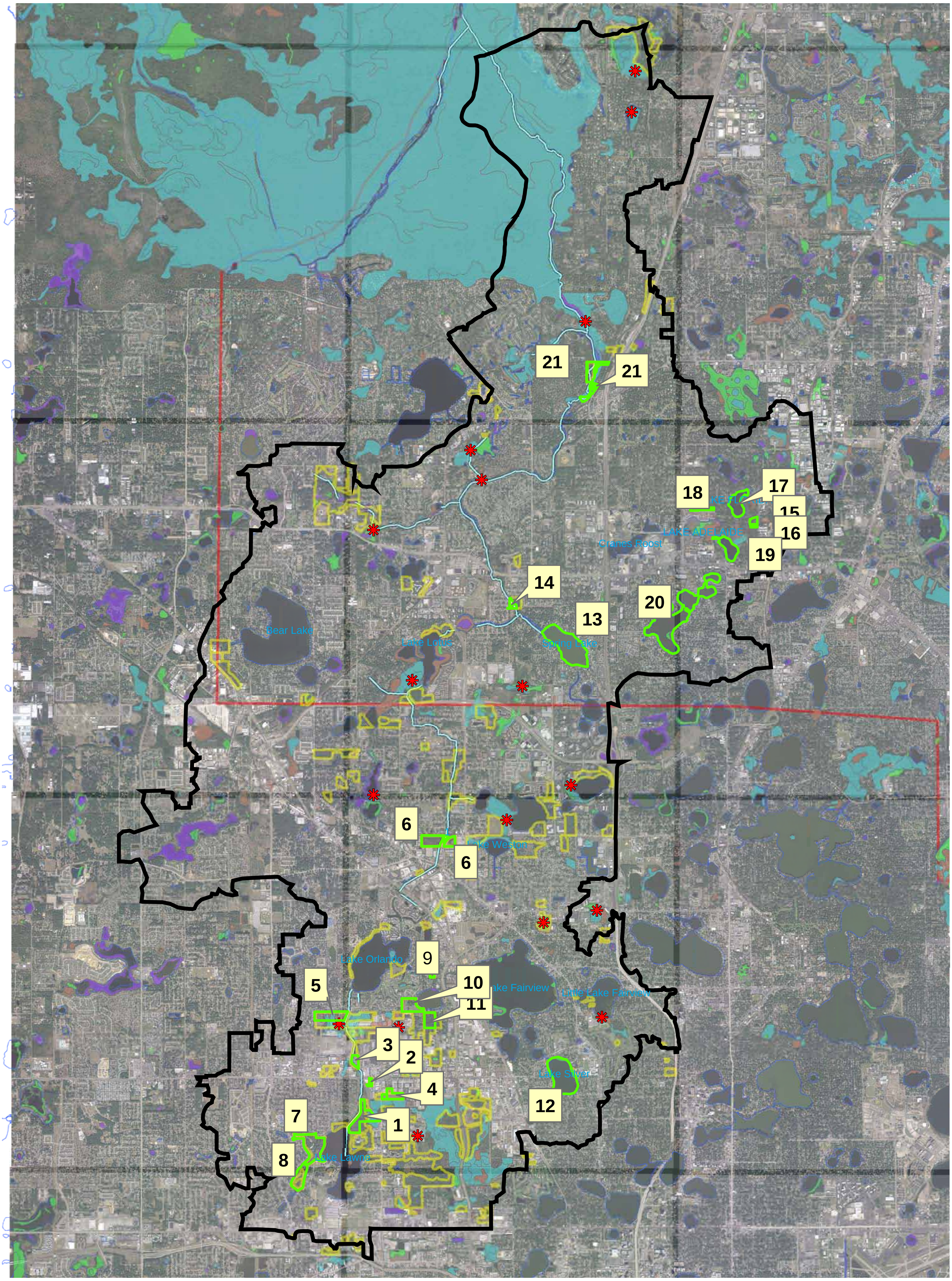
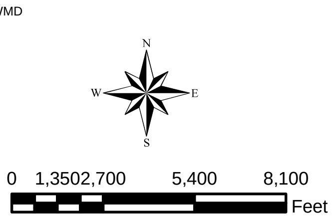
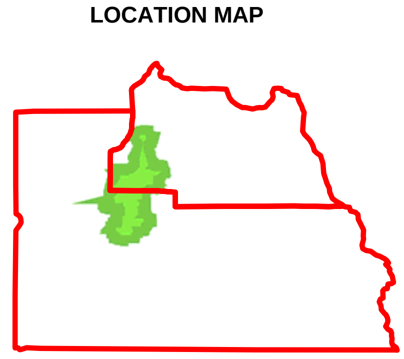


Source: 2004 DOQQs, SJRWMD



LOCATION MAP



LEGEND

- Basin Boundary
- Potential Retrofit Sites
- Verified Wetlands
- Little Wekiva River Main Stem

National Wetlands Inventory

- Aquatic Bed
- Emergent
- Forested
- Scrub-Shrub
- Undeveloped Land
- Water Bodies
- County Boundary

Little Wekiva River Watershed Management Plan

CDM

Figure 4-14
Potential Water Quality Retrofit Project Sites

- Importance to community - 10 having the highest social acceptability (e.g., recreational value, needs of the community);

- Permittability - 10 being the easiest to permit;

- Association with other projects - 10 having the opportunity to tie in with another ongoing project in order to provide multiple benefits and/or to reduce costs; and

- Flood severity - 10 having the greatest chance of flooding (based on ICPR modeling results).

The categories were also weighted based on input from the SJRWMD and the Participants, with some categories being weighted slightly more than others (i.e., operation and maintenance and water quality treatment potential). The resulting matrix is shown in **Table 4-25** with the projects sorted from highest priority to lowest priority. The projects that were ranked from 1 to 10 are shown as shaded on the table.

4.6.2 Conceptual Cost Estimates

Once the top ten projects were identified CDM then developed conceptual cost estimates for each water quality retrofit project. The conceptual cost estimates presented here are based on similar types of projects in the region and associated unit costs, not specific quantities. A detailed engineering analysis and cost estimate of recommended projects to address flooding concerns (which also incorporate some of the proposed water quality retrofit sites) are provided in Sections 5 and 6.

The conceptual cost estimates for the top ten water quality retrofit project sites are included in **Appendix L** and a summary of the costs by project is provided in **Table 4-26**. As part of the conceptual cost estimate development, CDM reviewed each site in detail and performed a tax record search for each. From this search it was found that some of the sites (i.e., project sites 2 and 4) already have structures built on them which were not apparent from the initial review of the 2000 DOQs. CDM prepared the conceptual cost estimates even though these three sites were developed, but also developed conceptual cost estimates for next three ranked undeveloped project sites shown on Table 4-25. These include projects 21, 15 and 17 (project site 10 was found to also have structures on it based on the tax record search). The individual cost estimates for these projects can also be found in Appendix L. Each of the conceptual cost estimates include clearing and grubbing, excavation and grading, berm construction, sodding and seeding, inlet and outlet structures, erosion control, fencing and several other miscellaneous cost items. The estimates do not include land acquisition, road construction, electrical and instrumentation, monitoring, and operation and maintenance (O&M) cost items. Several of these sites were incorporated into the alternatives analysis for flooding included in Section 5. A conceptual cost estimate is provided in Section 6 for those, however please note that the costs shown here may differ from the ones presented in Section 6 as more detail was provided as part of the alternatives analysis.

Table 4-25
Little Wekiva River Watershed Management Plan
Water Quality Retrofit Project Ranking Matrix

No.	Project	Jurisdiction		Impaired Water Body	Ease of Acquisition	Age of Development	Usable (Access)	Proximity to Main System	Magnitude of Load	General Cost (Construction)	O&M	Water Quality Treatment Potential	Importance to Community	Permittability	Association with other Projects	Flood Severity	TOTALS	RANKING
			Weight:	0.07	0.07	0.03	0.07	0.07	0.07	0.07	0.14	0.14	0.07	0.07	0.07	0.07	1	
5	Center of Commerce W. (Little Wekiva Canal)	City of Orlando		10	8	7	8	10	10	5	5	7	5	6	5	8	7.07	1
3	Dardanelle Drive/Seaboard Road South (Little Wekiva Canal)	City of Orlando		10	3	7	10	10	10	4	5	8	5	4	5	10	6.93	2
6	All American Blvd (Little Wekiva Canal)	Orange County		10	6	7	10	10	10	2	5	7	5	7	9	1	6.72	3
2	Princeton & Silver Star (Little Wekiva Canal)	City of Orlando		10	3	7	7	10	10	4	5	7	5	7	5	8	6.66	4
4	Mercy Star South (Little Wekiva Canal)	City of Orlando		10	3	7	10	6	10	3	5	8	5	7	5	8	6.66	4
7	West Lake Lawne	Orange County		10	10	10	8	10	4	2	6	8	9	4	5	1	6.62	6
1	Lake Lawne Outfall (Little Wekiva Canal)	City of Orlando		10	3	7	10	10	10	1	5	9	7	7	5	1	6.59	7
14	Little Wekiva River	Seminole County		5	3	10	8	10	8	4	5	7	5	7	5	6	6.21	8
11	South Bay Lake	Orange County		10	3	10	10	10	2	1	5	7	5	7	5	8	6.21	8
21	The Springs (Little Wekiva River)	Seminole County		5	2	9	8	10	8	3	5	7	5	4	5	10	6.10	10
10	West Bay Lake	Orange County		10	3	10	10	10	2	1	5	7	5	4	5	8	6.00	11
15	Newburyport Ave. West (Lake Florida)	City of Altamonte Springs		10	3	10	7	8	3	5	5	7	5	7	5	5	6.00	11
17	End of Pipe Treatment (Lake Florida)	City of Altamonte Springs		10	10	10	10	10	3	7	3	3	5	9	5	1	6.00	11
19	End of Pipe Treatment (Lake Adelaide)	Seminole County/City of Altamonte Springs		10	10	10	10	10	3	7	3	3	5	9	5	1	6.00	11
9	Lake Fairview System	Orange County		5	3	10	8	7	5	4	5	7	5	7	5	8	5.93	15
16	3rd Street South (Lake Florida)	City of Altamonte Springs		10	3	10	7	7	3	5	5	7	5	7	5	5	5.93	15
18	Sabal Palm North (Lake Adelaide)	City of Altamonte Springs		10	3	10	8	5	3	5	5	7	5	7	5	6	5.93	15
20	End of Pipe Treatment (Lake Orienta)	City of Altamonte Springs		10	10	8	10	10	2	7	3	3	5	9	5	1	5.86	18
12	End of Pipe Treatment (Lake Silver)	Orange County/City of Orlando		10	10	10	10	10	3	7	3	2	5	9	5	1	5.86	18
13	End of Pipe Treatment (Spring Lake)	Seminole County/City of Altamonte Springs		10	10	6	8	10	3	7	3	2	5	9	5	1	5.59	20
8	Southwest Lake Lawne	Orange County		10	10	10	6	7	3	2	5	4	5	7	5	1	5.45	21

Notes:
1. Impaired Water Body - 10 being the most impaired (i.e., TMDL water body, large pollutant loads generated in tributary area)
2. Ease of Acquisition - 10 being the easiest to acquire (i.e., lands already owned by the municipality)
3. Age of Development - 10 being the oldest (i.e., area was constructed before the stormwater management rules went into effect)
4. Usable - 10 being the most accessible
5. Proximity to Main System - 10 being the closest to the water body in question
6. Magnitude of Load - 10 being the greatest pollutant load
7. General Cost - 10 having the least expensive construction costs
8. O&M - 10 requiring the least O&M throughout its lifetime
9. Water Quality Treatment Potential - 10 having the greatest treatment efficiency for the pollutant in question
10. Importance to Community - 10 having the highest social acceptability (e.g., recreational value, needs of the community)
11. Permittabilty - 10 being the easiest to permit
12. Association with Other Projects - 10 having the opportunity to tie in with another ongoing project
13. Flood Severity - 10 having the greatest chance of flooding (based on preliminary ICPR results)

Table 4-26
Little Wekiva River Watershed Management Plan
Opinion of Probable Conceptual Project Cost Estimates for Prioritized Project Sites

No.	Project Site	Project Type	Water Body Affected	Conceptual Cost
5	Center of Commerce W.	Treatment Wetland	Little Wekiva Canal	$723,000
3	Dardanelle Drive/Seaboard Road South	Wet Detention	Little Wekiva Canal	$1,055,000
6	All American Blvd	Wet Detention	Little Wekiva Canal	$1,467,000
2	Princeton & Silver Star	Wet Detention	Little Wekiva Canal	$543,000
4	Mercy Star South	Wet Detention	Little Wekiva Canal	$1,329,000
7	West Lake Lawne	Treatment Wetland	Lake Lawne	$1,115,000
1	Lake Lawne Outfall	Wet Detention	Little Wekiva Canal	$5,679,000
14	Little Wekiva River	Wet Detention	Little Wekiva River	$759,000
11	South Bay Lake	Wet Detention	Bay Lake	$2,348,000
21	The Springs	Wet Detention	Little Wekiva River	$2,828,000
15	Newburyport Ave. West	Wet Detention	Lake Florida	$752,000
17	End of Pipe Treatment (Lake Florida)	End of Pipe Treatment	Lake Florida	$419,000