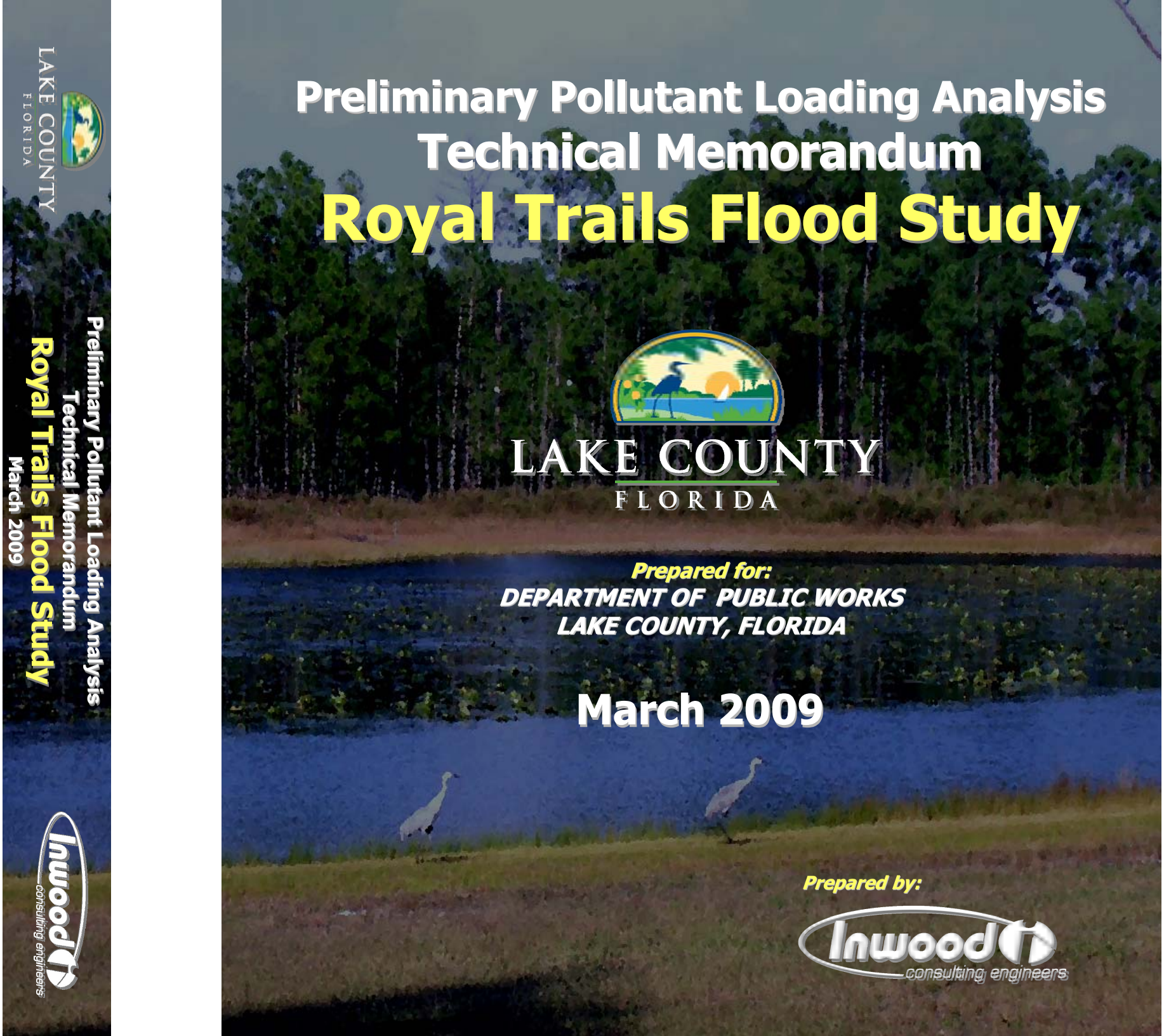
LAKE COUNTY
FLORIDA
Preliminary Pollutant Loading Analysis
Technical Memorandum
Royal Trails Flood Study
March 2009
Inwood
consulting engineers
Preliminary Pollutant Loading Analysis
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Technical Memorandum
Royal Trails Flood Study
LAKE COUNTY
FLORIDA
Prepared for:
DEPARTMENT OF PUBLIC WORKS
LAKE COUNTY, FLORIDA
March 2009
Prepared by:
Inwood
consulting engineers

Preliminary Pollutant Loading Analysis Technical Memorandum

Royal Trails Flood Study

LAKE COUNTY
FLORIDA

Prepared for:
Department of Public Works
Lake County, Florida

March 2009

Prepared by:

Inwood consulting engineers
3000 Dovera Drive, Suite 200
Oviedo, FL 32765
p 407.971.8850 f 407.971.8955

March 17, 2009 LAK-005-01

Mary Hamilton, Stormwater Project Manager
Lake County Public Works
437 Ardice Avenue
Eustis, Florida 32726

Re: Royal Trails Flood Study
Preliminary Flood Assessment Technical Memorandum
County PO # 20701804

Dear Ms. Hamilton,

Inwood Consulting Engineers, Inc. (Inwood) is pleased to submit two (2) copies of the Preliminary Pollutant Loading Analysis Technical Memorandum for the Royal Trails Flood Study for the County's review. If you have any questions please do not hesitate to contact the undersigned below.

Inwood is pleased to provide our services to Lake County on this project. If you have any questions regarding the attached, please contact us at 407-971-8850.

Very truly yours,

INWOOD CONSULTING ENGINEERS, INC.

Joshua M. Spence, E.I.
Engineer Intern

Mark W. Ellard, P.E.
Project Manager

Attachments:

Two (2) copies of Preliminary Pollutant Loading Analysis Technical Memorandum

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1.0 INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

This Technical Memorandum presents the results of the pollutant loading analysis for the Royal Trails subdivision. Inwood Consulting Engineers, Inc (Inwood) was tasked by Lake County Public Works to perform this analysis as part of the Royal Trails Flood Study. The study, as a whole, includes the following tasks:

- **Public Involvement Plan (Submitted September 2007) –** The plan provided detailed approach and schedule for interfacing with the subdivision residents. Plan included evaluating opportunities for public education during the course of the project to comply with NPDES requirements.
- **Preliminary Project Evaluation Technical Memorandum (submitted October 2008) –** Compilation of the data collection efforts, physical characteristics of the subdivision, and preliminary engineering analysis tasks performed.
- **Preliminary Flood Assessment Technical Memorandum (submitted concurrently with this report) –** Compilation and summary of results of flood and level of service (LOS) modeling to prioritize problem areas for deficiency correction.
- **Preliminary Pollutant Loading Analysis Technical Memorandum (this report) –** Compilation and summary of results of water quality modeling to prioritize problem areas for BMP implementation.
- **Preliminary Deficiency Correction Plan Technical Memorandum –** A summary report to provide recommendations for the most appropriate corrective action to address drainage problems, correct level of service deficiencies, and improve water quality.
- **Final Project Study Report –** Report will include a reiteration of the Preliminary Evaluation, Flood Assessment, Pollutant Loading Analysis, and Deficiency Correction Plan with final recommendations. Final version will reflect relevant permitability information obtained from the permit determination coordination with SJRWMD. Final Report will also include a summary of the Public Involvement efforts including copies of all public issue documents, presentations, meeting summaries, etc.

1.2 PURPOSE

A predominant portion of the Royal Trails subdivision is located within the Wekiva Protection Area (WPA) indicating that surface and/or groundwater discharges from this area can make their way to the Wekiva River. The Wekiva River is classified as an "Outstanding Florida Water" and was afforded protection by the State under the Wekiva Parkway and Protection Act (WPPA). Per the WPPA, a Master Stormwater Management Plan (MSMP) was developed to implement procedures to promote conservation and improvement of surface and ground waters in the region of the Wekiva River system. Accordingly, this pollutant loading analysis was conducted for the Royal Trails subdivision to aid in identifying potential pollutant reduction strategies in conjunction with those goals.

The scope of work completed in this task includes:

- Develop a spreadsheet-based pollutant loading analysis utilizing landuse-based reference event mean concentration (EMC) values to predict average annual mass loads of Total Nitrogen, Total Phosphorus, Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) generated by surface runoff.
- Identify priority areas for improvement through the implementation of BMP's.

The results of this study will be used in the subsequent Deficiency Corrections Task to develop BMPs for pollutant reduction.

1.3 SITE LOCATION

The Royal Trails subdivision is located in northeastern unincorporated Lake County. Royal Trails is in Section 36 of Township 17 South, Range 28 East, Section 31 of Township 17 South, Range 29 East, Sections 1,12,13,24, of Township 18 South, Range 28 East, Sections 4, 5, 6, 7, 18 of Township 18 South, Range 29 East. The subdivision is within the jurisdiction of the St. Johns River Water Management District (SJRWMD) and lies within the St. Johns River Watershed. The subdivision is located within Lake County Commission District 5 and most of the subdivision lies within the Wekiva Protection Area. Royal Trails extends from west of SR 44 to east of Lake Tracy. The project site is shown on Figure 1-1.

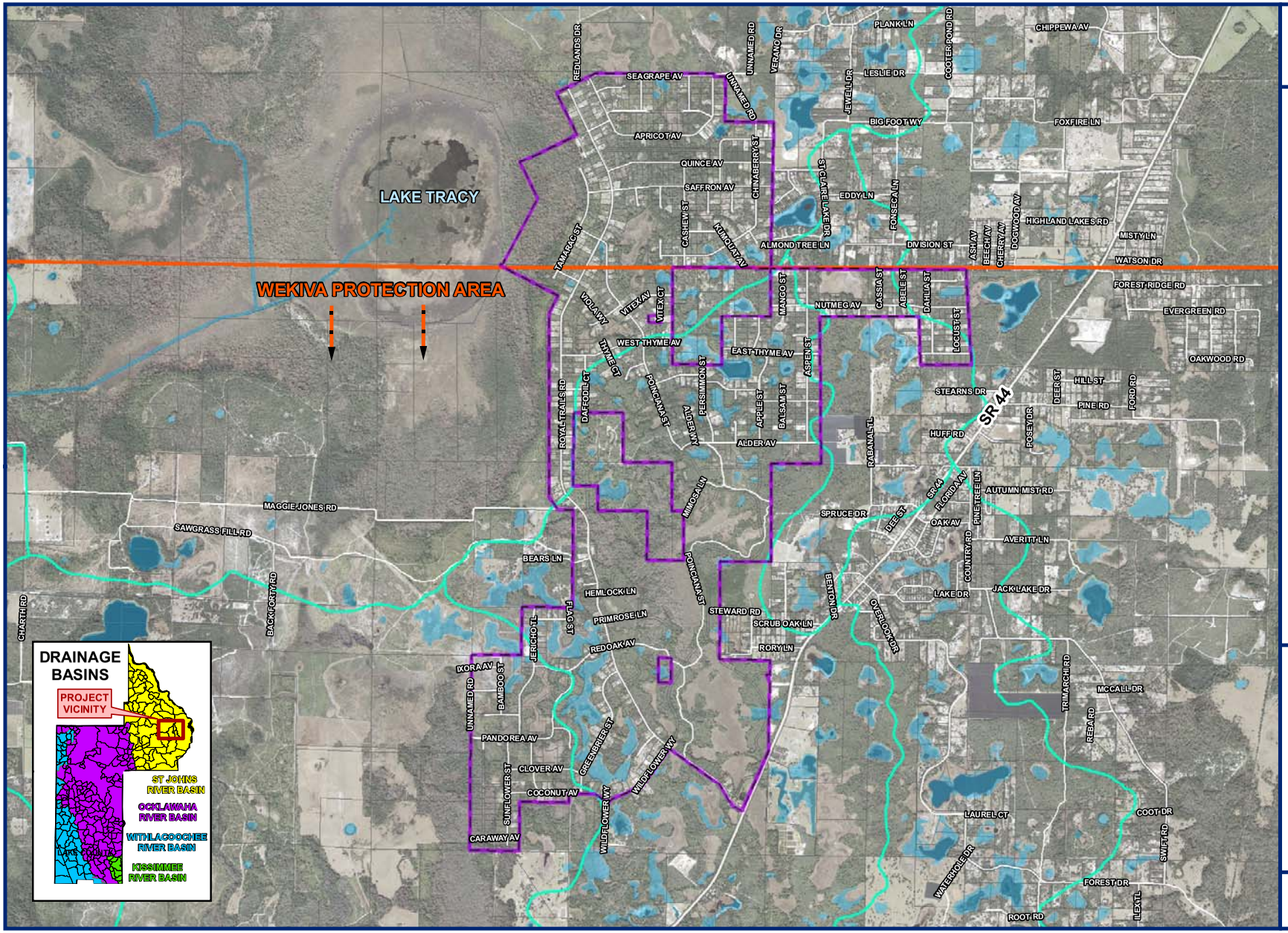


FIGURE 1-1

PROJECT SITE MAP

Royal Trails Flood Study

Inwood consulting engineers

2.0 PROJECT AREA CHARACTERIZATION

2.1 WEKIVA PARKWAY AND PROTECTION ACT

The Wekiva Protection Area which spans parts of Lake, Orange and Seminole Counties, was designated by the WPPA with a goal to protect the Wekiva River system through the improvement and preservation of surface water and groundwater resources. As part of the WPPA, local governments located within the Wekiva Study Area (WSA) coordinated to develop a MSMP to address the concerns including potential/actual declines in spring flow and water quality, increased water usage, and dramatic land use changes. Two regional strategies have been adopted for the WSA: 1) surface water conservation, groundwater protection and reuse, and 2) surface water treatment and flood control. See Figure 2-1 for a regional map featuring the WPA.

2.2 SUBBASIN DELINEATION

In order to perform pollutant loading calculations, identify existing Best Management Practices (BMPs), and identify priority areas for improvement, the pollutant loading analysis for the Royal Trails subdivision was conducted using discrete drainage subbasins. Subbasins used for the pollutant loading assessment were those delineated as part of the concurrent flood modeling efforts for the Flood Assessment Task for the Royal Trails Flood Study. Refer to the *Preliminary Flood Assessment Technical Memorandum* for the subbasin delineation methodology.

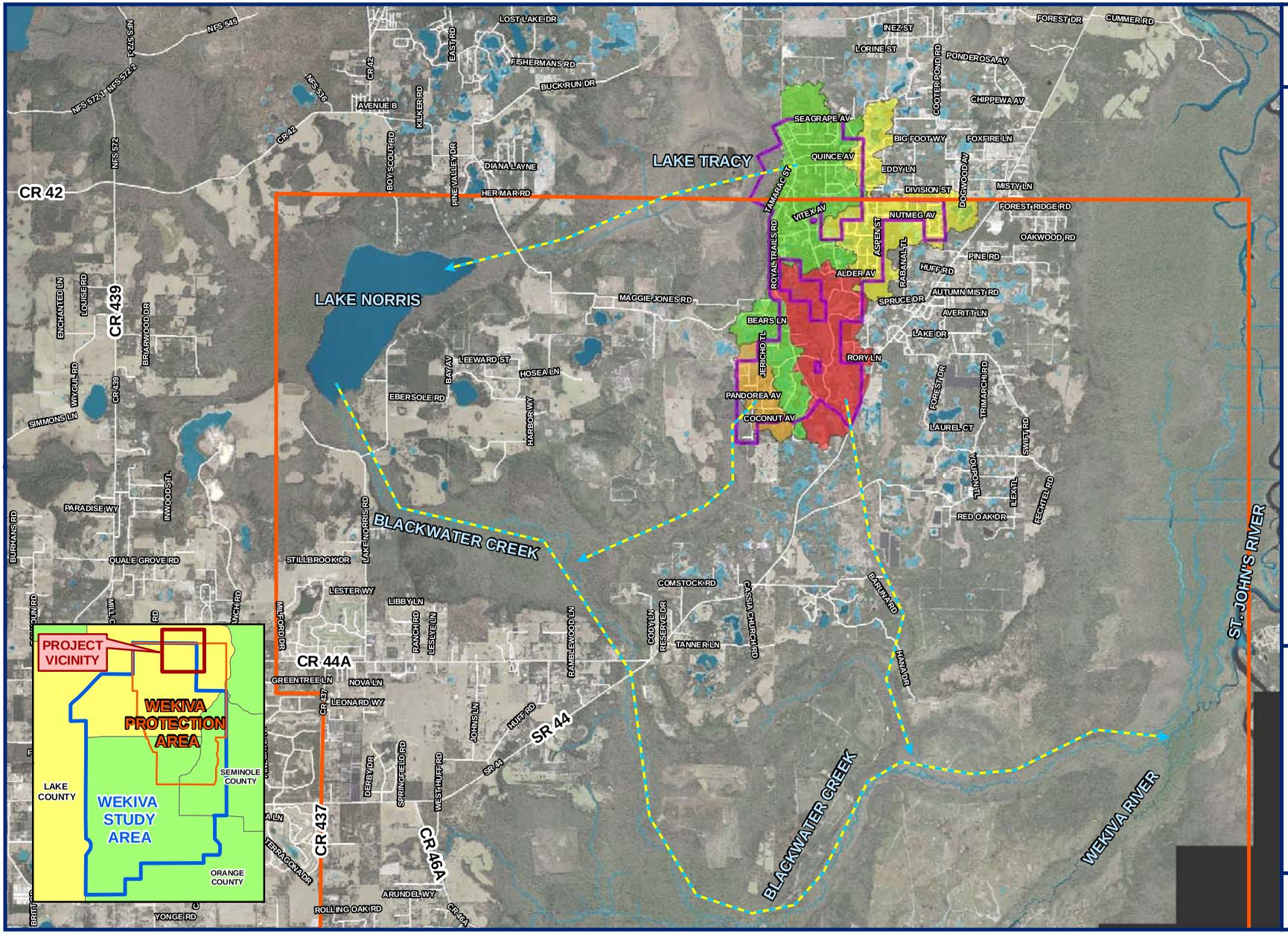
It is important to note that the subbasins delineated for the flood assessment extend beyond the boundary of the Royal Trails subdivision. For the purposes of the pollutant loading assessment for this project, only subbasins within or immediately adjacent to the subdivision were analyzed. Additionally, subbasins were placed in four separate outfall groups according to common discharge points – Lake Tracy, Blackwater Creek, State Road 44, and Land Locked. Land Locked subbasins were those that did not discharge during the 100 year storm event as modeled during the Flood Assessment Task. Subbasins are shown in Figure 2-2.

2.3 EXISTING BMPS

Royal Trails is a rural subdivision that is only partially developed. The area considered in the pollutant loading analysis consists predominantly of natural systems and open space with sporadic pockets of low density residential land uses. Predating current stormwater regulations which mandate the use of stormwater treatment BMPs, the subdivision lacks engineered BMPs with the exception of grassed swales along some of the roads. These swales were designed specifically for drainage, but provide some level of treatment through retention and infiltration. A significant portion of the subdivision drains to Lake Tracy, doing so through a series of the drainage canals. These canals have structures in which to place risers to control discharge and attenuate flow. However, the risers no longer exist and the canals have since reverted to strictly providing conveyance.

2.4 SEPTIC TANK USAGE

Royal Trails and its vicinity is a rural, low-density residential area which is 100% dependent on septic tanks for household wastewater treatment and disposal. Typically, loading factors for areas with septic tanks assume the septic tanks to be in good working order and thus not a significant contributing factor to nonpoint source loadings. However, Septic tanks can be an



LAKE COUNTY
FLORIDA

0 3,000 6,000
Feet

LEGEND

- OUTFALL PATH
- WEKIVA PROTECTION AREA
- ROYAL TRAILS SUBDIVISION

ROYAL TRAILS OUTFALL GROUPS

OUTFALL GROUP

- BLACKWATER CREEK
- LAKE TRACY
- LAND LOCKED
- STATE ROAD 44
- WATER BODIES

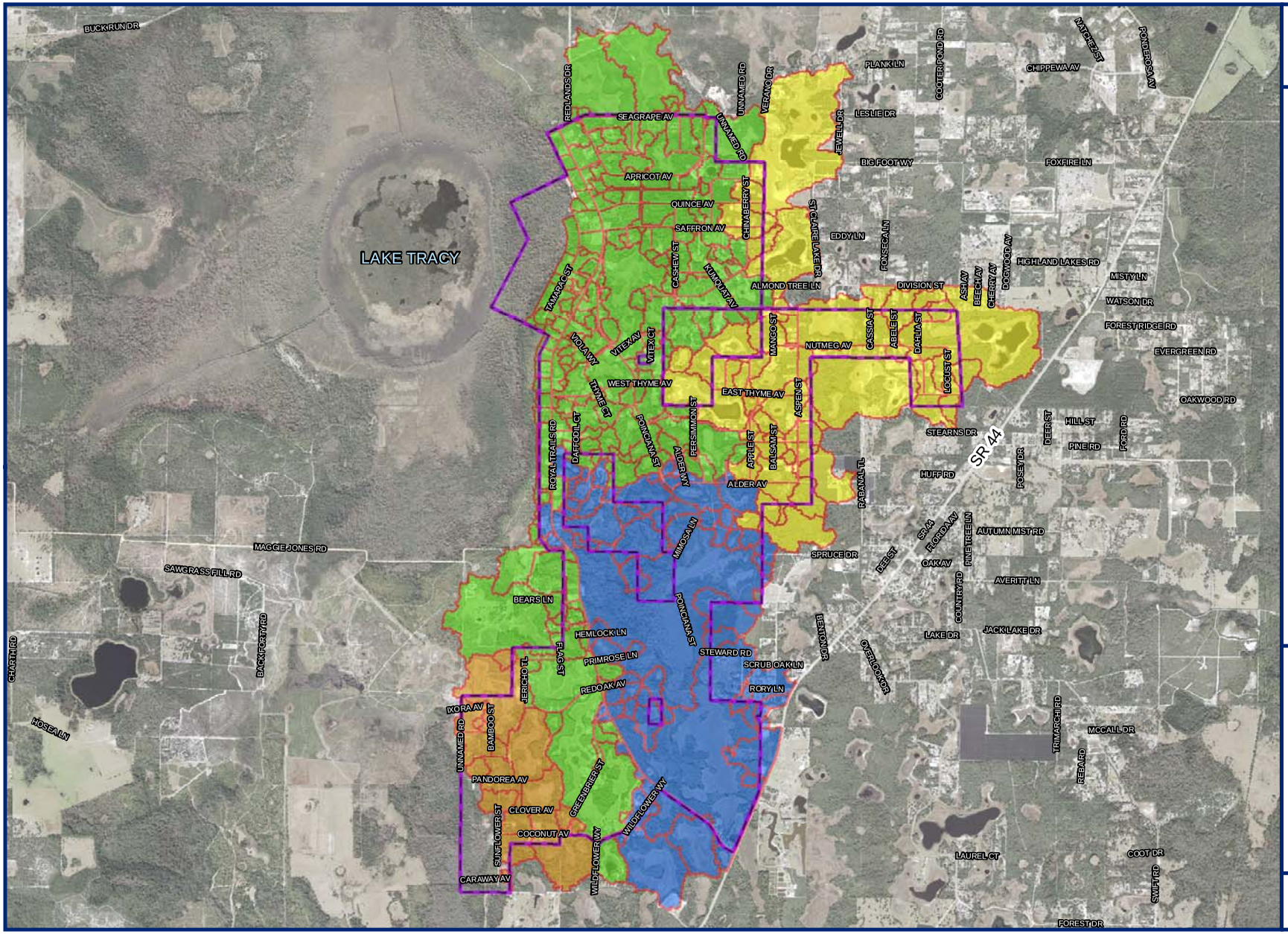
DATA SOURCES:
SUBDIVISION: LAKE COUNTY, 2006
WATER BODIES: LAKE COUNTY, 2003
ROADS: LAKE COUNTY, 2004
AERIAL: LAKE COUNTY, 2008

FIGURE 2-1

REGIONAL MAP

Royal Trails Flood Study

Inwood consulting engineers



LAKE COUNTY
FLORIDA

0 1,250 2,500
Feet

LEGEND

- ROYAL TRAILS SUBDIVISION
- ROYAL TRAILS SUBBASINS
- OUTFALL GROUP
  - BLACKWATER CREEK
  - LAKE TRACY
  - LAND LOCKED
  - STATE ROAD 44

DATA SOURCES:
SUBDIVISION: LAKE COUNTY, 2006
ROADS: LAKE COUNTY, 2004
AERIAL: LAKE COUNTY, 2008

FIGURE 2-2

SUBBASIN MAP

Royal Trails Flood Study

Inwood consulting engineers

important item of concern with regards to water quality. Failed septic tanks can introduce nutrients and other contaminants which result in localized water quality impacts. This includes groundwater impacts, which can contribute contaminated base flow to lakes and streams.

Septic tank failure was an issue considered in the WPPA MSMP. The regional Watershed Management Model (WMM) completed by CDM for the MSPA considered a 1 percent failure rate for septic tanks in a given year. The impact of that 1 percent failure was enforced by a multiplier applied to the typical EMC values for total nitrogen and total phosphorous (2.0 and 2.1 respectively). A limited sensitivity analysis by CDM indicated that a 1% failure rate from a residential area could at most increase the surface loading 1% over the base load.

While the Royal Trails area is 100% serviced by septic tanks, it is far from being completely built out. The total area of occupied residential land use in the area considered for the pollutant loading analysis is 17.4 percent. Within this area, there are approximately 508 residences presumably being serviced by septic tanks. Utilizing the criteria above, a 1 percent failure rate would yield approximately 5 septic tank failures in a given year and would amount to doubled nitrogen and phosphorous loads for roughly 0.2 percent of the area being analyzed. Considering this, surface water loadings from failed septic tanks were determined to be insignificant with respect to the overall pollutant load for the area and were not included in the project pollutant loading analysis. Also, it is important to note that because the study is focused on modeling surface runoff only, the impact of potential pollutant migration from failed septic systems through groundwater transport was not considered.

3.0 POLLUTANT LOADING MODEL METHODOLOGY

In order to estimate the mass of pollutants from surface runoff for the Royal Trails subdivision on an annual basis, a project-specific pollutant loading model was developed to estimate the impact of nonpoint source loads. The model was limited to evaluation of surface runoff only, and did not account for other sources such as groundwater seepage or atmospheric deposition. The pollutant loading model used for this analysis was a spreadsheet-based model that predicts annual pollutant loads based on an average annual rainfall distribution and land use/soil type combinations. The procedures used to develop this pollutant loading model were based upon the methodology created by Harper and Baker in the report *Evaluation of Nonpoint Source Loadings to Lake Harris/Little Lake Harris (ERD, 2006)*. This methodology was used primarily for consistency between projects within Lake County.

The model's procedure can be broken into several basic steps:

1. Develop a curve number (CN) and directly connected impervious area (DCIA) for each land use/soil type combination.
2. Estimate the average annual runoff using the CN method and a rainfall frequency distribution.
3. Predict average annual pollutant loads for each subbasin using average annual runoff and typical loading rates.

The following pollutants were considered in this analysis:

- Nitrogen and phosphorous are nutrients that stimulate the growth of algae and aquatic plants. The presence of these pollutants in excess can produce algal blooms, create turbid conditions, and lead to decreased dissolved oxygen content in surface waters. Sources can include partially treated/untreated sewage, fertilizers, animals and organic debris. Though nitrogen and phosphorous naturally occur in several species in a system (e.g. nitrate, ammonia, orthophosphate, etc.), this study is only concerned with total nitrogen and total phosphorus.

- BOD – Biochemical oxygen demand is a measure of oxygen needed by organic materials as they decompose. Excessive BOD can deplete dissolved oxygen in surface waters which can impact aquatic species, lead to increased anaerobic microorganisms and potentially increase the solubility of other pollutants. Sources for BOD include partially treated/untreated sewage, organic debris, and urban or agricultural runoff.

- TSS – Total suspended solids included suspended matter and sediment such as sand, silt, clay and organic matter which is generated primarily through erosive forces due to rainfall and runoff. Sources for TSS include ground disturbing activities (construction, agriculture, mining, etc.) and urban runoff.

The following subsections provide a detailed explanation of the steps taken to prepare and execute the pollutant loading model including data preparation, model inputs and calculations.

3.1 DATA PREPARATION

Several data sets were required and prepared as inputs to the pollutant loading model. These are described in the following subsections.

3.1.1 Subbasins

Subbasins in the project area were delineated as was described in Section 2.2. Subbasins are illustrated in Figure 2-2.

3.1.2 Land Use

Original source data for the land use was the SJRWMD Land Use layer updated in 2004. These data were further modified and updated, based upon 2008 aerials and updated parcel data, during the Flood Assessment Task of the Royal Trails Flood Study. In general, land use in and around the subdivision consisted of low-density residential, upland forests, rangeland, and wetlands.

The land use layer, as used in the Flood Assessment Task, was based upon FDOT Florida Land Use, Cover and Forms Classification System (FLUCFCS) designations. These designations are too specific for use in this analysis because stormwater runoff EMC reference values are typically only available for generalized landuse designations. FLUCFCS groups were aggregated in general accordance with the format as used by Harper and Baker (ERD, 2006). The resulting distribution of land use after aggregating into general classes is approximately 17% low-density residential, 55% open space, 5% water, 22% wetland with agriculture and medium density residential making up less than half a percent respectively. Table 3-1 summarizes the land use breakdown for the project area. See Figure 3-1 for a land use map.

Table 3-1 – General Land Use Categories

General Land Use Category	FLUCFCS Code	FLUCFCS Description
Agriculture	2431	Nurseries and Vineyards - High Density
Low-Density Residential	1100	Residential Low Density - 1 to 2 Acre Lots
	1101	Residential Low Density > 2 Acre Lots
Medium-Density Residential	1200	Residential Medium Density < 1 Acre Lots
Open	1110	Residential Low Density - Vacant Lots
	1920	Open Land
	3100	Rangeland, Herbaceous
	3200	Shrub and Brushland
	3300	Mixed Rangeland
	4110	Upland Coniferous Forests
	4200	Upland Hardwood Forests
	8200	Communications
Water	5200	Lakes
Wetland	6110	Wetland Hardwood Forests
	6210	Wetland Coniferous Forests
	6300	Wetland Forested Mixed
	6410	Vegetated Non-Forested Wetland

In addition to indicating EMCs to predict surface runoff loads, land use in conjunction with soil type impacts runoff. This pollutant loading model used a curve number based methodology. Curve numbers for the generalized land used categories are listed in Table 3-2. The curve numbers are based on reference data from the NRCS publication *Urban Hydrology for Small*

LAND USE TABLE								
GENERAL LAND USE CATEGORY	CURVE NUMBER BY SOIL HYDROLOGIC					% IMPERVIOUS	% DCIA	% OF TOTAL AREA
	A	B	C	D	WATER			
AGRICULTURE	59	74	82	86	98	1	0	0.4
LOW-DENSITY RES	51	69	79	84	98	20	0	17.0
MEDIUM-DENSITY RES	54	70	80	85	98	25	0	0.4
OPEN	39	61	74	80	98	1	0	55.4
WATER	98	98	98	98	98	100	100	5.0
WETLAND	98	98	98	98	98	100	100	21.8

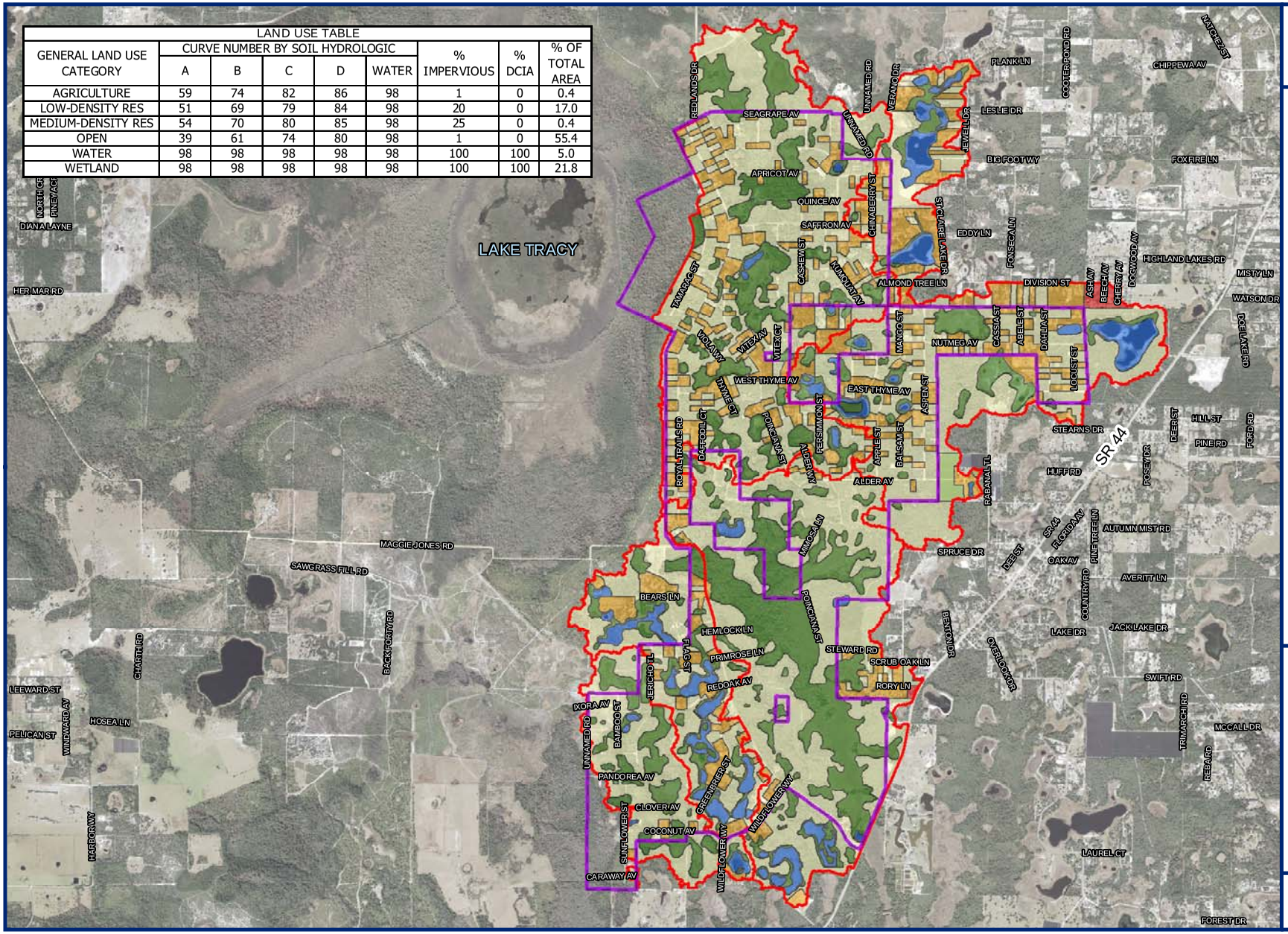


FIGURE 3-1

LAND USE MAP

Royal Trails Flood Study

Inwood consulting engineers

Table 3-2 – Curve Numbers and Percent Impervious by Land Use

	Curve Number by Hydrologic Soil Group[1]					% Impvervious/Pervious[2]		
General Land Use	**A**	**B**	**C**	**D**	**Water**	**DCIA**	**Impervious**	**Pervious**
Agriculture	59	74	82	86	98	0	1	99
Low-Density Residential	51	69	79	84	98	0	20	80
Medium-Density Residential	54	70	80	85	98	0	25	75
Open	39	61	74	80	98	0	1	99
Water	98	98	98	98	98	100	0	0
Wetland	98	98	98	98	98	100	0	0

Data Sources:

1. NRCS. *Urban Hydrology for Small Watersheds*, Technical Release No. 55. USDA-NRCS, 1986.
2. Inwood. Royal Trails Flood Study – Flood Assessment Task.

Urban Watersheds - Technical Release 55. In addition to curve numbers, other important parameters included percent impervious area and percent directly connected impervious area (DCIA). These values were developed specifically for this area during the Flood Assessment Task of this study and are also shown in Table 3-2.

3.1.3 Soils

Soils data were obtained from the Southwest Florida Water Management District (SWFWMD) for this study. These data were used to be consistent with the Flood Assessment Task. See the *Preliminary Flood Assessment Technical Memorandum* for an explanation of soil data source selection. Based on the soils data, the soils in the area considered for the pollutant loading analysis consist approximately of 29.1% hydrologic group A, 0.1% hydrologic group B, 21.3% hydrologic group C, 3.2% hydrologic group D, 14.4% hydrologic group A/D, 31.8% hydrologic group B/D, and 2.6 % water. Soil hydrologic groupings give a general indication of performance with regard to infiltration and surface runoff generation with hydrologic group A being classified as well drained soils and generating the least runoff and hydrologic group D being poorly drained and generating the most runoff. The type of soil present will affect the CN specified for a given land use – see Table 3.2. For the purposes of this analysis, dual classification hydrologic soil groups A/D and B/D were assumed to function as poorly drained type D soils to be conservative. See Figure 3-2 for a map depicting the soils for the study area.

3.1.4 Rainfall

Rainfall data are necessary to calculate average annual runoff volumes which transport pollutants. This pollutant loading model uses a rainfall frequency distribution representing an average rainfall year. The rainfall distribution was referenced from Harper and Baker (2006) and was developed using an analysis of 62 years of hourly rainfall data from the Orlando International Airport. The resulting analysis predicted an average annual rainfall of 49.8 inches consisting of 142 discrete events. This distribution was assumed to reflect an average annual rainfall year for the Central Florida area as a whole and therefore was applicable for use in Lake County. See Table 3-3 for the rainfall frequency distribution.

3.1.5 BMP Attenuation

As was noted in Section 2.3, there were no significant existing BMPs located in Royal Trails subdivision through which to provide attenuation for stormwater runoff and associated pollutant loading volumes. There are numerous swales which would be expected to provide some level of treatment; however, their placement is sporadic and not consistent. Thus, BMPs were not considered significant and the model did not account for attenuation of pollutant mass loadings through BMPs.

3.1.6 Conveyance Attenuation

The Harper methodology, adapted for pollutant loading prediction in this study, has an ability to account for potential reduction of pollutant loads through attenuation of runoff volume and pollutant load as it passes through the conveyance system. The attenuation factors bear the most relevance in areas where BMPs are common such as in urban or mixed use areas. Also, their use increases the complexity of the model. Considering the rural nature of the study area and limited BMPs, the impact of using attenuation factors was considered to not be significant relative to the complexity of its incorporation and therefore was not used.

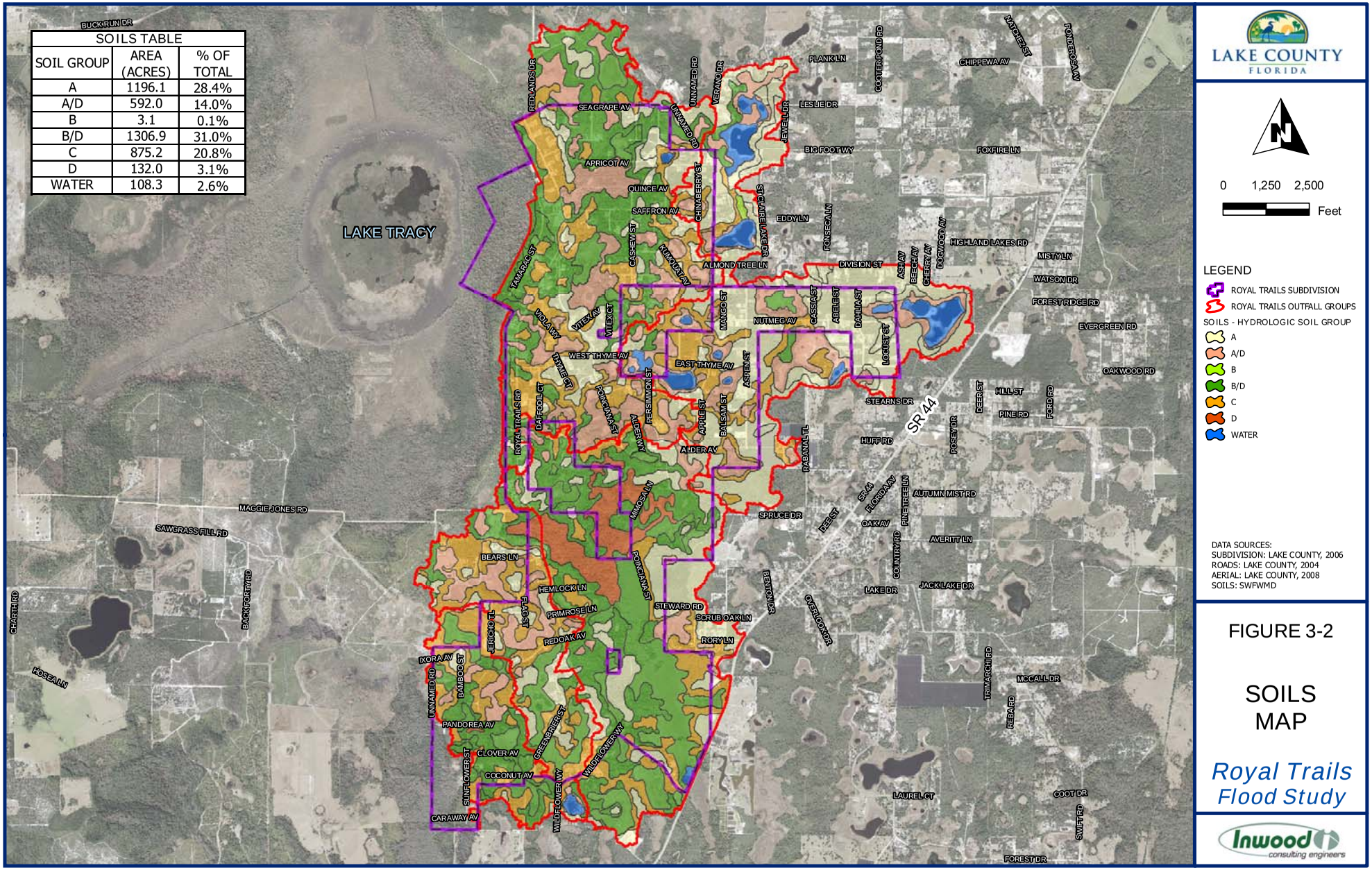

SOILS TABLE
SOIL GROUP | AREA (ACRES) | % OF TOTAL
A | 1196.1 | 28.4%
A/D | 592.0 | 14.0%
B | 3.1 | 0.1%
B/D | 1306.9 | 31.0%
C | 875.2 | 20.8%
D | 132.0 | 3.1%
WATER | 108.3 | 2.6%
LAKE TRACY
LAKE COUNTY FLORIDA
0 1,250 2,500
Feet
LEGEND
ROYAL TRAILS SUBDIVISION
ROYAL TRAILS OUTFALL GROUPS
SOILS - HYDROLOGIC SOIL GROUP
A
A/D
B
B/D
C
D
WATER
DATA SOURCES:
SUBDIVISION: LAKE COUNTY, 2006
ROADS: LAKE COUNTY, 2004
AERIAL: LAKE COUNTY, 2008
SOILS: SWFWMD
FIGURE 3-2
SOILS MAP
Royal Trails Flood Study
Inwood consulting engineers

Table 3-3 – Rainfall Frequency Distribution

Rainfall Event Range (in)	Rainfall Interval Point (in)	Number of Annual Events in Range
0.00-0.10	0.039	66.82
0.11-0.20	0.151	20.30
0.21-0.30	0.252	11.18
0.31-0.40	0.353	7.43
0.41-0.50	0.456	6.31
0.51-1.00	0.713	16.99
1.01-1.50	1.228	6.96
1.51-2.00	1.718	3.06
2.01-2.50	2.230	1.53
2.51-3.00	2.687	0.64
> 3.00	4.512	1.05

Data Source: Harper, Harvey, H. and David M. Baker, Evaluation of Nonpoint Source Loadings to Lake Harris/Little Lake Harris (NPLSM Model), Environmental Research and Design, Inc., 2006.

3.1.7 Event Mean Concentrations

This pollutant loading model predicts load in stormwater runoff using event mean concentrations (EMCs). EMCs are flow-weighted average concentrations of pollutants in stormwater runoff for different land uses. These values are used in conjunction with runoff volume estimates to calculate pollutant load mass in stormwater runoff. This model uses EMC values referenced from the work conducted by Harper and Baker (2006). See Table 3-4 for the list of EMCs by land use as used in this model.

Table 3-4 – Typical Stormwater Runoff Event Mean Concentrations

Land Use Category	Typical Runoff Concentration (mg/l)			
	Total N	Total P	BOD	TSS
Low-Density Residential	1.77	0.117	4.4	19.1
Medium-Density Residential	2.29	0.300	7.4	27.0
High-Density Residential	2.42	0.490	11.0	71.7
Institutional	2.29	0.300	7.4	27.0
Commercial	2.83	0.430	17.2	94.3
Industrial	1.79	0.310	9.6	93.9
Transportation	2.08	0.340	5.6	50.3
Agriculture	2.32	0.344	3.8	55.3
Recreational	1.25	0.053	1.5	11.1
Open	1.25	0.053	1.5	11.1
Wetland	1.60	0.190	4.6	10.2
Water	1.25	0.110	1.6	3.1

Source: Harper, Harvey, H. and David M. Baker, Evaluation of Nonpoint Source Loadings to Lake Harris/Little Lake Harris (NPLSM Model), Environmental Research and Design, Inc., 2006.

3.2 CALCULATIONS

As mentioned previously, the model processes and calculations can be broken down into several general steps. These steps are detailed in the following subsections.

3.2.1 Curve Numbers and Impervious Area

To begin this step, three data layers were prepared in GIS: Subbasins, Land Use and Soils. The Subbasins layer was intersected with the Land Use and the resulting layer was then intersected with the Soils. The result was each subbasin being broken into subareas consisting of individual combinations of land use and soil type. The attributes of this layer consisted of subbasin names, total subbasin area, subarea area, land use categories, percent impervious area and percent DCIA, curve numbers and hydrologic soil group. The attributes of the layer were then exported from GIS and loaded into an Excel spreadsheet.

After the GIS data was brought into Excel, the pertinent data was copied to the runoff calculation worksheet. Pervious area, Impervious Area, DCIA, and total non-DCIA area were computed for all subareas. In this case, non-DCIA area referred to all area within the subarea, both pervious and impervious, that was not DCIA. See the Appendix CD for a summary table of subbasin statistics.

3.2.2 Average Annual Stormwater Runoff

Continuing on the runoff calculation worksheet, surface runoff volumes were calculated for each subarea using the curve number method as shown in the following equations. Runoff from non-DCIA was calculated as follows:

$$CN\,nDCIA_x = \frac{(CN_x * 100 - IMP_x) + 98(IMP_x - DCIA_x)}{(100 - DCIA_x)}$$

$$S_X = \left(\frac{1000}{CN\,nDCIA_x} - 10\right)$$

$$Q\,nDCIA_{ix} = N_i\left(\frac{(P_i - 0.2S_x)^2}{(P_i + 0.8S_x)}\right)$$

where:

CN_x	=	Curve number for pervious area in subarea x
IMP_x	=	Percent impervious area in subarea x (%)
DCIA	=	Percent directly connected impervious area in subarea x (%)
CN $nDCIA_x$	=	Curve number for non-DCIA area in subarea x
S_x	=	Soil storage for non-DCIA area in subarea x (inches)
P_i	=	Median rainfall depth for rainfall event interval i in rainfall frequency distribution (inches)
N_i	=	Number of rainfall events in rainfall event interval i in rainfall frequency distribution
Q $nDCIA_{ix}$	=	Runoff depth for non-DCIA area of subarea x for rainfall interval i (inches)

Runoff from DCIA was calculated as follows:

$$Q\,DCIA_{ix} = N_i(P_i - 0.1)$$

when: $P_i \geq 0.1$

where:

$Q\,DCIA_{ix}$ = Runoff depth for DCIA of subarea x for rainfall interval i (inches)

The value 0.1 is the assumed initial abstraction rate to account for storage from surface irregularities. Runoff from DCIA will not be generated unless the depth of rainfall exceeds this threshold.

After surface runoff for the non-DCIA area and DCIA was computed individually, total runoff depth over the subarea was calculated with the following equation:

$$RO_{ix} = \frac{(Q\,nDCIA_{ix} * A\,nDCIA_x) + (Q\,DCIA_x * A\,DCIA_{ix})}{A_x}$$

where:

RO_{ix} = Runoff depth over subarea x for rainfall interval i (inches)
$A\,nDCIA_x$ = Non-DCIA area for subarea x (acres)
$A\,DCIA_x$ = DCIA for subarea x (acres)
A_x = Total area of subarea x (acres)

Finally total runoff volume is calculated as follows:

$$V_x = \left[\sum_{i-1}^{Z} RO_{ix}\right] * \frac{1}{12} * A_x$$

where:

V_x = Total runoff volume from subarea x (acre-feet)

3.2.3 Pollutant Load Generation

After total runoff volume was calculated, the results were moved to the loading worksheet. The estimated average pollutant loads for total nitrogen, total phosphorous, BOD and TSS were computed for each subarea with the following equation:

$$L_x = 2.72 * V_x * EMC$$

Where:

L_x = Nutrient/pollutant mass loading for subarea x (lb/year)

2.72 = conversion factor for $\left(\frac{mg * ac * ft}{L * yr}\right)$ to $\left(\frac{lb}{yr}\right)$

After pollutant loads were computed for each subarea they were summed for each subbasin on the summary worksheet. The pollutant loading model spreadsheet is available on the Appendix CD.

4.0 POLLUTANT LOADING MODEL RESULTS

The low-density residential, open space and wetland land use types account for roughly 94% of the cover area. These predominant landuses have relatively similar EMC values. The major factor for variation in estimated pollutant load was the percent impervious and DCIA area, total subbasin size, and soils. Larger subbasins tended to have larger pollutant loads. Also subbasins with large areas of impervious, particularly DCIA, and/or large areas of poorly draining soils (such as wetlands) also generated higher pollutant loads. These results are lacking in the "hot spots" typically fond in a more urban environment due to an absence of high mass load land uses such as commercial, industrial or high-density residential.

Total average annual pollutant mass loads and areal loads are summarized in Table 4-1. Pollutant loading results for the study area are shown by pollutant type in Figures 4-1 through 4-4. Complete results are included on the Appendix CD.

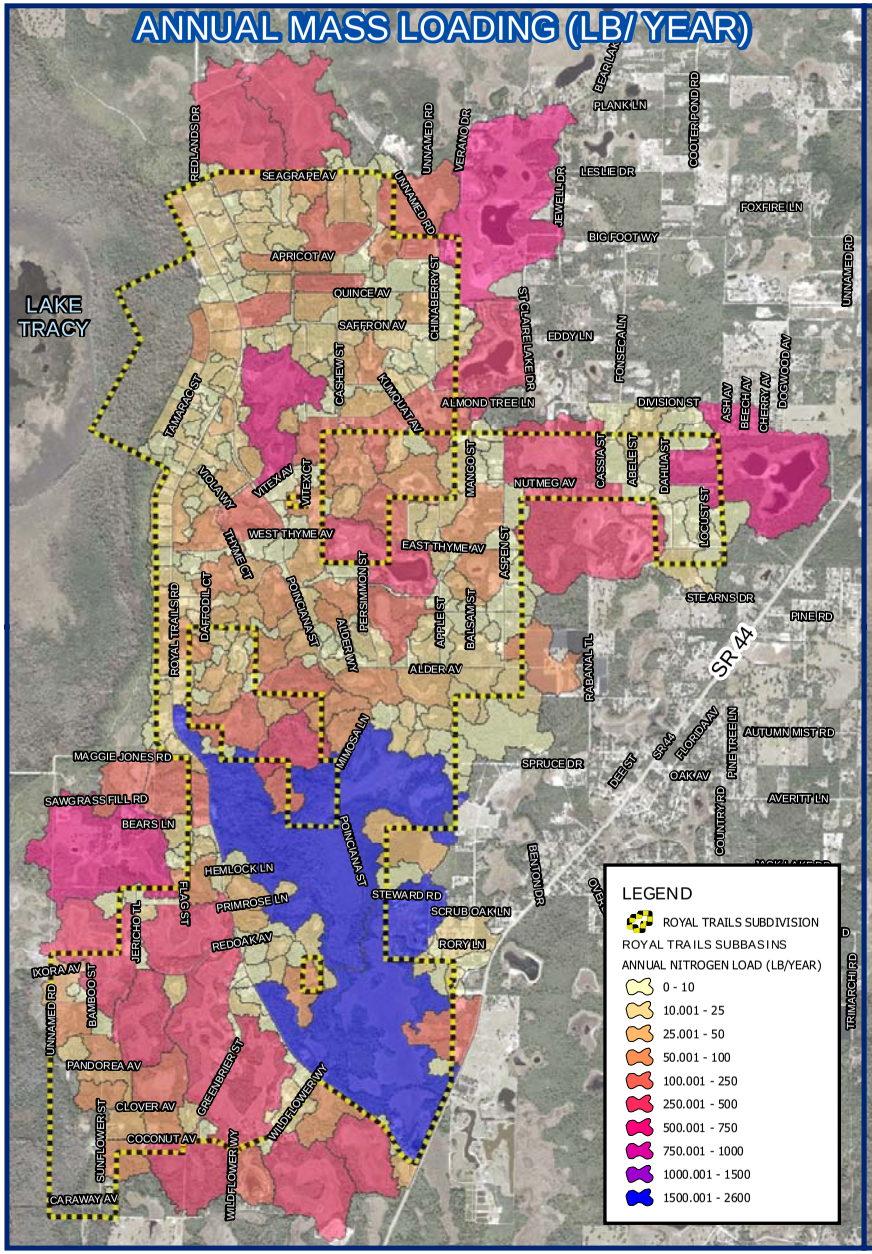
Table 4-1 – Average Annual Pollutant Mass Loading

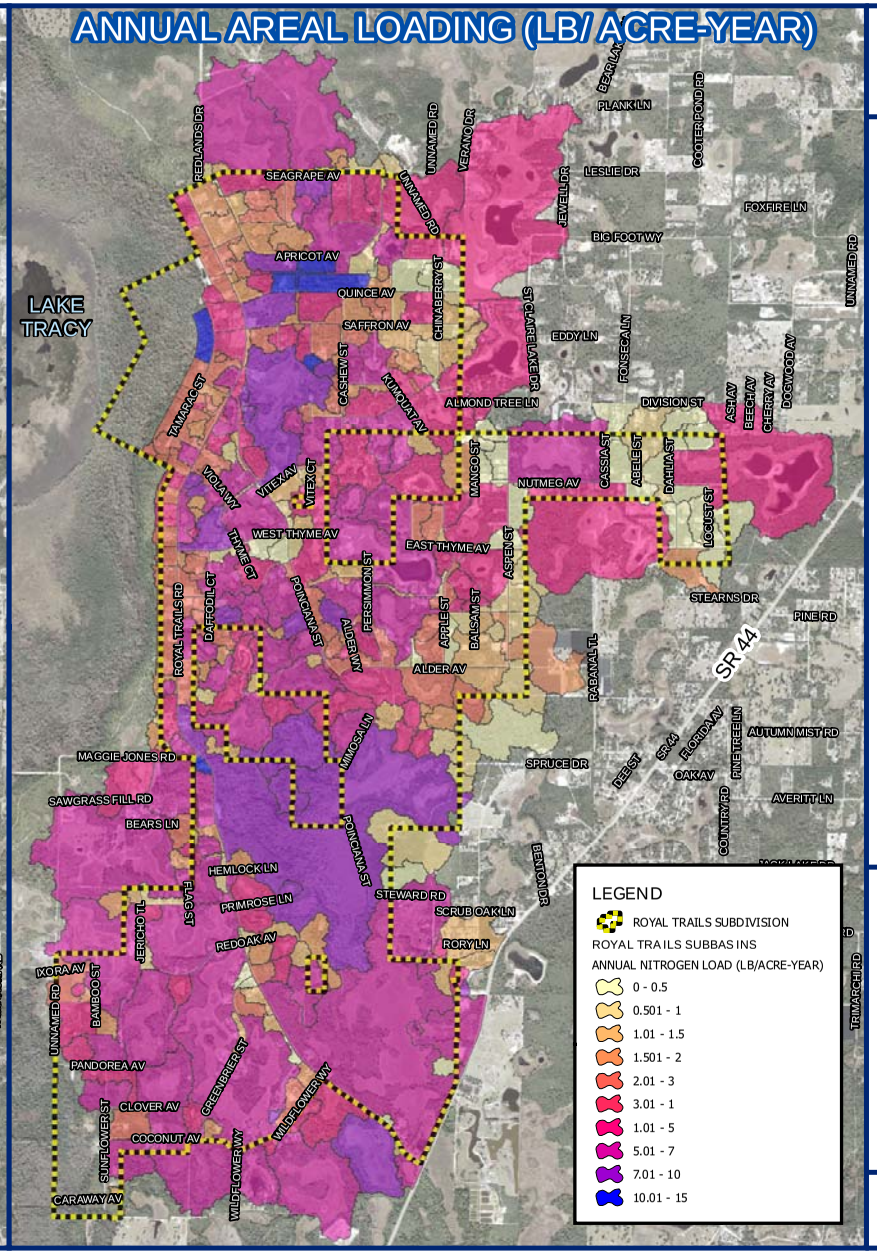
Outfall Group	Area	Pollutant Mass Loading/Average Areal Loading							
		Total N		Total P		BOD		TSS	
	(ac)	(lb/yr)	(lb/ac-yr)	(lb/yr)	(lb/ac-yr)	(lb/yr)	(lb/ac-yr)	(lb/yr)	(lb/ac-yr)
Blackwater Creek	298	1631	5.5	168	0.6	4136	13.9	11162	37.4
Lake Tracy	1689	7982	4.7	774	0.5	19180	11.4	55239	32.7
Land Locked	1101	3615	3.3	345	0.3	7866	7.1	22050	20.0
State Road 44	1126	6706	6.0	716	0.6	17364	15.4	43972	39.1
Total	4214	19935		2003		48547		132423	

As was mentioned in Section 2.2, the subbasins were divided into outfall groups based upon common discharge points to facilitate interpretation of results and to aide in identifying appropriate locations for BMP implementation. Land Locked subbasins, those that did not discharge during the 100 year storm event, make up approximately 26% of the total land area. This effectively removes these pollutants from impacting downstream bodies. Notice, however, that the Land Locked subbasins tend to produce low mass loads. This was a function of these subbasins generally having low amounts of impervious areas and a predominance of well drained soils. This is also evidenced by the average areal loadings for this group, which are the lowest of the four.

Conversely, the subbasins which discharge via the culverts under State Road 44 have much higher mass loads – nearly double – than the Land Locked subbasins though they are approximately the same proportion of the overall study area – approximately 27%. This is largely due to the preponderance of poorly drained soils in this area and large proportion of impervious area due to wetland and water land uses. Correspondingly, the State Road 44 group has the highest average areal loadings of the four groups. Similar observations can be made for the subbasins discharging to Blackwater Creek.

Those subbasins discharging to Lake Tracy either directly overland or via drainage canals tend to fall somewhere in the middle of the two extremes. This area has a significant amount of poorly drained soils; however, this is tempered by a lower proportion of impervious area.





LAKE COUNTY
FLORIDA

0 1,250 2,500
Feet

DATA SOURCES:
SUBDIVISION: LAKE COUNTY, 2006
ROADS: LAKE COUNTY, 2004
AERIAL: LAKE COUNTY, 2008

FIGURE 4-1

ANNUAL NITROGEN LOAD PER SUBBASIN

Royal Trails Flood Study

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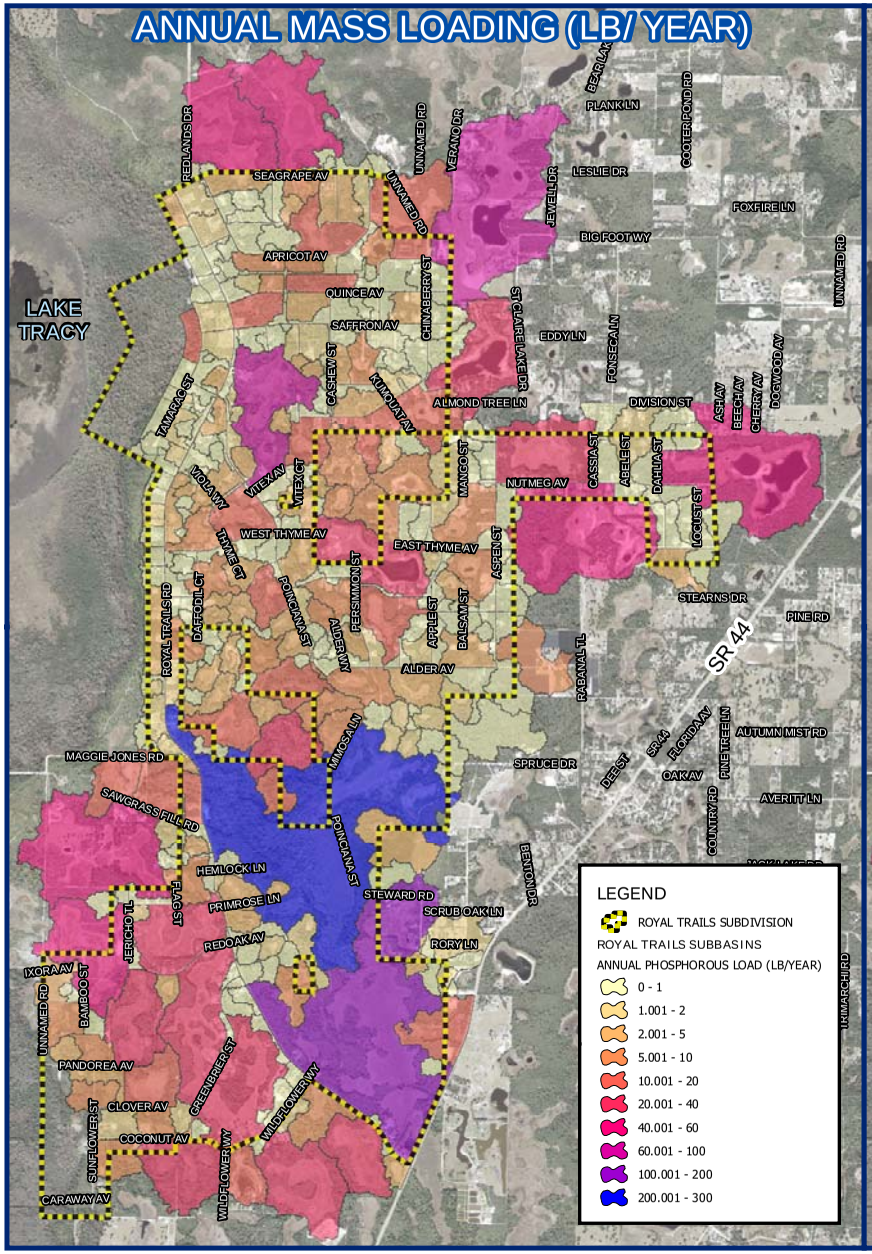

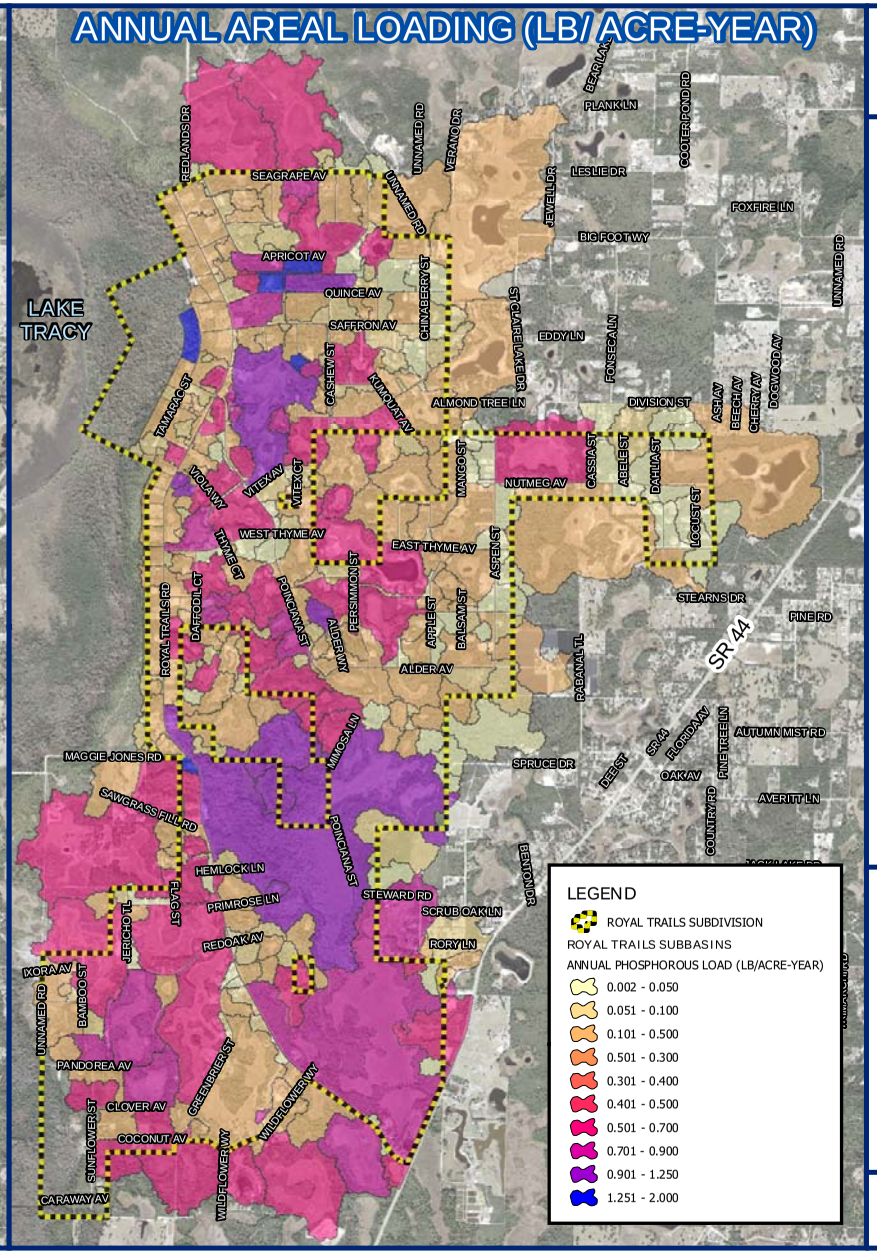

LAKE COUNTY
FLORIDA

0 1,250 2,500
Feet

DATA SOURCES:
SUBDIVISION: LAKE COUNTY, 2006
ROADS: LAKE COUNTY, 2004
AERIAL: LAKE COUNTY, 2008

FIGURE 4-2

ANNUAL PHOSPHOROUS LOAD PER SUBBASIN

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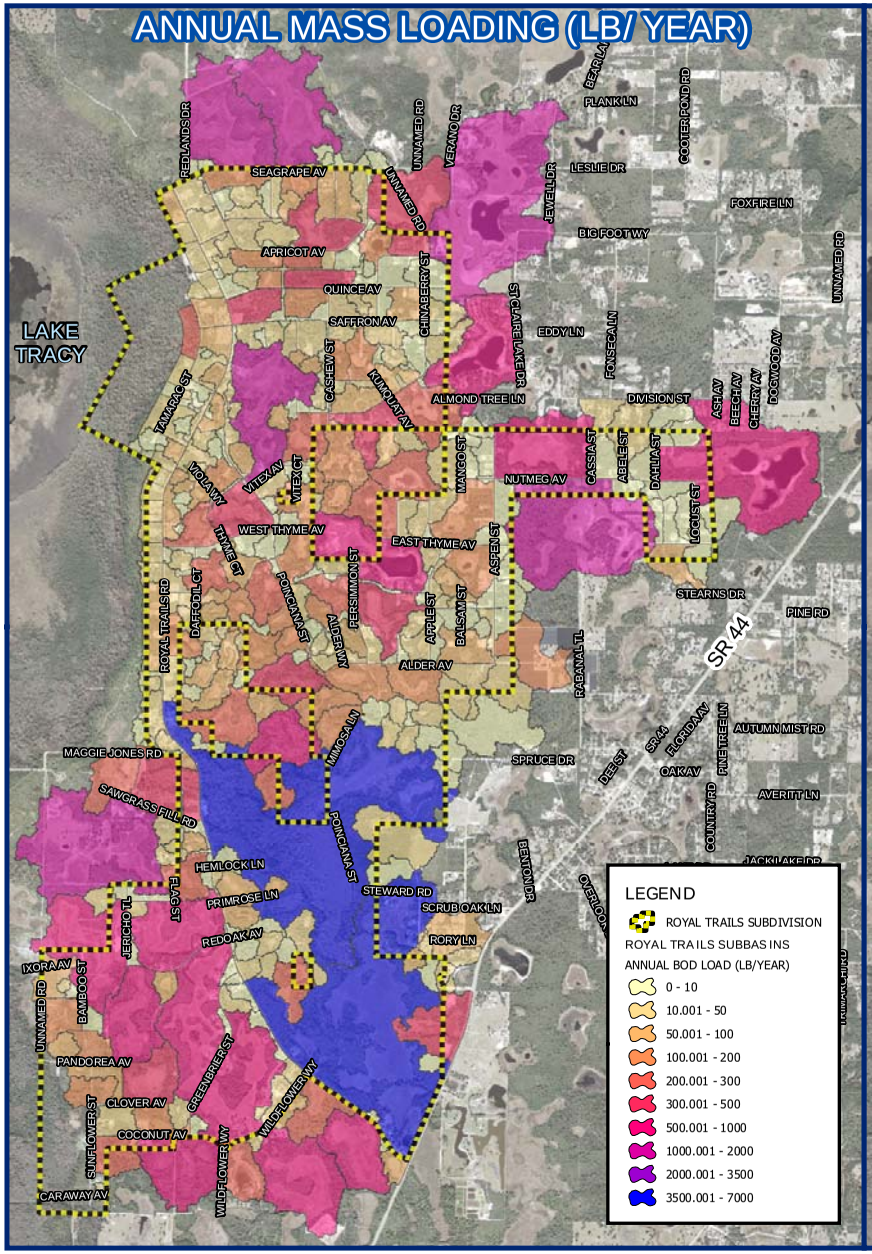

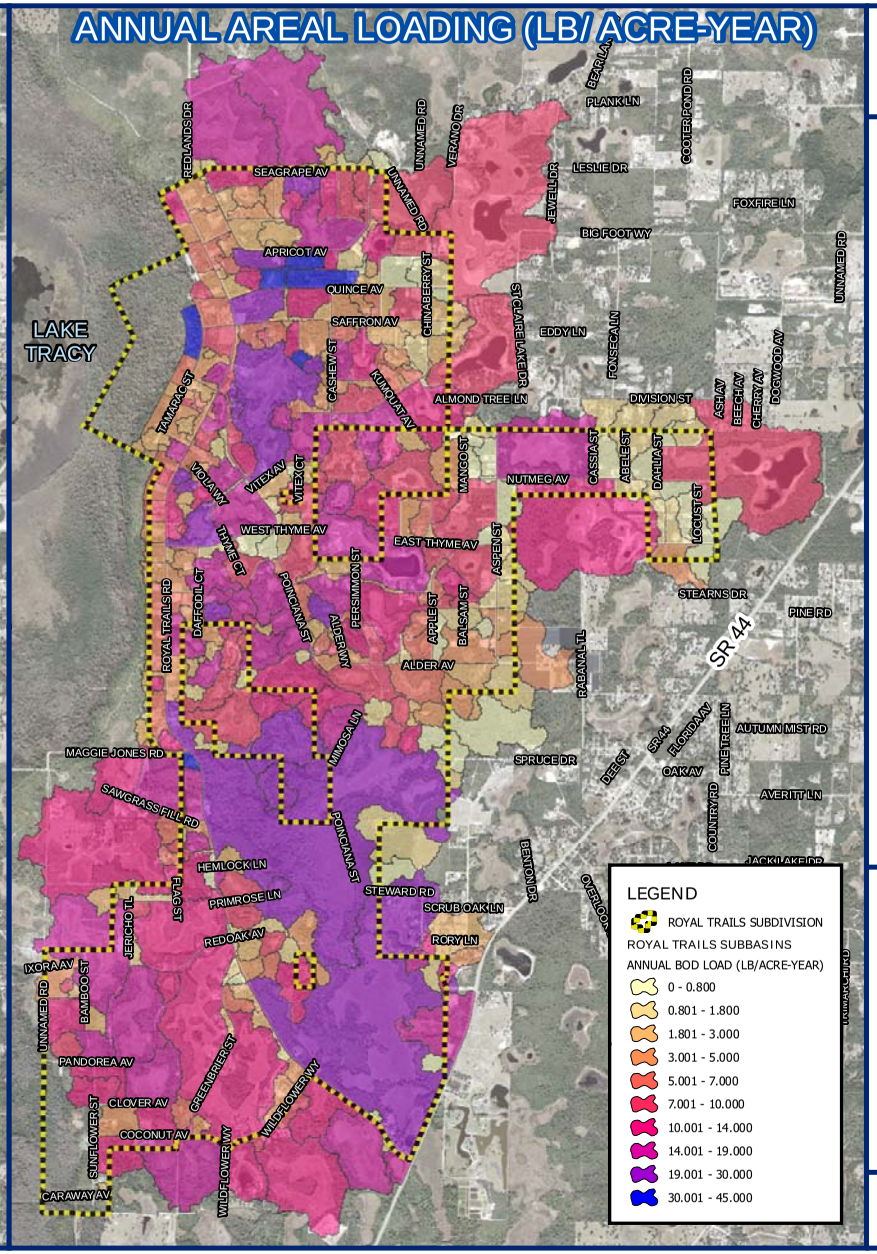

LAKE COUNTY
FLORIDA

0 1,250 2,500
Feet

DATA SOURCES:
SUBDIVISION: LAKE COUNTY, 2006
ROADS: LAKE COUNTY, 2004
AERIAL: LAKE COUNTY, 2008

FIGURE 4-3

ANNUAL BOD LOAD PER SUBBASIN

Royal Trails Flood Study

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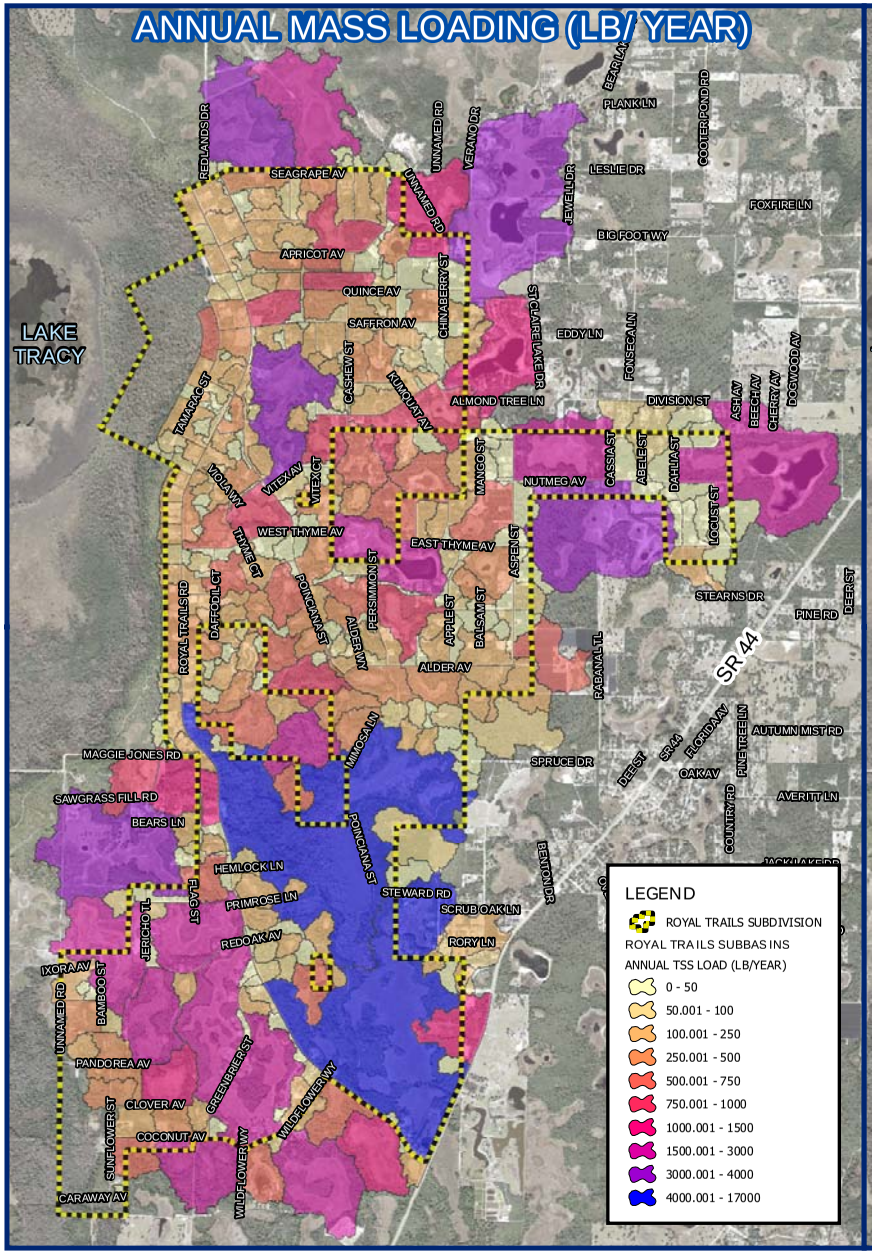

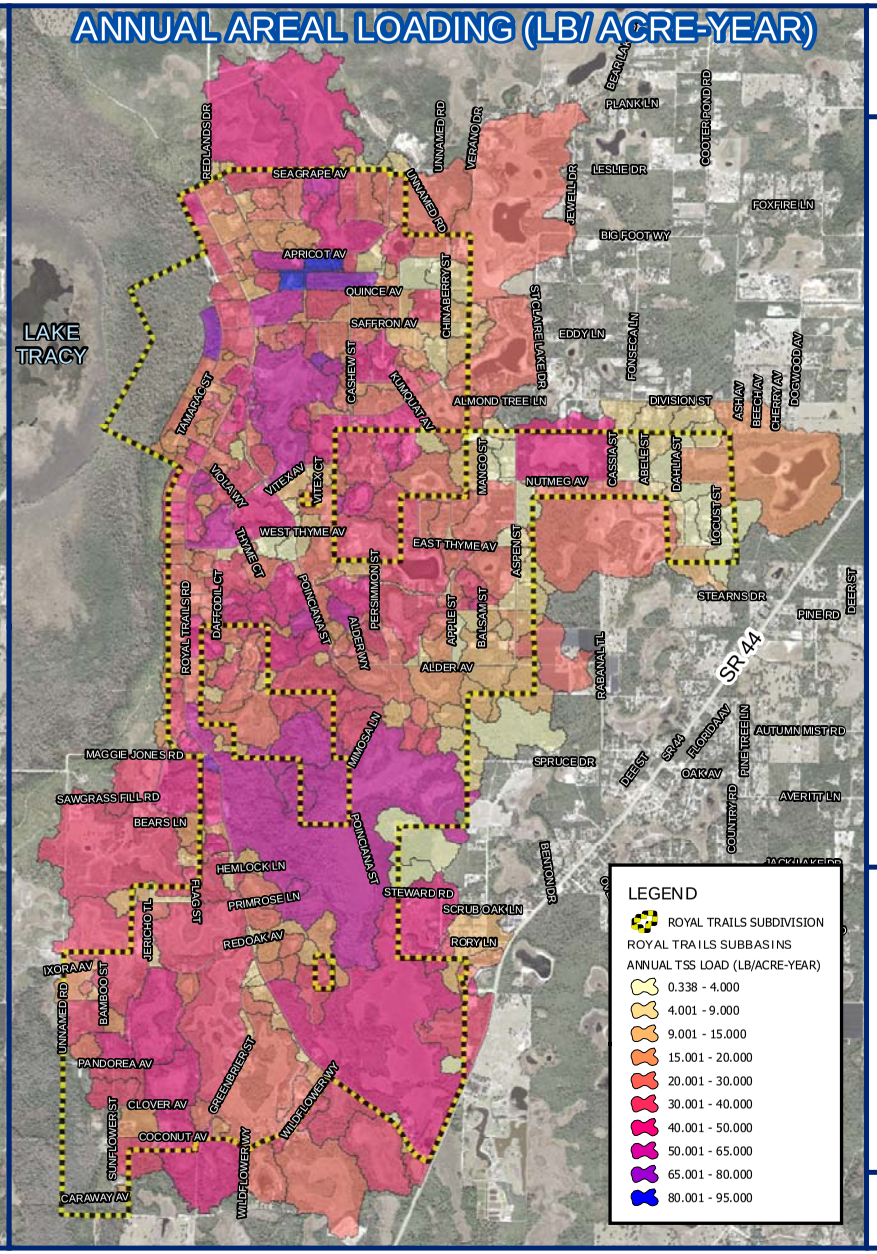

LAKE COUNTY
FLORIDA

0 1,250 2,500
Feet

DATA SOURCES:
SUBDIVISION: LAKE COUNTY, 2006
ROADS: LAKE COUNTY, 2004
AERIAL: LAKE COUNTY, 2008

FIGURE 4-4

ANNUAL TSS LOAD PER SUBBASIN

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5.0 CONCLUSIONS AND RECOMMENDATIONS

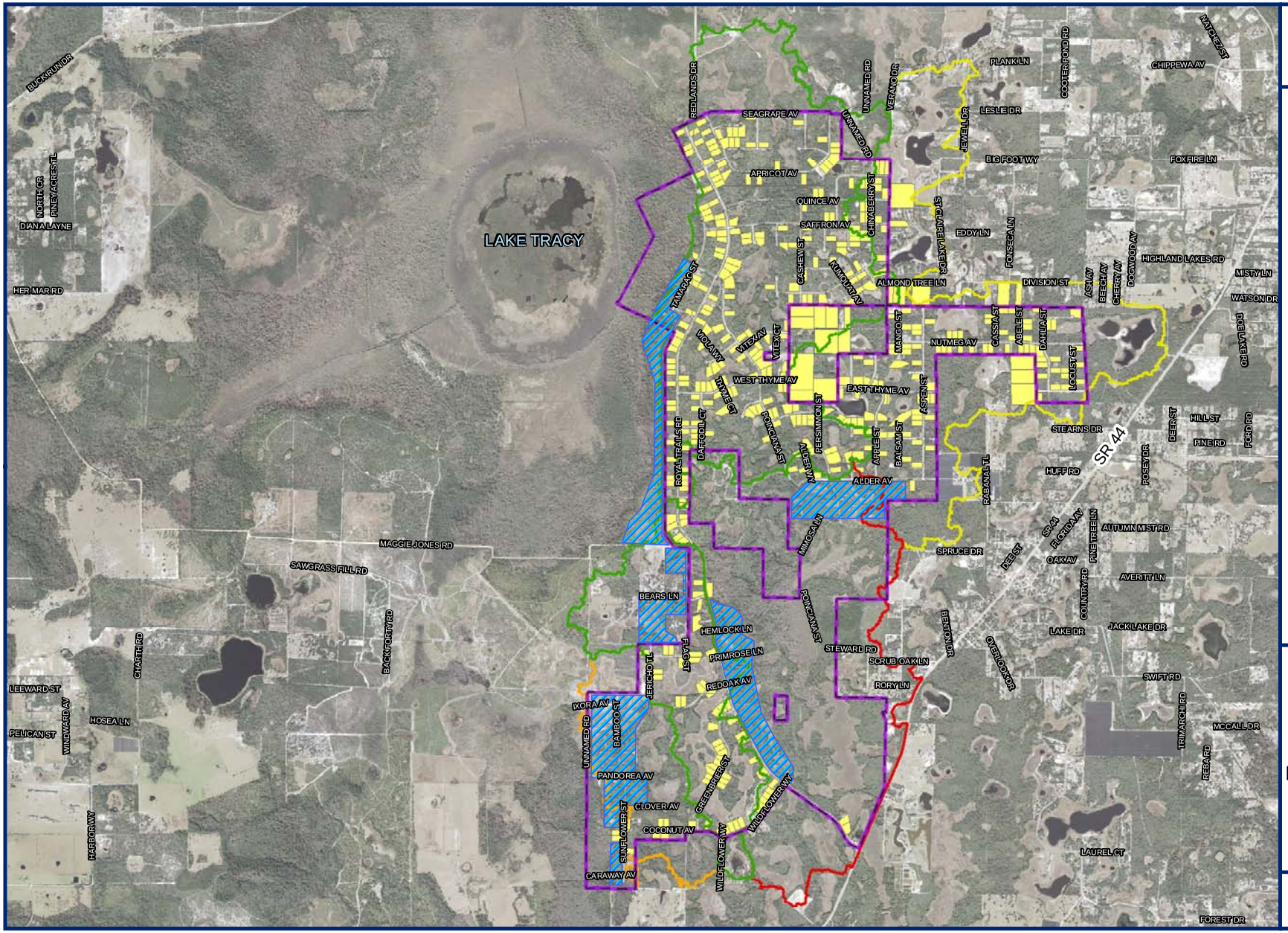
This analysis was conducted to establish estimated annual pollutant mass loadings from surface runoff for subbasins in the Royal Trails subdivision. This effort included gathering the pertinent data and developing a spreadsheet based pollutant loading model. This model was based on the methodology of Harper and Baker (2006) from the report *Evaluation of Nonpoint Source Loadings to Lake Harris/Little Lake Harris* for consistency between projects within Lake County. For the purposes of this model, the pollutant reduction affect of BMPs was not included due to the rural nature of the study area and the limited presence of BMPs. Additionally, septic tank loading was not included because incorporation of that methodology would not be expected to result in any significant difference in calculated annual pollutant loads.

Pollutant loading is an important consideration for this study area. The majority of the Royal Trails subdivision lies within the Wekiva Protection Area which is afforded protection under the Wekiva Parkway and Protection Act. A Master Stormwater Management Plan is in effect for Lake County for areas that fall within the Wekiva Protection Area. This Master Stormwater Management Plan provides specific goals and approaches for the conservation and preservation of surface and groundwater resources in the area including identifying areas to implement BMPs to improve water quality.

A total of four nutrients/pollutants were considered in this analysis – total nitrogen, total phosphorous, BOD, and TSS. The study area produces an estimated annual mass of 19,935 lb, 2003 lb, 48,547 lb and 132,423 lb for these pollutants respectively. Approximately 26% of the subbasin area in the study is considered landlocked, effectively nullifying any downstream effect of their annual loadings from surface discharges. The remainder of the subdivision discharges to one of three outfall locations, which can ultimately reach the impaired waters of the Blackwater Creek and then the Wekiva River.

In general, it is hard to determine priority areas for BMP implementation because of the general consistency of land covers and the absence of localized high pollutant mass yield land covers. Mass loading estimates were influenced by total volume of stormwater resulting from poorly drained soils and high impervious area percentages. However, it is possible to identify general areas of currently undeveloped space adjacent to the discharges points of the subdivision where BMPs could be placed to provide some treatment to stormwater runoff. These identified areas are shown on Figure 5-1.

These areas should be considered in the evaluation of potential BMPs to reduce pollutant loads addressed in the subsequent Deficiency Correction Task of this project. The implementation of BMPs in the subdivision will assist Lake County in meeting the goals of the WPA MSMP.



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0 1,250 2,500
Feet

LEGEND

- POTENTIAL BMP AREAS
- ROYAL TRAILS SUBDIVISION

ROYAL TRAILS OUTFALL GROUPS

OUTFALL GROUP

- BLACKWATER CREEK
- LAKE TRACY
- LAND LOCKED
- STATE ROAD 44
- OCCUPIED PARCELS

NOTE:
OCCUPIED PARCELS BASED ON OCTOBER 2007 FIELD OBSERVATIONS.

DATA SOURCES:
SUBDIVISION: LAKE COUNTY, 2006
ROADS: LAKE COUNTY, 2004
AERIAL: LAKE COUNTY, 2008

FIGURE 5-1

AREAS FOR POTENTIAL BMP IMPLEMENTATION

Royal Trails Flood Study

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REFERENCES

1. CDM. *Wekiva Parkway and Protection Act – Master Stormwater Management Plan Support*, Final Report, November 2005.
2. Florida Department of Transportation. *Florida Land Use, Cover and Forms Classification System Handbook*, January 1999.
3. Harper, Harvey H. and David M. Baker. *Evaluation of Nonpoint Source Loadings to Lake Harris/Little Lake Harris* (NPSLM Model), Environmental Research and Design, Inc., 2006.
4. NRCS. *Urban Hydrology for Small Watersheds*, Technical Release No. 55, USDA-NRCS, 1986

Appendix CD

Contents:

- Pollutant Loading Model Spreadsheet
- Subbasin Summary Statistics Spreadsheet
- Royal Trails Preliminary Pollutant Loading Analysis Technical Memorandum (pdf)


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