SARASOTA COUNTY POLLUTANT LOADING MODEL DEVELOPMENT (W552) DRAFT DESIGN REPORT

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1.0 INTRODUCTION

The objective of this phase of the project is to develop a verified pollutant load model that will be used to accurately estimate loads from proposed land development designs, to estimate the effectiveness of projects intended to reduce pollution, and to relate pollutant load to water quality conditions in receiving waterbodies. In the first phase of this project, Jones Edmunds developed a County-wide pollutant loading model within a GIS framework for Sarasota County. The model is referred to as the Spatially Integrated Model for Pollutant Loading Estimates (SIMPLE) uses computational methods from the Watershed Management Model (WMM) and the Harvey Harper Method (used in the Lemon Bay Model) as well as additional methods to predict seasonal and annual loads from point sources, non-point sources (direct runoff and base flow) and septic tanks.

This second phase of the project builds on the first phase by adding to the model functionality. Potential enhancements to the model include improved inputs of atmospheric deposition (dry deposition and rainfall), best management practices (BMPs), land use, wastewater, air deposition, and septics, as well as improved outputs (in GIS or tabular format) on a finer time scale, at a finer geographic scale, and with the ability to compare scenarios.

This design report presents details on the proposed model and data enhancements. Each proposed model enhancement is presented in a separate section of the report. It is important to note that the enhanced version of the model is intended to operate in two different modes: seasonal/annual and daily. As a naming convention, these two modes will be referred to as SIMPLE-Seasonal and SIMPLE-Daily. Although each mode will share many of the same elements, they will exist as two separate models with different input requirements and output capabilities. It is possible that not all enhancements will be included in both modes. Please note that daily could become a different time-scale—such as weekly or monthly—depending on the final needs of the receiving water modeling that will be performed on the County's bays.

2.0 TIME-STAMPED GIS DATA

Many of the model enhancements proposed in the following sections are predicated on having GIS data (e.g., land use and point source discharges) with temporal changes embedded in it. It is important to determine how these time-varying data will be stored and the rate/amount of change that will be stored. Since very large data sets are used in this process, it is important to develop a data design that is as compact as possible and that can be readily updated. How and what is stored for each type of data will vary by type and is dependent on availability of the data, the nature of the data, and sensitivity of results from its end use. Each of the data types are discussed below.

2.1 LAND USE

Significant development has occurred in Sarasota County over the past several decades and will continue in the foreseeable future. In terms of land use, development usually means a shift from open, forest, or agricultural land to an urban land use such as medium-density residential development or commercial development. These shifts result in a difference in runoff volumes and pollutant loads, so it is important to track and account for them in the pollutant loading model. Since most developments take on the order of months to years to complete and their progress and completion are not tracked at fine time scale, recording land use changes on a yearly basis is likely the most reasonable interval.

GIS land use data exist as a polygon feature class, with the most pertinent attribute being the FLUCCS code. The most efficient way to embed temporal changes into the land use data is to include two additional attributes: the pre-development condition land use and the date (year) of transition between pre-developed and developed conditions. This method of storage allows land use data from multiple years to be stored in a single feature class and avoids issues related to differences between how polygons were drawn or defined for the same development for different land use feature classes.

The County's primary need for temporally changing land use and its effect on pollutant loading is for the period used in most of the existing TMDLs (i.e., approximately the last 10 years). There is an additional need to compare earlier (i.e., un-urbanized) conditions, but this is probably best handled in a separate feature class that is developed for that single use.

The following four sources were used to create a single land use feature class with embedded temporal changes:

- 1990 land use shapefile from SWFWMD
- 2004 land use shapefile from SWFWMD
- Parcel and platt shapefiles from Sarasota County
- Parcel database from Sarasota County

Since this feature class will only be applied for approximately the last 10 years worth of data, the FLUCCS attribute from the 1990 shapefile was generally used as the predevelopment condition and the FLUCCS attribute from the 2004 shapefile was used as the post-development condition. In order to reconcile slight differences between the two, the land uses were intersected and the following rules were applied:

- If the 1990 and 2004 land uses were both non-urban or both urban, the 1990 land use was over-written with the 2004 land use.
- If the 1990 land use was urban and the 2004 land use was non-urban, the 1990 land use was over-written with the 2004 land use.

The intersection of the two land use shapefiles was again intersected with a platt shapefile provided by the County. The platt shapefile contributed data regarding the average year built for each parcel within the platt. The average year built for any urban land uses is considered to be the date of land use change. Figure _ shows a sample of the resulting shapefile attribute table. It was determined that using the platt rather than the individual parcel information allowed for consolidation of small yet similar (with respect to year built) areas. This will reduce model run times.

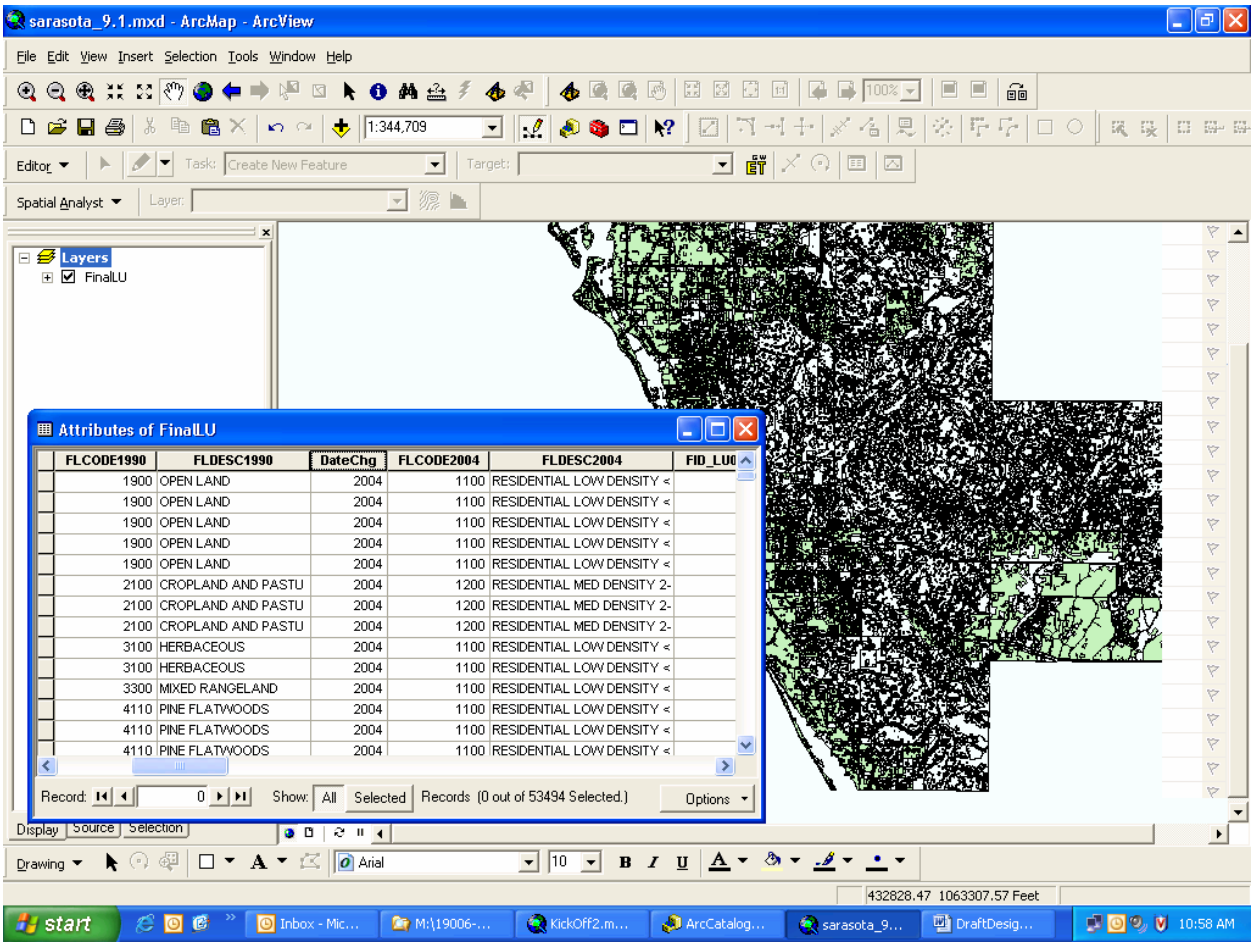

Figure 1-1 Preliminary Land Use Time Stamped Shapefile and Table

There are a few limitations to this straightforward methodology of developing the land use data. First, urban redevelopment cannot be accommodated without editing the attributes of individual features. However, it is our understanding that urban redevelopment within this timeframe has been minimal, and differences to loading may not be significant. Second, a similar situation occurs with changes in non-urban lands. Third, the transition year attribute inherits whatever inaccuracies are introduced by using an average of the year-built data from the parcel database. However, these data should generally be close, and it is unlikely that these errors will introduce significant inaccuracies in the loading predictions.

2.2 SOILS

No changes are currently proposed to the soils feature class. It is possible that compaction and alteration of the native soils during construction may have an impact on infiltration and runoff characteristics. Accounting for this impact would be possible to track in the soils feature class and include in the model, but there is minimal data to support it. Our recommendation is to include this in a future enhancement if deemed necessary and supported by adequate data.

2.3 NON-POINT SOURCE BEST MANAGEMENT PRACTICES

Consistent with the enhancements to the GIS land use database discussed above, the non-point source BMP feature class also needs to track temporal changes. Similar to the land use data enhancements, the BMP data will incorporate temporal changes with the addition of two attributes: the pre-development BMP type (no BMP for all cases currently considered) and the date (year) of transition between pre-developed and developed conditions. In order to maintain consistency with the land use data, the transition date is based on an intersection with the land use data and inheritance of the land use transition date.

2.4 SEPTIC TANKS

Since the County has an aggressive and ongoing septic tank removal program and because of the magnitude of the septic loads, it is important to track when septic tanks are removed. In order to include this information in the septic tank GIS feature class, the date of removal is proposed to be added to the feature class. Since land use and BMP data will be recorded as yearly changes and connections during removal projects take place incrementally, a transition year attribute is proposed for the septic tank data. The model will assume that the septic tank is no longer used in and after the transition year.

2.5 RAINFALL

There are two options for historical rainfall data for the time period required for the model: NEXRAD-derived data and a number of rainfall gages. Since the spatial distribution and periods of record of the gage data are very limited for the applications considered under this project, the NEXRAD data appear to be the preferred option. However, comparisons of the NEXRAD-derived data with several years of flow data at the CPS1 and MAT1 ARMS gages suggests that

the NEXRAD-derived data may contain significant inaccuracies. These comparisons were provided in the January 9, 2007, technical memorandum to the County and District, which is included in this report as Appendix a. Despite the potential inaccuracies, the NEXRAD-derived data is still likely the best rainfall record over the required time period.

The District maintains 15-minute interval NEXRAD-derived rainfall data through OneRain back through 1994, and the data exist as text and xml files. In order to be used in the model, the data have been imported into 10 Microsoft Access databases. Export routines will be generated once the final interval (e.g., hourly or daily) needed for the model is determined.

Based on availability of data, it is currently proposed that a single table of concentrations (i.e., non-time varying concentrations) be used for the rainfall, although it would not be difficult to incorporate time-varying and/or spatially varying rainfall concentrations if the County and the District determine that it is important and the data to support the changes exist. It is also important to note that rainfall concentrations will only be applicable to calculating direct rainfall loads on the bays since rainfall concentrations are implicit in direct runoff load computations.

2.6 DRY DEPOSITION

Constant rates and concentrations are proposed for dry atmospheric deposition. As with rainfall, dry atmospheric deposition loading will only be applicable to direct loads on the bays since dry deposition loads are implicit in direct runoff load computations.

2.7 BASE FLOW

In the current version of the model, seasonal base flows are input as constant flows with constant concentrations for each major basin. No changes are proposed to the base flow data for SIMPLE-Seasonal. For SIMPLE-Daily base flow rates could use the same method or be computed based on antecedent rainfall, basin characteristics, and (potentially) irrigation inputs. Therefore, base flow rates for SIMPLE-Daily are discussed in Section 4. Constant concentrations for base flow are proposed for both versions of the model.

2.8 WASTEWATER EFFLUENT DISPOSAL

For SIMPLE-Seasonal, wastewater effluent data are applied as model input in the form of a point shapefile containing average flows and concentrations for the 55 wastewater treatment plants within the County. The average values were calculated from a period of record spanning January 1998 through May 2005. Spatial location of the load was based on effluent disposal location. Data for these are available on a monthly average basis, which would facilitate moving to a finer time increment. In instances where concentration data were not available, calculations were used to derive the remainder of modeled constituents, and this would remain the case for SIMPLE-Daily. Due to the lack of great variation between values, updating point source loads on a monthly rather than daily basis for SIMPLE-Daily should be adequate.

2.9 UNTREATED WASTEWATER DISCHARGES

Untreated wastewater discharges (i.e., sewage spills) are not currently considered in the model since they are rare and data on them are sparse. However, it would be possible to include them in the model. If included, they may be best represented by three types of data. The first would be a lookup table of raw sewage concentrations. We propose to use this table globally across all major basins. The second type of data would be a point feature class containing a point ID. The third type of data would be a spill record containing point ID, date, and volume of spill for each record. Loads would then be computed as flow volumes from the spill record times concentrations from the lookup table and summed spatially.

2.10 IRRIGATION

For the purposes of this report, irrigation is limited to groundwater sources and stormwater reuse. Wastewater effluent reuse is considered under wastewater effluent disposal.

There are two methods that could be utilized to simulate irrigation. The first and simplest method would be to assume that irrigation inputs are essentially all lost to evapotranspiration. The influence of irrigation would then be handled by limiting how dry the pervious areas can get during dry periods. The second method would be to allow direct input of irrigation and compute outflows and loads.

If the second method is used, one type of stormwater reuse data is proposed for SIMPLE-Seasonal and two types of data are proposed for SIMPLE-Daily. For SIMPLE-Seasonal, stormwater reuse would be a point feature class with constant reuse rates included as attributes for the wet and dry seasons. For SIMPLE-Daily, the first type of stormwater reuse data would be a point feature class with a point ID. The second type of data would be a database file with point ID, date, and rate for each record. Loads (i.e., reductions) would be computed by subtracting the reuse volumes times a user-supplied return fraction from the base flow loads, since it is assumed that stormwater would largely be taken during base flow conditions in the case of direct withdrawals or be replaced by base flow in the case of withdrawals from ponds.

Data for irrigation from groundwater wells and/or potable water would be similar to that of stormwater reuse, except the flows and loads would be simple additions after the irrigation return rate is applied and a separate lookup table of concentrations would be required.

A small concern with including irrigation is that is unlikely that we will have definitive monitoring data to determine return rates. In the absence of these data, we will use findings from relative modeling studies in the area.

3.0 SIMPLE-SEASONAL

SIMPLE-Seasonal will undergo several improvements which came about after user input.

Wet and dry season lengths in SIMPLE-Seasonal are currently hard-coded. As part of this project, the user will have control over the duration of the wet and dry periods simulated. This has direct effect on the conversion factor used when calculating loads, which will be changed from hard coded to calculated based on the user-input.

Since the original model was written explicitly for Sarasota County, it was assumed that all required input files would be available. SIMPLE-Seasonal currently will not run without the user pointing to at least a dummy place-holder shapefile for point sources, BMPs or septic tanks. To run the model in areas where this information may not be available, the model will be altered to accept blank in the input file selection screen where the user points to the location of these files. In this case, the user has the ability to produce final loads resulting only from runoff.

The new version of the model will be more easily updated by the user. Currently, the modeler must have some knowledge of GIS and the use of Domains and Aliases to be able to simulate a new BMP.

Output of the model will also be streamlined. Feature class names and field titles and table names will be uniform and easier to understand.

4.0 SIMPLE-DAILY

This section addresses proposed computational enhancements to go from SIMPLE-Seasonal to SIMPLE-Daily. Output reporting is covered separately in Section 5.

4.1 DIRECT RUNOFF

One of the goals of this phase of the project is to move from a seasonal/annual pollutant loading model to a loading model that predicts at a finer time increment. SIMPLE-Seasonal currently uses runoff coefficients that are derived from the Lemon Bay Model. The Lemon Bay Model uses the 'Harvey Harper method', which consists of the following:

- Long-term rainfall events are subdivided into 19 volume ranges, with the average computed for each range based on the actual events within that range.
- Direct runoff from pervious and unconnected impervious areas is computed using the Curve Number (CN) method. The non-directly connected impervious area CN is based on weighted average of a standard CN for the pervious area and a CN of 98 for the unconnected impervious area. The pervious area CN is reduced from average antecedent conditions for the dry season and increased for the wet season.
- Direct runoff from directly connected impervious area calculated as the rainfall volume minus 0.1 inch for initial abstraction/depression storage.

So, the Harvey Harper method uses dry antecedent moisture conditions for all events that occur in the dry season and wet antecedent moisture conditions for all events that occur in the wet season. To test the sensitivity of the runoff results to this type of method and others, Jones Edmunds applied five methods to 25-years of rainfall data and reported monthly runoff volumes. Jones Edmunds then developed and distributed a memo summarizing the methods and results on September 9, 2006. The memo is included as Appendix B in this report. The following items are four pertinent conclusions than can be made from the sensitivity analysis:

- Monthly and event-based runoff volumes are significantly sensitive to antecedent moisture conditions.
- The CN method without a separate method for calculating DCIA runoff will under-predict runoff from smaller rainfall events.
- Use of runoff coefficients from the previous WMM model produces significantly higher runoff volumes than the other methods.
- There are significant differences in the event-based and monthly runoff volumes between all methods.

Based on the conclusions above, there appeared to be two methods that would likely yield the most accurate runoff volumes, but the results from the two methods differed significantly on an event and monthly basis—much less so on an average annual basis. Those two methods are SWMM-based hydrology and the Harvey Harper method with CNs reflective of antecedent conditions based on actual antecedent rainfall instead of season in which the rainfall occurred.

We envisioned that measured rainfall and flow data from Sarasota County would be used to determine which method yields the more accurate results. Results from applying these two methods were presented in a January 9, 2007, memo. The primary pertinent conclusions that can be taken from that memo are the following:

- Inaccuracies in the rainfall data, the flow data, or perhaps both significantly limit its usefulness in determining the more accurate of the two methods.
- There is not a way to determine the most accurate method prior model enhancements without installing a significant number of rain gages, waiting for the monitoring data, and impacting the desired schedule.
- Use of the model for hindcasting flows and loads will be limited in accuracy by (presumably) the NEXRAD-derived rainfall data.

Based on the information above, there are three primary options for the direct runoff portion of SIMPLE-Daily:

- A modified version of the Harvey Harper method – This method offers the advantages of general consistency with the Lemon Bay Model and simpler preprocessing to obtain the flow time series database.
- SWMM hydrology – This method offers the advantage of consistency with the District's other primary loading model.
- Modified WMM method – This method would use pervious and impervious runoff coefficients like WMM, but the pervious runoff coefficient would be varied based on antecedent conditions. This method offers the simplest preprocessing and general consistency with the previous WMM model.

Regardless of the method, it is likely that these computations will be applied as a 'preprocessing' step to generate a hydrograph data base for each land use/soil/NEXRAD pixel/other combination. By making this a preprocessing step, the user will generally not have to access this part of the model—only the results from it. The data base generated from this step could exceed 1 billion records for daily flows and 20 billion for hourly flows, and adding base flow could double those estimates. Additional details will be added to this section once the final method has been determined.

4.2 RAINFALL

The rainfall component of loading is generally discussed in Section 2.5. The primary design decision to be made for accommodating direct rainfall input onto the bay segments is whether to pass the rainfall into the rest of the hydrograph data base in the preprocessing steps or use it directly during other computations.

4.3 BASE FLOW

As discussed in Section 2, SIMPLE-Daily could use constant seasonal base flow rates or compute base flow based on antecedent rainfall, basin characteristics, and (potentially) irrigation inputs. Examination of existing ARMS data shows that base flow can change significantly over a relatively short timeframe. For example, Figure 1 shows the total and base flow hydrographs from MAT1 for approximately 2 years worth of data. Figure 2 shows just the base flow hydrograph presented in Figure 1. A discussion of how the base flow hydrograph was determined was presented in the January 9, 2007, memo (Appendix A).

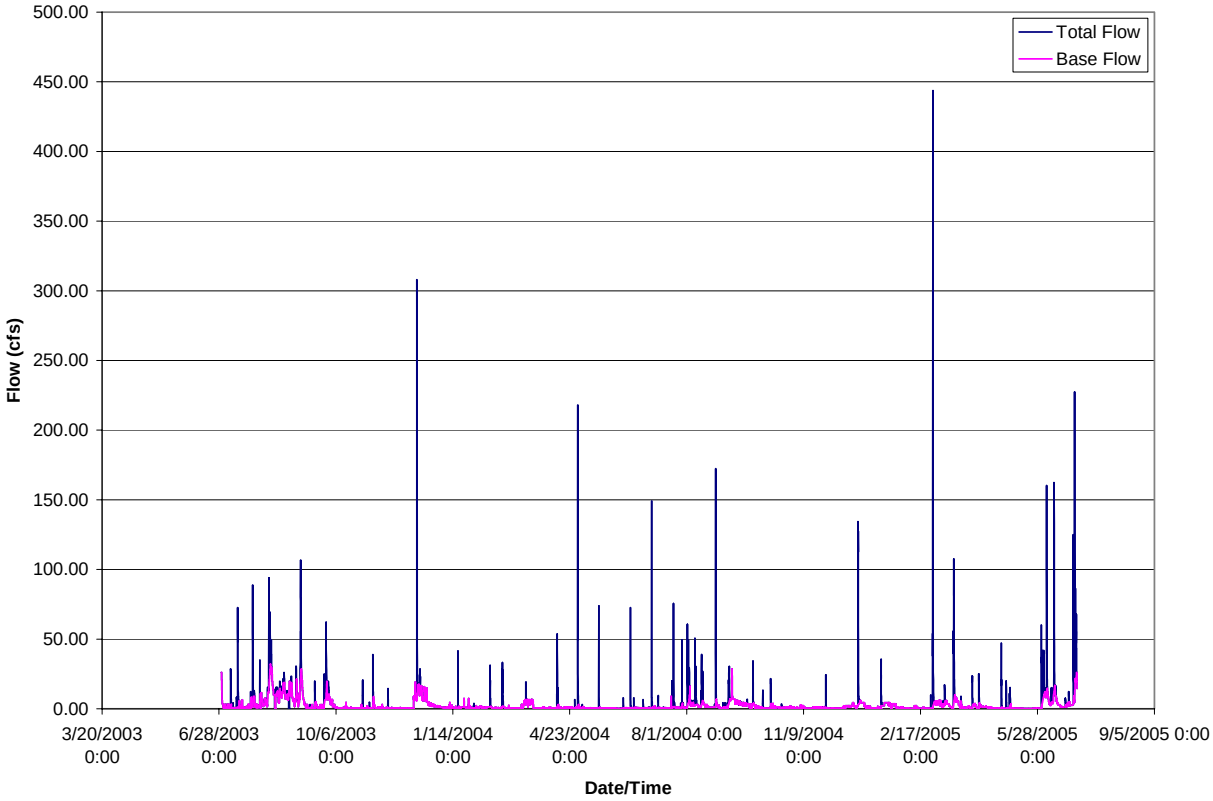

Figure 4-1 Total and Base Flow Hydrographs from MAT1

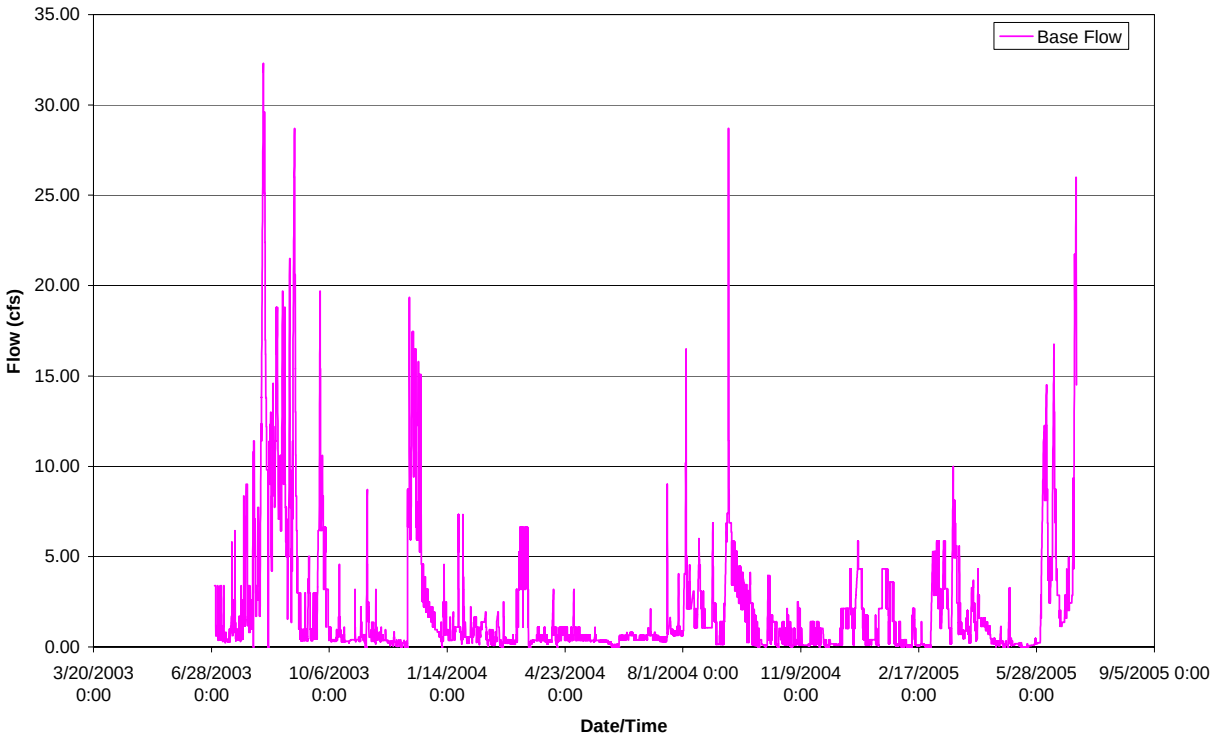

Figure 4-2 Base Flow Hydrograph from MAT1

There are several options for computing base flow based on antecedent rainfall and other inputs, with the most feasible being the following:

- Regression-based relationships – It is possible to perform the base flow separation analysis done on the MAT1 and CPS1 gages, perform regression analyses between base flow and rainfall, and then generalize the results of the regression analyses to be applicable to all areas (gaged and ungaged). An advantage of this method is that it would yield a computationally efficient method of producing rainfall-dependent base flow. Disadvantages are that it would take considerable effort to perform the analyses (a possible inevitability), errors inherent in the measured data would be propagated into the outcome of the analyses (another possible inevitability), and there will need to be assumptions about factors such as irrigation and imperviousness.
- Simplified base flow-rainfall relationship – If more temporal averaging is acceptable, then the method above could be reduced to a simpler analysis and equation.
- SWMM hydrology – SWMM has a shallow groundwater routine that could be used to generate the base flow hydrograph. Advantages are that it could be incorporated into the same preprocessing step, it would be based on established routines, and it keeps infiltration and base flow coupled into the same sets of equations. It would have the same disadvantages as the method above, although not as many gages would be required since the method should be adequately calibrated using fewer gages.

- Braden River WMP method – As part of the Braden River Watershed Management Plan, Jones Edmunds developed a spreadsheet-based model that is similar to SWMM hydrology, except that it uses a better predictive method for evapotranspiration. Advantages and disadvantages are similar to that of using SWMM hydrology.

As presented in the January 9, 2006, memo, base flow represents approximately two-thirds of the total surface discharge in MAT1. It is likely that this finding will be similar in other watersheds. Although the relative magnitude of base flow loads are reduced by the lower pollutant concentrations found in base flow, base flow will still account for a significant portion of the total load in many of the watersheds so it will be important to accurately predict base flow volumes at the desired time step.

4.4 SEPTIC TANKS

With the possible exception of not accounting for evapotranspiration losses that may occur from the time septic flow leaves the drain fields to the time it emerges as base flow, the current flow algorithms in the model should be reasonably accurate. It may be possible to improve on the theoretical basis for concentrations. However, it is unlikely that there will be supporting monitoring data for the theory during this phase of the project. Potential improvements may be based on analysis summarized in the October 20, 2006 report from Jon Perry entitled *Phillippi Creek Septic System Replacement Program: GIS Analysis of Environmental Parameters for Reprioritization*. In this report, the following parameters were used to prioritize septic tank replacement:

- Approximate age of the system
- Lot sizes within a sub-area
- Distance from a water conveyance
- Location served by a stormwater treatment facility
- Soil type
- Location within the County's delineated flood plain
- Repairs/number of hookups

In lieu of the current failure rate method, it would be possible to develop most of these data into each septic tank record in the GIS data base and develop an expanded set of concentration (and potentially flow) lookup tables based on these attributes.

4.5 RAINFALL

As discussed in Section 2.5, NEXRAD-derived rainfall data are proposed to be used with SIMPLE-Daily. Direct pollutant loading from rainfall will be restricted to bay segments (i.e., areas currently outside of the major basin boundaries) since loads from rainfall are implicit in the direct runoff loads. Rainfall loads will be a simple calculation of rainfall volume times concentration. Rainfall concentrations are proposed to be static and spatially uniform (i.e., a single lookup table of concentrations that is applied to all areas over the entire analysis period).

4.6 DRY DEPOSITION

Dry deposition is proposed to be handled in much the same way as rainfall. Dry deposition rates are proposed to be constant over time (with the exception of adjusting to zero during periods of rainfall), and rates are proposed to be constant over the County.

4.7 WASTEWATER EFFLUENT DISPOSAL

Point source data are proposed to be converted from shapefile input to a combination of shapefile and lookup table of monthly flow and concentration data. The period of record can also be updated.

4.8 UNTREATED WASTEWATER DISCHARGES

Untreated wastewater discharges are discussed adequately in Section 2.9.

4.9 IRRIGATION

Untreated wastewater discharges are discussed adequately in Section 2.9.

5.0 SCENARIO COMPARISON AND ENHANCED OUTPUT REPORTING

In SIMPLE-Seasonal, the model output consists of 31 tables and several feature classes. So, there is a considerable amount of spatial output data available, but the user must build the display of their desired output from scratch. However, it is likely that the same type of output display will be built for most applications of the model, making it desirable to automate some of the output display and reporting. Additionally, it is likely that a common use of the model will be to compare output from two scenarios. This section discusses potential enhancement to automate output display functions and scenario comparisons.

5.1 OUTPUT REPORTING

The first step in automating output reporting is to identify the outputs that would typically be desired by the user. Typical questions for which the user may want answers and discussions of those questions (i.e., possible ways to 'tell the story' through graphics and tables) are as follows:

- *What land uses, BMPs, point sources, and septic tanks exist in the watershed?* – This question could be answered visually in a single graphic. It may also be useful to summarize the graphical data with tabular data (i.e., up to four tables). It would be necessary for the user to specify the year that the data represent since the base data will be time-stamped.
- *What is the relative contribution of each pollutant source?* – This question may be answered best visually with pie charts for each pollutant. A supporting table with absolute and relative contributions by pollutant would also be useful. The relative contribution is important for several reasons. For instance, it highlights the percentage of loads that may be managed and provides a direction for the most cost-effective load reduction alternatives.
- *What is the relative contribution of non-point source pollution throughout the watershed?* – This question may be best answered with a color-coded map showing the variation in load per unit area for each pollutant. It will be important to fix the range of the color codes uniformly across all watersheds for each pollutant so that an apples-to-apples comparison can be made between watersheds. Supporting tables showing loading rates and total loads by watershed would also be useful.
- *How have seasonal or annual loads changed from one time period to another?* – Several of the outputs discussed above may be applicable in answering this question. Figures and supporting tables showing inputs would need to be created for each scenario, and it may be useful to display them on the same page for easy comparison. Two pie charts showing relative pollutant contributions from each scenario may be important to understand how the relatively loading has changed. Bar graphs of loads from the two scenarios would also be helpful in visualizing both total and relative loads. Two non-point source loading maps displayed on the same page may also be useful in understanding loading increases due to development. A table summarizing total loads from the two scenarios would also be important.

- *What is the difference in seasonal, annual, or long-term time series loads between two treatment scenarios?* – A visualization of the treatment scenarios would be a helpful first graphic to answer this question. The graphic of treatment scenarios would contain existing and proposed BMPs and land use changes, septic tank removals, point source consolidations, and reuse. A set of summary tables would accompany the graphic. Output reporting would be the same as for the scenario discussed above.

Examples of some of the potential outputs discussed above are provided below. Because of the amount of input data that there is to display, it is likely that several figures will be needed to adequately see the data. Figure 5-1 shows point sources and septic tanks. Figure 5-2 shows land use and BMPs. Figure 5-3 shows the relative impacts of each pollutant source (point source, baseflow, direct runoff, and septic tanks) on the total nitrogen loading for Alligator Creek clearly emphasizing the importance of septic tanks for this major basin. This information could also be displayed in a column or bar chart as shown in Figure 5-4. Figure 5-4 shows the relative contributions from each source for the eastern portion of Sarasota County.

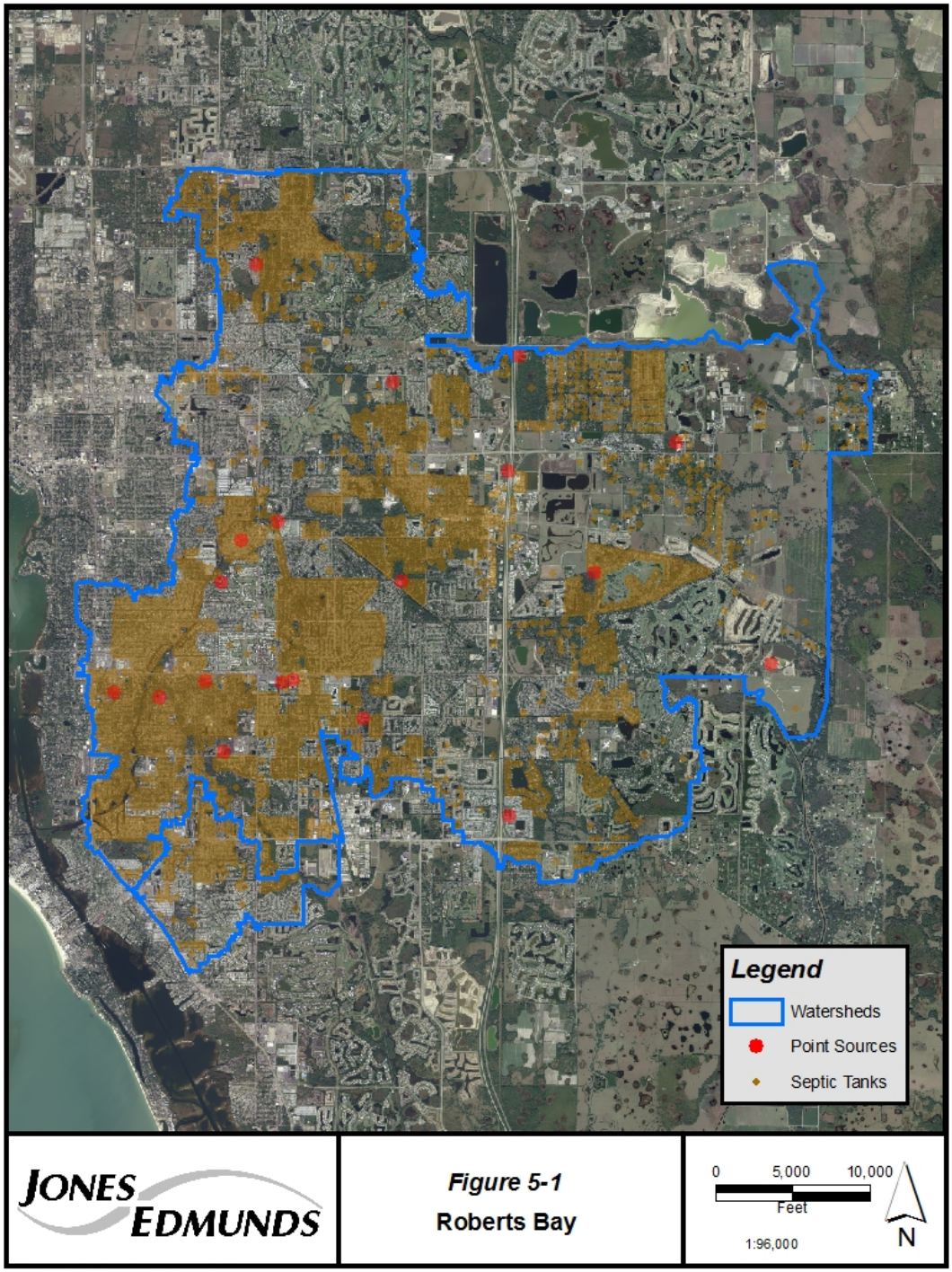

Figure 5-1 Example Map of Point Source and Septic Tank Input Data

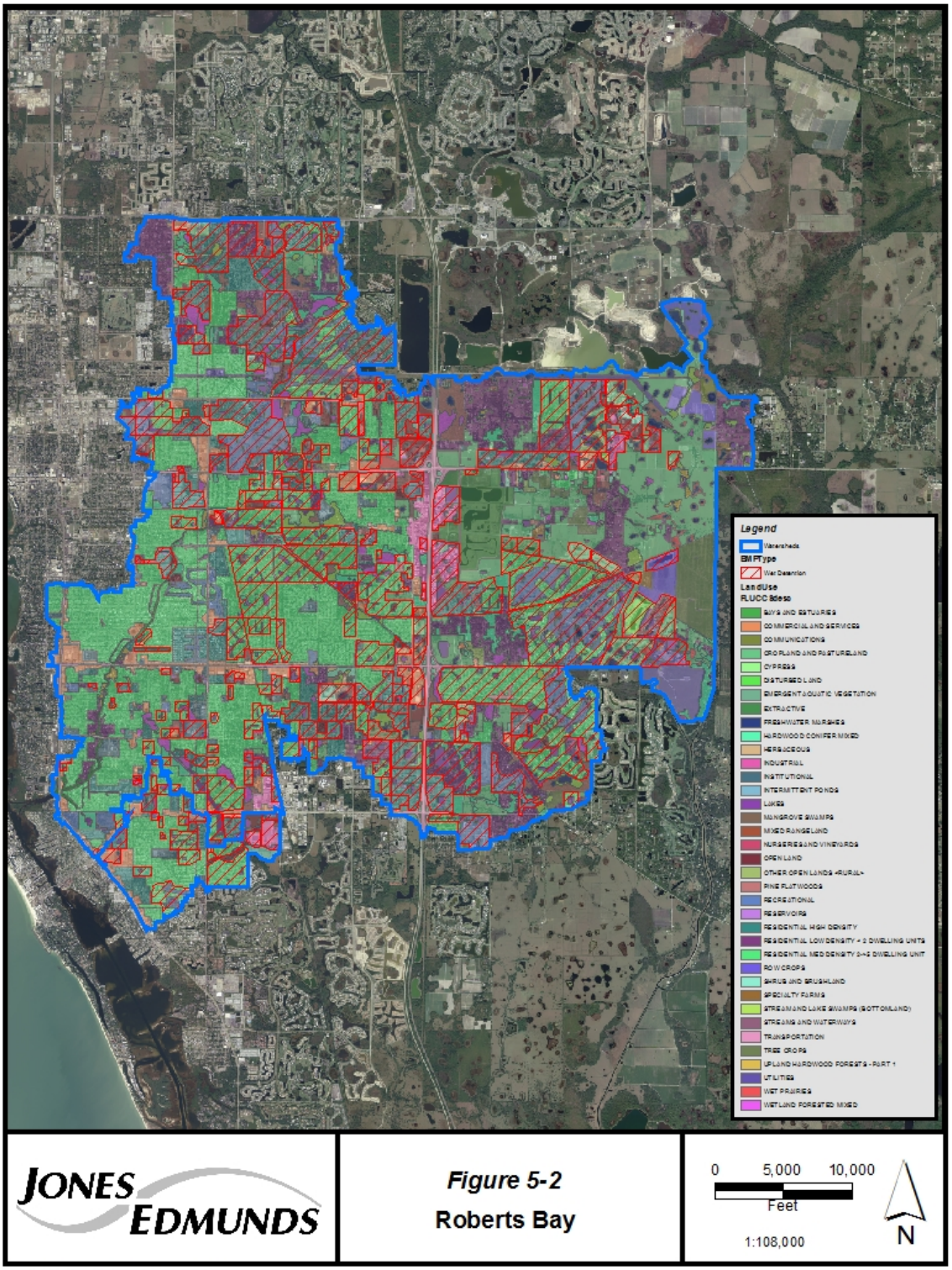

Figure 5-2 Example Map of Land Use and BMP Data

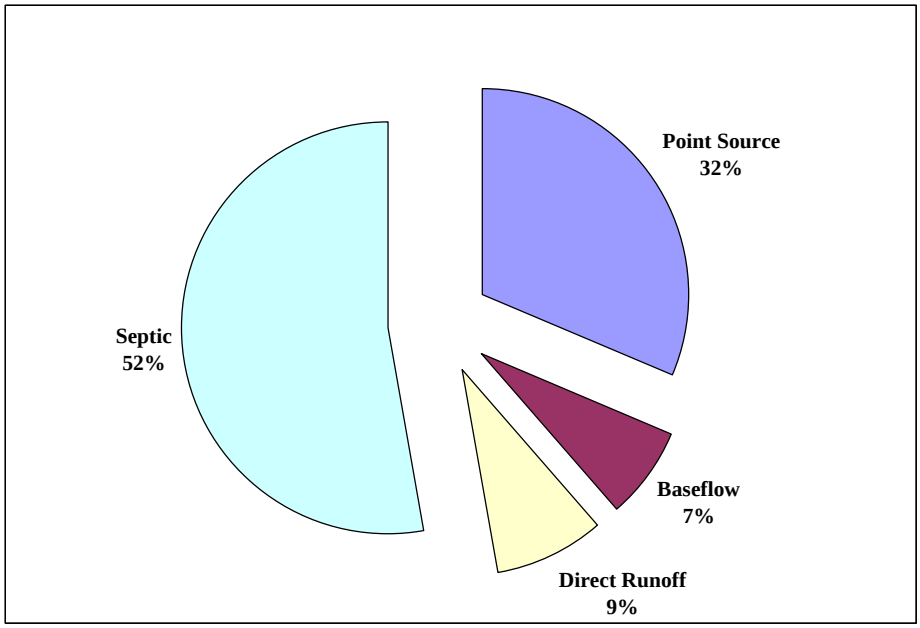

Figure 5-3 Distribution of TN Loading by Source for the Alligator Creek Basin

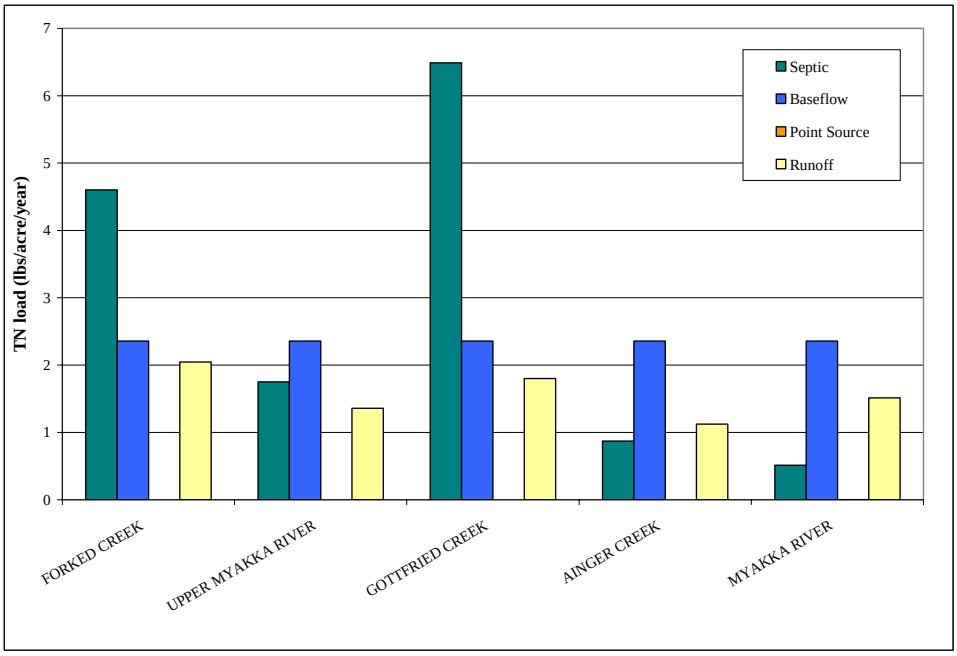

Figure 5-4 TN Loading by Source for Eastern Sarasota County

Figure 5-5 shows the normalized TSS runoff loading for the major basins in western Sarasota County which allows the user to compare basins and identify potential areas of concern.

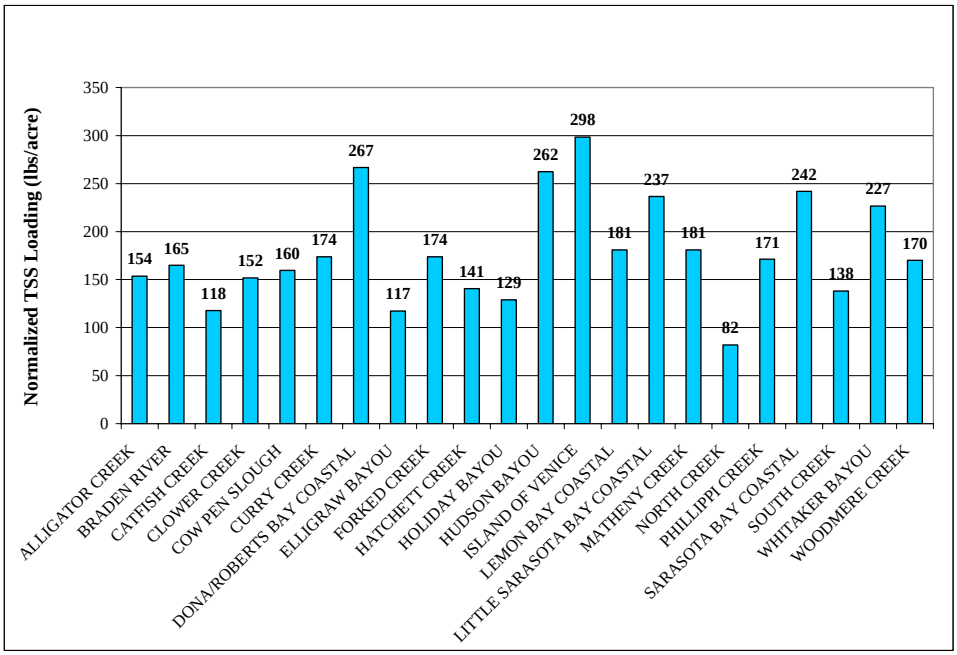

Figure 5-5 Normalized TSS Loading (lbs/acre/year) for Major Drainage Basins in Western Sarasota County

Figure 5-6 shows the TP direct runoff loading for each unique land use and soil combination with the BMP removal efficiencies applied. These figures will allow users to spatially identify areas of concern due to high pollutant loading.

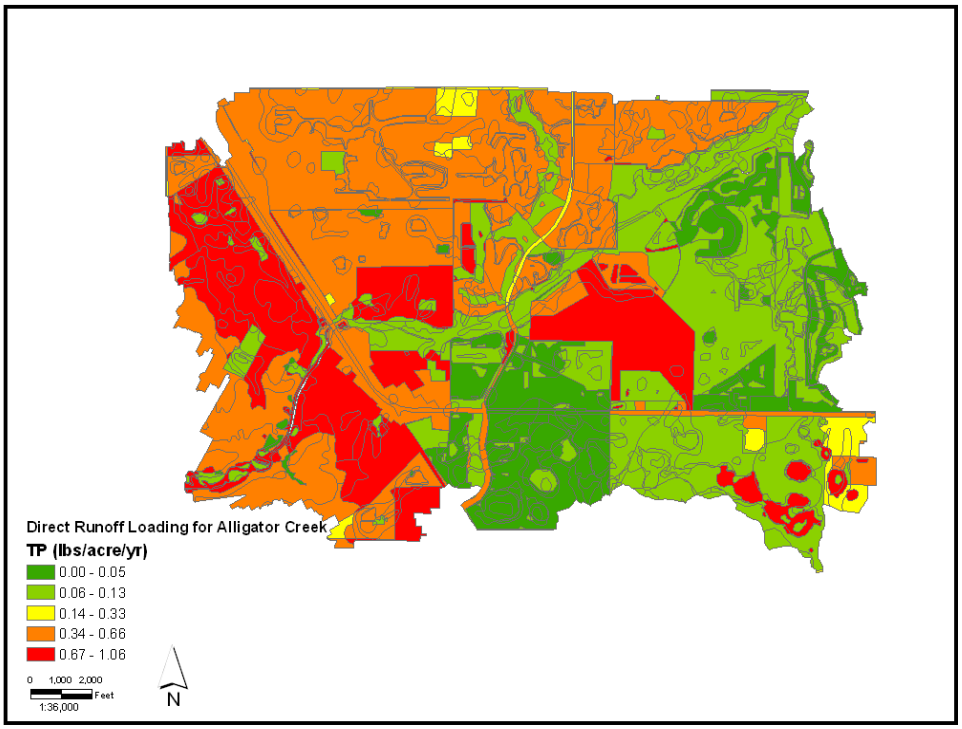

Figure 5-6 Direct Runoff TP Loading (lbs/acre/yr) for the Alligator Creek Basin

Table 5-1 shows an example of formatted output data. This table is based on the results generated in ArcGIS with minor formatting for clarification.

Table 5-1 Calculated Annual Loading (lb/year) within Sarasota County

Major Basin	BOD	COD	TSS	TDS	TP	DP	TKN	NO2	Pb	Cu	Zn	Cd	NH3	N	Oil and Grease	Fec. Col. (bill. col/yr)
ALLIGATOR CREEK	91,964	618,181	1,042,684	1,197,045	2,488	1,003	11,494	2,487	574	335	702	15	2,832	19,729	6,786	594,420
BRADEN RIVER	3,722	29,108	49,247	36,338	119	52	485	124	23	17	19	1	116	744	343	33,554
CATFISH CREEK	34,703	245,818	469,556	469,628	886	409	4,183	1,054	279	132	304	5	1,024	7,284	2,177	249,544
CLOWER CREEK	3,448	24,900	43,175	37,024	79	42	394	84	47	15	32	1	95	624	461	28,628
COW PEN SLOUGH	343,317	2,503,319	6,565,950	4,876,451	10,193	4,927	43,478	14,369	1,506	1,029	2,000	35	10,503	74,837	22,723	1,489,301
CURRY CREEK	70,217	505,597	1,112,082	978,987	1,934	901	8,679	2,480	492	273	652	10	2,114	14,980	4,373	506,890
DONA/ROBERTS BAY COASTAL	37,236	277,587	517,559	436,290	1,089	551	4,636	1,336	368	184	376	7	1,116	7,824	3,186	314,993
ELLIGRAW BAYOU	5,473	36,355	55,399	63,845	153	56	705	125	35	19	34	1	174	1,152	539	36,398
FORKED CREEK	58,212	410,750	1,018,533	775,068	1,577	750	6,961	2,209	247	198	362	7	1,684	11,985	4,489	253,596
HATCHETT CREEK	37,139	260,635	469,647	478,684	878	402	4,352	893	351	134	296	6	1,063	7,261	3,467	270,501
HOLIDAY BAYOU	2,114	15,751	25,878	20,920	55	27	257	53	28	9	18	0	62	394	342	19,206
HUDSON BAYOU	52,627	392,448	631,474	512,750	1,330	657	6,330	1,257	725	234	440	10	1,519	9,668	8,685	484,848
ISLAND OF VENICE	55,778	441,140	742,623	561,720	1,325	716	6,368	1,385	770	253	482	10	1,528	10,085	4,511	610,147
LEMON BAY COASTAL	52,059	374,493	835,685	631,348	1,631	742	6,674	2,081	221	214	351	8	1,609	11,197	4,986	291,265
LITTLE SARASOTA BAY COASTAL	47,472	344,838	641,321	565,075	1,450	670	6,087	1,672	359	216	419	8	1,475	10,291	3,710	369,813
MATHENY CREEK	25,386	185,332	311,783	249,244	742	330	3,194	702	222	108	161	5	770	5,014	2,945	201,802
NORTH CREEK	13,635	94,736	190,692	163,980	398	169	1,734	434	79	51	92	2	422	2,858	1,360	81,931
PHILLIPPI CREEK	470,709	3,391,749	6,068,182	5,564,724	13,514	5,616	60,447	12,776	3,570	1,724	3,197	74	14,738	97,383	43,453	3,801,652
SARASOTA BAY COASTAL	52,994	382,051	678,219	582,026	1,656	757	6,874	1,824	417	248	432	10	1,657	11,266	6,454	388,484
SOUTH CREEK	89,376	639,861	1,744,454	1,265,169	2,267	1,102	10,507	3,311	395	227	443	8	2,544	17,976	6,146	354,026
WHITAKER BAYOU	74,689	575,307	957,980	746,252	1,988	967	9,062	1,991	878	335	585	14	2,177	14,133	8,688	742,074
WOODMERE CREEK	18,866	139,798	250,730	197,175	608	261	2,461	650	87	80	95	3	594	4,024	1,598	136,664

*Unless otherwise specified

Appendix A – Analysis of Measured Data Memorandum

Appendix B – Runoff Sensitivity Memorandum