SARASOTA COUNTY
POLLUTANT LOADING
MODEL DEVELOPMENT (W552)
DESIGN REPORT

Prepared for:

SARASOTA COUNTY
1001 Sarasota Center Boulevard
Sarasota, Florida 34240

and

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
2379 Broad Street
Brooksville, Florida 34604-6899

Prepared by:

JONES EDMUNDS & ASSOCIATES, INC.
730 NE Waldo Road
Gainesville, Florida 32641
Certificate of Authorization #1841

with

PBS&J

and

UNIVERSITY OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL ENGINEERING SCIENCES AND
DEPARTMENT OF AGRICULTURAL AND BIOLOGICAL ENGINEERING

and

DEWBERRY

and

BETTY RUSHTON

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1.0 INTRODUCTION

The objective of this phase of the project is to develop a verified pollutant loading model that accurately estimates pollutant loads and the effectiveness of projects intended to reduce pollution. 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) and 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 (e.g., direct runoff and base flow), and septic tanks.

This second phase of the project added model functionality and changed the model timestep from seasonal to monthly to synchronize with the approximate time sensitivity of the response from the County's bay systems to pollutant loads. Model enhancements included a significant change in the hydrologic calculations, the addition of wet and dry deposition of pollutants and three forms of irrigation, refinements to septic tank loading, and improved output formatting (both geographic and tabular). As in the first version of the model, simulations of best management practices (BMPs), wastewater discharges, and septic tanks are included but now have the added dimension of time. This phase also required a significant amount of data development to achieve the functionality listed above.

In essence this phase of the project adds a second mode to SIMPLE. As a naming convention, the two modes of the model will be referred to as SIMPLE-Seasonal and SIMPLE-Monthly. Although each will share many of the same elements, they exist as two separate modes with different input requirements and output capabilities.

SIMPLE-Monthly has the following advantages over SIMPLE-Seasonal: 1) it provides output at a time scale similar to the response of the County's estuaries/bays, 2) it may be calibrated more robustly since it can be compared to measured data at a finer time scale, 3) it can account for more time-variability in point source data, and 4) it provides finer detail for hydrology calculations by accounting for temporal and spatial differences in rainfall. Conversely, SIMPLE-Seasonal has the advantages of greater computational efficiency and smaller data storage requirements.

In March 2007, Jones Edmunds prepared a report presenting the draft model design functionality, computational methodologies, and data. The report was reviewed by Sarasota County (County), SWFWMD, and Post Buckley Shuh & Jernigan (PBS&J). This design report incorporates comments from those reviews and includes the final decision on methodologies (still undecided at the time of the draft report). This report presents details on all model and data enhancements. Appendix A describes methodologies not included in the final model design but that were presented as an option in the draft report.

After the hydrologic model is run, the pollutant loading portion of the model is split into six modules— direct runoff, base flow, wet/dryfall, irrigation, point-source, and septic tank—which may be run together or separately. Each module, along with the data enhancements created for that module, is presented in a separate section of the report.

2.0 HYDROLOGIC MODEL

In general terms the hydrologic engine is a continuous simulation spreadsheet model designed to feed SIMPLE-Monthly calculated runoff, calculated base flow, and rainfall volumes using NEXRAD-derived rainfall for the NEXRAD period of record. The result of the hydrologic engine simulation is a hydrologic lookup table. The hydrologic lookup table contains monthly rainfall, base flow, and runoff values for all unique combinations of NEXRAD pixel, event mean concentration (EMC) land use, and hydrologic soil group in Sarasota County. The hydrologic lookup table was created so that the hydrologic model only needs to be run once to generate all hydrologic data used by SIMPLE-monthly until new rainfall data are acquired, thus greatly increasing the computational efficiency of SIMPLE-monthly. The spreadsheet model is loosely based on the Visual Basic for Applications (VBA) model originally developed for the Braden River Surface Water Resource Assessment (Jones Edmunds, 2007) and other projects requiring a continuous simulation hydrologic model. The model was developed to do the following:

- Evaluate the water budget of a watershed using a daily timestep.
- Simulate the interaction between infiltration to, evapotranspiration from, and groundwater flow and leakance from the surficial aquifer.
- Use NEXRAD rainfall data.
- Regenerate infiltration capacity during dry periods and account for time-variable rates such as evapotranspiration.

Irrigation was not included in this version of the hydrologic model—but rather as an independent module—so that irrigation loads could be tracked separately from direct runoff and base flow loads. It should also be noted that the use of a separate hydrologic model supports the modular approach to SIMPLE-Monthly and allows the user the flexibility of switching to a different hydrologic model to populate the hydrologic lookup table if desired.

2.1 HYDROLOGIC INPUT DATA

2.1.1 Rainfall

There are two options for historical rainfall data for the period required for the model: NEXRAD-derived data and a number of rainfall gauges. Since the spatial distribution and periods of record of the gauge data are very limited for the applications considered under this project, using NEXRAD data was the preferred option.

NEXRAD rainfall, available based on a 2-kilometer-by-2-kilometer grid, was provided by the Southwest Florida Water Management District. The District maintains 15-minute interval NEXRAD-derived rainfall data through OneRain beginning in 1994, and the data exist as text and xml files. Rainfall data were exported as daily values into the hydrologic model for each of 489 pixels for the 1994-2007 period of record. EMC-land use and soils combinations were simulated in each pixel. EMC land uses are explained in Section 4 of this report.

2.1.2 Evapotranspiration

Previous versions of the hydrologic model have used modified Penmen-Monteith, Thornthwaite, and Priestly-Taylor equations to calculate potential evapotranspiration (ET) losses. The accuracy of any ET prediction is hindered by the spatial distribution of available data, which may or may not provided adequate coverage for the entire county or any given area of interest. Recently, daily ET data calculated using the Priestly-Taylor method on a 2-km by 2-km pixel grid have become available from the United States Geological Survey (USGS) Integrated Science Center. The pixel data, available for the entire State of Florida, were validated against 18 monitoring locations in the state but none in Sarasota County (Jacobs et al., 2008). For Sarasota County, data were available from June, 1995 through December, 2004 for 391 pixels. While this data set represents an improvement of readily available ET data for large areas, the spatial accuracy from pixel to pixel has yet to be validated. As such, an average of ET for the 391 pixels in Sarasota County was used for the available period of record. Required ET data outside this period were determined as the historical average for all pixels within the County for that Julian day. The average standard deviation for each Julian day for all pixels during the period of record was 0.036 inches. Sensitivity runs using the pixel-based daily ET and the daily-average ET showed no significant difference for monthly runoff and base flow volumes, validating the use of the daily-averaged ET data.

2.1.3 Soils and Groundwater Data

Soil storage information was extracted from the Natural Resources Conservation Service (NRCS) electronic soil survey data. These data can be downloaded from http://www.fgdl.org/. Soils files for Sarasota County were used to parameterize the primary groundwater and vadose zone parameters. Root depth information was based on aerial photography and generalized land uses.

2.2 HYDROLOGIC COMPUTATIONS

The continuous simulation hydrologic model code is generic to any water budget, although some modules were specifically modified for SIMPLE-Monthly. One workbook was used for model input and output for each NEXRAD pixel. The input worksheets include the following:

1. PARAMETERS—the sheet contains the pixel id and landuse/soil combination code used to lookup parameters from the HYDROLOGY sheet. Parameters held constant across the County, such as computational area and initial conditions, are also stored in this sheet

2. TIMESERIES—the sheet contains all of the weather data that are critical input for the model on a daily time step. For SIMPLE-Monthly, only rainfall and ET data are considered. The sheet also stores the daily outputs of importance—runoff and base flow.

3. MODEL—the sheet contains all model calculations used to determine runoff and base flow on a daily time step.

4. HYDROLOGY—the sheet contains all parameters specific to land use and/or soil hydrologic classification.

The primary water budget equation for SIMPLE-Monthly can be summarized as:

Change in Storage (One Subbasin) = Rainfall – Evapotranspiration – Groundwater (Base) Flow – Direct Runoff

2.2.1 Runoff and Vadose Zone

Jones Edmunds modeled stormwater runoff and infiltration using a modified version of the Natural Resource Conservation Service's Technical Resource 55 (NRCS TR-55) methodology. The primary modification included the treatment of directly connected impervious area (DCIA) as a separate variable. Curve numbers (CN) were subsequently generated for the remaining area using Sarasota County's method of using 78 for pervious areas (largely in recognition of the high water tables) and 98 for unconnected impervious areas. CNs for each land use/soil combination were generated for Antecedent Moisture Condition (AMC) II. CNs for AMC I and III were based on the AMC II values and Dingman, 1994. Two exceptions to this CN assignment were wetland and water land uses. Both wetland and water land use would be considered impervious in event-based modeling, but since the hydrologic engine is a continuous simulation model the CNs had to be altered for these land uses to allow for recharge. For example, wetland CN was set to 98 during AMC III conditions, but set to 78 during AMC II and 60 during AMC I. This adjustment creates a situation where runoff from a wetland polygon only occurs when the soil profile is at or near saturation. Conversely, the wetland area is allowed to act as a sponge for rainfall during dry conditions. Similarly in order to allow for reservoir recharge, water CNs were set at 98, 95, and 92 for AMC III, II, and I, respectively.

The AMC was calculated at each time step using the previous time step soil moisture storage. In general terms, if the water table was within 8 inches of the soil surface, the following time step was set to AMC III. If the water table was below 36 inches beneath the soil surface, the following time step was set to AMC I. All other conditions were set to AMC II. The actual model logic is slightly more complicated since soil moisture contents were calculated as an average for the entire vadose zone depth. AMC was calculated in the model as follows: If the soil-moisture deficit ([Soil Moisture Content - Wilting Point] * Depth of the Vadose Zone) was less than a soil-moisture deficit of [Field Capacity - Wilting Point] * 8 inches, the AMC is set to AMC III for the following time step. If the soil-moisture deficit was greater than a soil-moisture deficit of [Field Capacity - Wilting Point] * 36 inches, the AMC is set to AMC I for the following time step. All other conditions are set to AMC II.

Initial abstractions for pervious and unconnected impervious areas (UCIA) were modeled using the relationship of Ia = 0.2S per TR-55 for small watersheds. Based on experience with measured

data in nearby watersheds, literature values, and the Harvey Harper model, initial abstractions for DCIA were fixed at 0.1 inch. For any time step, if precipitation is less than Ia no runoff will occur and all rainfall from the pervious area and UCIA will infiltrate. If precipitation exceeds Ia, the ponded depth (precipitation minus Ia) will become runoff according to the following equation for pervious area and UCIA:

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S}$$

In this form of the equation, P represents the entire precipitation for that day and S is the potential maximum abstraction. Q is in inches and is converted to a volume using area. For DCIA the entire depth above Ia becomes runoff.

Once a volume is infiltrated from the surface, it passes into the vadose zone, where soil moisture is tracked in the model. If soil moisture increases beyond field capacity, the excess volume of water will pass into the saturated zone—and the depth of the vadose zone decreases while the depth of the saturated zone increases. Soil moisture in the vadose zone then returns to field capacity. Evapotranspiration from the vadose zone will stop if the soil moisture content drops below the wilting point.

2.2.2 Base Flow

The infiltrated volume (from the vadose zone) next becomes part of the saturated groundwater module. For the saturated groundwater module it was necessary to use a formula that gave a reasonable base flow response based on the level in the groundwater table depth. The Dupuit-Forcheimer equation was chosen because it has wide application in predicting surficial aquifer groundwater flow. This equation is one of the options used in the Stormwater Management Model (SWMM) and is well documented in the *SWMM Manual* (Huber and Dickinson, 1992). It was implemented in the model as follows:

$$GWFLW = (D1 - BC)^2 * \frac{C * K}{L^2}$$

In this form of the equation, GWFLW is the flow rate from the saturated zone for the surficial aquifer, D1 is the average depth of the surficial aquifer, BC is the depth of the receiving water body measured from the bottom of the water body to the bottom of the surficial aquifer, C is a coefficient that was used to calibrate, K is the saturated horizontal hydraulic conductivity, and L is equivalent to average overland flow length. GWFLW is set to zero if D1 < BC. D1 is influenced by the infiltrated volume and is adjusted for each time step. D1 is calculated based on the depth of the saturated zone from the previous time step plus the infiltrated volume at the current time step. The hydraulic conductivity, K, was parameterized using the NRCS soil surveys, and the subbasin length, L, was calculated as 25% of the computational unit length. C and BC were determined during calibration, with C allowed to vary between landuse while BC was held constant across the County.

A deep percolation (leakance) loss was also added to the model. The loss is a user input, entered as ft/day and allowed to vary by land use, drawing from the saturated zone following base flow calculations.

2.2.3 Evapotranspiration

As stated in Section 2.1.2, USGS data were used for potential ET. Crop coefficients were initially set based on communication with David Sumner at USGS (Swancar, 2006; Swancar, 2007), but were considered a calibration parameter. The actual ET extracted from the soil profile is varied based on the water table level and soil moisture content of the profile. ET in the rootzone (a depth variable by landuse) is calculated as the product of potential ET and the crop coefficient for the given landuse, occurring when the water table level is at or above the rootzone depth. If the water table level is below the rootzone depth, ET varies depending on soil moisture content. If the soil moisture content is above the wilting point, ET is the product of potential ET, the crop coefficient for the given landuse, and a secondary coefficient accounting for deeper extraction. If the soil moisture content reaches the wilting point, no ET occurs. This variable ET calculation method allows for a more accurate ET simulation through time without varying crop coefficients with time.

Two more specific scenarios are also accounted for by the ET module. First, if the water table level is below the rootzone depth and the soil moisture content is above the wilting point but the calculated ET is larger than the available water in the soil profile, only the available water in the soil profile will be lost to ET. In other words, in this situation ET can only reduce the soil moisture content in the soil profile to the wilting point—not below. Second, if the soil profile is at the wilting point and rain occurs during this time step, calculated ET is extracted from the calculated infiltration resulting from the rain event.

2.2.4 Results

While the hydrologic analysis takes place on a daily time step, the results are summed over each month for use in the pollutant loading portion of the model. Results are reported for land use and soil combinations over a unit subbasin size (ft^3/ft^2). Actual areas used in pollutant loading calculations are determined based on the intersection of land use and soil data in GIS.

3.0 POLLUTANT LOADING MODEL

This section of the report describes general information about SIMPLE-Monthly, including general design features, model code and data format, general data development, and controls input by the user.

3.1 INSTALLATION AND PLATFORM

The pollutant loading portion of the model is what most end-users will become familiar with. Similarly to SIMPLE-Seasonal, this version is also run from an open instance of v9.2 ArcMap with Service Pack 3 or greater. Rather than referencing a Visual Basic macro such as SIMPLE-Seasonal, Simple-Monthly will run as an ArcMap extension developed as a VB.Net dll file. This makes the extension more easily deployable and stable and likely will give the code greater longevity. To install the model, the user must have the installation package, which includes an executable file to guide the user through the installation process.

3.2 FUNCTIONALITY

As for SIMPLE-Seasonal, functionality was a key factor driving the design of this version of the County-wide model. Critical functional characteristics of the model include the following:

- The user can perform all functions within ArcMap Version 9.2.
- The user has control over drainage basins and groups for which reporting will be done.
- The user can select which drainage basins, land use, soils, and BMP feature classes to use for the calculations.
- The user can specify which months to simulate for February, 1994 through March, 2008.
- The program automatically generates a log file that will allow quick duplication of a previous run.
- The program automatically validates the user's inputs to verify that all fields required are present.
- The user has control over previously hard-coded parameters such as conversion factors.
- All lookup tables are readily updatable by the user.
- The model supports multiple BMP types, each with its own set of removal efficiencies.
- Items such as land use types, BMP types, and pollutants are readily expandable.

3.3 MODEL AND DATA DEVELOPMENT

As in SIMPLE-Seasonal, to begin a simulation in SIMPLE-Monthly the user clicks on a button in ArcGIS available after installation, which will prompt the model graphic user interface to display. As before, the user selects the pertinent input data layers, which are shown on the Setup

Tab in Figure 3-1. To run the model, the user then moves to the Run Model Tab (as seen in Figure 3-2) to select a validation button and ensure that the input data are formatted correctly. A new feature added to SIMPLE-Monthly is that each type of pollutant loading exists as a separate module, allowing the user to select the type of loading calculations to perform. All efforts were made to keep SIMPLE-Monthly as easy to use as SIMPLE-Seasonal, while still creating a more robust version of the model. The only user-inputs required before simulation are selecting the major basins for which the model will perform the calculations and a start and end month and year. All other model inputs exist in either the input spatial coverages or the template model geodatabase, which is provided separately on CD.

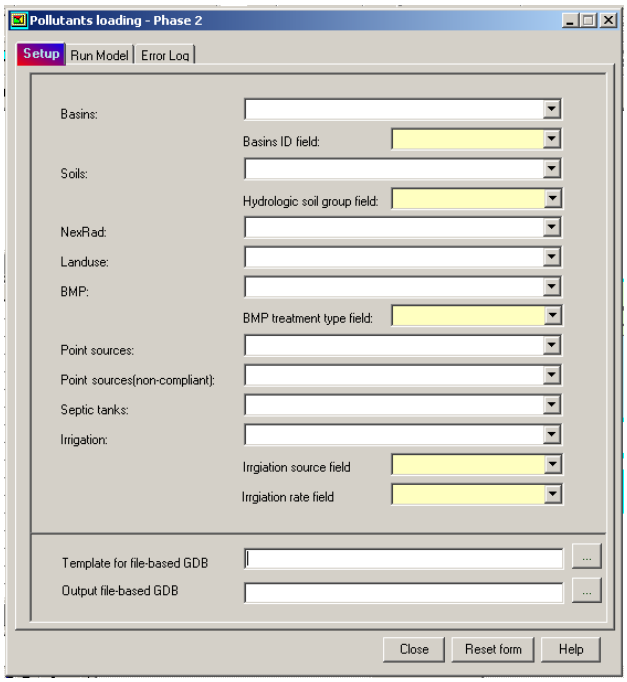

Figure 3-1 Graphic User Interface for SIMPLE-Monthly Setup Tab

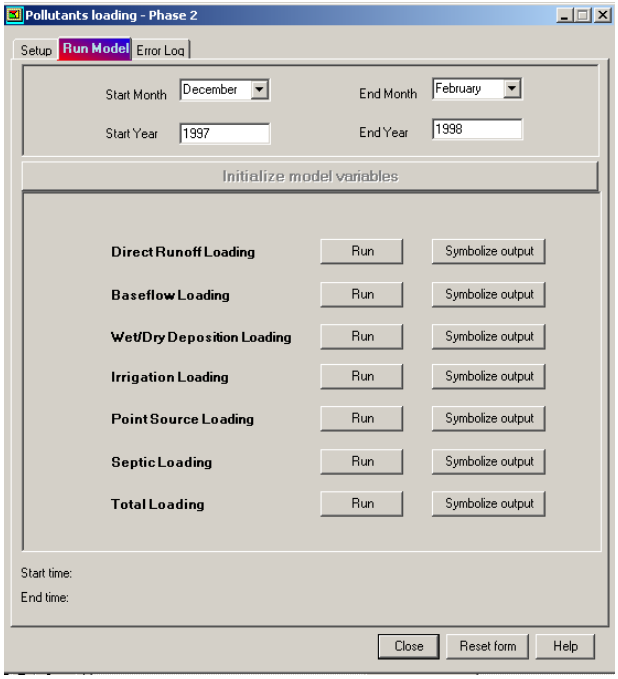

Figure 3-2 Graphic User Interface for SIMPLE-Monthly Run Model Tab

The model requires the use of a file-based geodatabase template (unique to ESRI ArcGIS v. 9.2 and newer), which is where all lookup tables, some input data, and all output tables exist. The geodatabase template is where changes to input data such as event mean concentrations (EMCs), BMP types and efficiencies, and constituent concentrations for each pollution type may be changed by the user when better data become available. Also as in SIMPLE-Seasonal, SIMPLE-Monthly creates a copy of the template unique to the model simulation currently being run. All input data in this output geodatabase (also file-based, rather than personal, as in SIMPLE-Seasonal) will be clipped to the basin or reporting units selected for simulation. During a simulation, temporary tables to store interim data and relates between tables and feature classes are populated, and these are intended to be strictly used for model functions rather than by the end-user.

In SIMPLE-Seasonal, all conversion factors used during pollutant-load calculations are hard-coded into the model, so units for inputs must be fixed. For SIMPLE-Monthly, the user may change conversion factors in an xml file of settings if input units or desired output units ever change from the original design. However, this is not recommended for users who are not very familiar with the model.

The basin input layer is the reporting unit layer for SIMPLE-Monthly. Each type of load will be summed over each basin. For SIMPLE-Monthly, the addition of basin polygons representing bays was included. In addition to the 33 major (land) basins in Sarasota County, wet and dryfall loads may now be calculated for Lemon Bay, Dona/Roberts Bay, Blackburn Bay, Little Sarasota Bay, Roberts Bay, and Sarasota Bay. Wet and dryfall loads are discussed further in Section 6 of this report. Casey Key, Longboat/Lido Key, and Siesta Key were also considered major basins for this version of the model.

Many of the model enhancements were predicated on having GIS data (e.g., land use and point source discharges) that included temporal changes. Since very large data sets were used in this process, it was important to develop a data design that was as compact as possible and that could be readily updated. How and what was stored for each type of data varied by type and depended on the availability of the data, the nature of the data, and the sensitivity of results from the data's end use. Each of the data types and their development are discussed within the pertinent modules.

4.0 DIRECT RUNOFF MODULE

Several methods of calculating direct runoff volume from rainfall were discussed in the Draft Design Report, which is included as Appendix A. It was determined at that time that one of two methods—a modification of the Harvey Harper method or SWMM hydrology—would likely provide the most accurate runoff results. The method used to compute direct runoff in the hydrologic model is a modification of the Harvey Harper method that allows for more direct use in continuous simulation, as described in previous sections of this report.

4.1 DATA AND MODEL DEVELOPMENT

Time-stamping the spatial inputs to the model was necessary to simulate the model at a monthly time step. This section describes methods used for time-stamping layers required for the Direct Runoff Module.

4.1.1 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 these shifts in the pollutant-loading model. Since most developments take months to years to complete and their progress and completion are not tracked at a fine time scale, recording land-use changes yearly was determined by Jones Edmunds to be 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 and error-resistant way to embed temporal changes into the land-use data for this model and to maintain the data is to include two additional attributes: the pre-development condition land use and the date (year) of transition (YR_BUILT) 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., less-urbanized and un-urbanized) conditions, but this is more appropriately handled in a separate feature class 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 plat shapefiles from Sarasota County
- Parcel database from Sarasota County

Since this feature class will only be applied for approximately the last 10 to 15 years' 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. 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 plat shapefile provided by the County. The plat shapefile contributed data regarding the average year built for each parcel within the plat. The average year built for any urban land uses is considered to be the date of land-use change. Figure 4-1 shows a sample of the resulting shapefile attribute table. It was determined that using the plat 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.

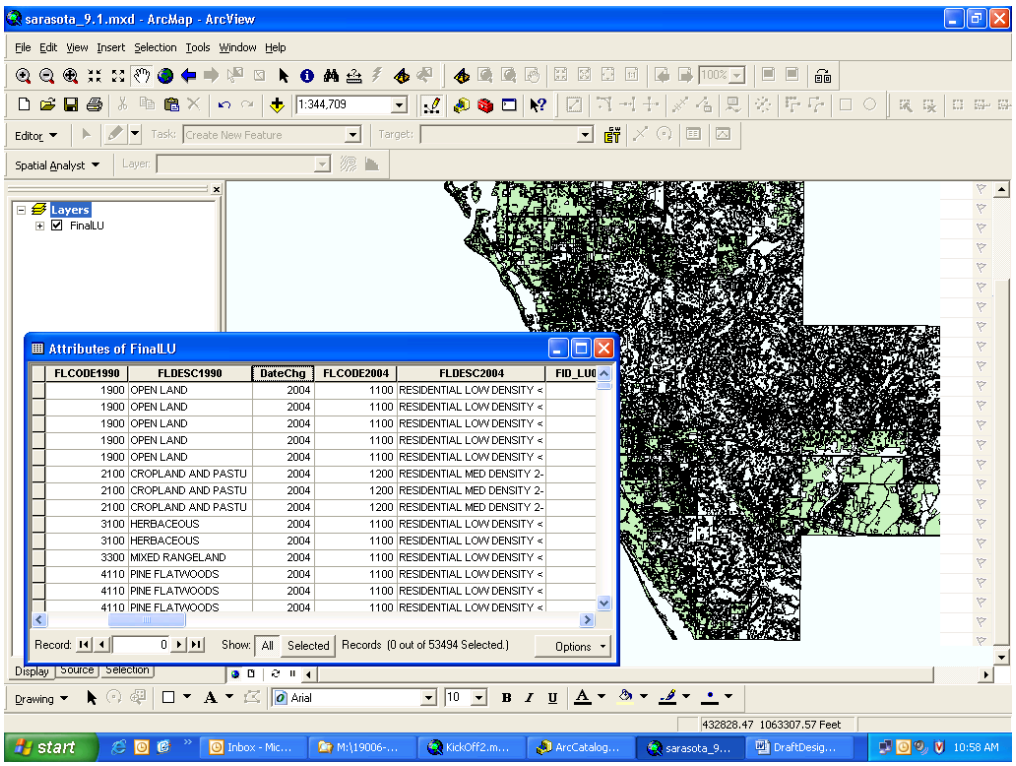

Figure 4-1 Time-Stamped Land-Use Shapefile and Attribute Table

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, we understand 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 into the loading predictions.

4.1.2 BMP

Consistent with the enhancements of the GIS land-use database discussed above, the non-point source BMP feature class tracks temporal changes. Similar to the land-use data enhancements, the BMP data incorporate temporal changes with the addition of the date (year) of transition (YR_BUILT) between pre-developed and developed conditions. To maintain consistency with the land-use data, the transition date are based on an intersection with the land-use data and inheritance of the land-use transition date.

The BMP layer is similar to that used during the development of SIMPLE-Seasonal. This layer is easily updatable by adding polygons to known areas treated by BMPs. The necessary attributes for this layer are now BMP type and YR_BUILT. BMP type will be used to determine removal efficiencies by joining the input layer with the table Lookup_BMPTreatment in the template geodatabase.

4.1.3 Soils

No changes were applied to the soils coverage. Compaction and alteration of the native soils during construction may impact infiltration and runoff characteristics. It would be possible to track this impact in the soils feature class and include it in the model, but there are minimal data to support it. Our recommendation is to include this in a future enhancement if deemed necessary and if supported by adequate data.

4.2 MODEL ACTION

The Direct Runoff methodology was altered from SIMPLE-Seasonal to ensure proper soil hydrologic group assignment. The main alteration was re-ordering the land use clip to occur before the soils intersect. Model operations are as follows:

1. Clip the land use input layer to the selected basin and copy into the output geodatabase. Simplify this layer by compressing each land use polygon (for both pre-development and developed land use) into one of 16 land use types where EMC data are available. Use the Lookup_LandUseCompress table in the template geodatabase to do so.

2. Clip the input soils layer to the selected basin and copy into the output geodatabase. Intersect the soils layer with the clipped land use layer. Simplify the soil input layer by compressing dual hydrologic soil groups into one of four hydrologic soil groups, based on the most recent land use. Use the Lookup_SoilCompress table in the template geodatabase.

3. Clip all remaining Direct Runoff input layers to the selected basin and copy them into the output geodatabase.

4. Perform a GIS union between the Land Use, NEXRAD Pixel, Soils, BMP, and Basin feature classes in the output geodatabase. This union results in a new feature class of many polygons called *DirRun*, each carrying all attributes from the included layers.

5. For each polygon in DirRun the model calculates the following equation for each month of the simulation (results are in pounds per month for each pollutant):

   Runoff (inches) * Polygon Area (acres) * EMC (mg/L) * (1-BMP efficiency) * Conversion Factor

6. For each month, the results are summed over each basin and reported to an output table. Results are also available in the units of pounds/acre/month.

Depending on what month/year the model is simulating, the above equation should use the EMC and runoff values appropriate to whichever land use exists at that time. This logic is important to most of the modules created for SIMPLE-Monthly and will be referenced when applicable in the remainder of this report. The model logic is as follows:

If simulation time < YR_BUILT, use pre-development land use EMC.
If simulation time >= YR_BUILT, use developed land use EMC.

Each item in the above equation is found in lookup tables in the template geodatabase or the DirRun feature class. The conversion factor is specific to this equation to create results in the units of pounds/month, but the user can change this number in an editable xml file of settings.

4.3 REQUIRED DATA

User-Input Spatial Data

- Major drainage basin and bay boundaries (area) with Basin ID
- Soils (Hydrologic Soil Group, area)
- Time-stamped Land Use (FLUCCS Code, YR_BUILT, area)

- Time-stamped BMPs (YR_BUILT, area)
- NEXRAD Rainfall Pixels (Pixel ID)

Reference Tables in Template Geodatabase

- Lookup_LandUseCompress: *relate* FLUCCS landuse *to* EMC landuse *for finding* EMC landuse
- Lookup_SoilCompress: *relate* hydrologic soil group *to* land use *for redefining* dual class hydrologic soil groups
- HydrologyTimeSeries: *relate* unique pixel/landuse/soil/BMP/Date combination *for finding* runoff volume
- Lookup_EMC: *relate* EMC landuse *to* pollutant *for finding* concentrations for the following constituents:
    - Biochemical Oxygen Demand (BOD5) (mg/L)
    - Chemical Oxygen Demand (COD) (mg/L)
    - Total Suspended Solids (TSS) (mg/L)
    - Total Dissolved Solids (TDS) (mg/L)
    - Total Kjeldahl Nitrogen (as N) (mg/L)
    - Total Nitrogen (as N) (mg/L)
    - Ammonia (mg/L)
    - Nitrate/Nitrite (mg/L)
    - Total Phosphorus (mg/L)
    - Dissolved Phosphorus (mg/L)
    - Oil & Grease (mg/L) – Note that this may estimate may be very approximate
    - Fecal Coliform (#/100 ml) – Note that this may estimate may be very approximate
    - Total Recoverable Copper (mg/L)
    - Total Recoverable Lead (mg/L)
    - Total Recoverable Zinc (mg/L)
    - Total Recoverable Cadmium (mg/L)
- Lookup_BMPEfficiency: *relate BMP type to* pollutant *for finding* removal rates.
- Lookup_BMPTreatment: *relate BMP type to* coded value *used with* BMPEfficiency table
- DirectRunoffLoadfromRainfall_lb_month: result table
- DirectRunoffLoadfromRainfall_lb_acre_month: result table

5.0 BASE FLOW MODULE

Several methods of simulating base flow were discussed in the Draft Design Report, which included as Appendix A.

5.1 DATA AND MODEL DEVELOPMENT

In SIMPLE-Seasonal, seasonal base flows are input as constant flows with constant concentrations for each major basin. For SIMPLE-Monthly base flow volumes are calculated as part of the hydrologic model described in Section 2. Base flow was calculated for each unique NEXRAD Pixel/Land Use/ Soil combination for date available for simulation using a continuous simulation hydrologic model that was described in previous sections of this report. This base flow portion of the model uses methodology similar to SWMM hydrology—which has a shallow groundwater routine—but with a better predictive evapotranspiration calculation. This method was chosen because it could easily be incorporated into the same hydrology preprocessing step, it is be based on established routines, and it keeps infiltration and base flow coupled into the same sets of equations.

It is important to note that irrigation was not considered during those hydrologic calculations but is handled as a separate module. The user should calculate irrigation losses from base flow after simulation if stormwater reuse is used as an irrigation source, as discussed in Section 7. Constant concentrations for base flow are again used in SIMPLE-Monthly and are the same as those used in WMM (CDM, 1993) before calibration.

5.2 MODEL ACTION

Model operations are as follows:

1. Perform Steps 1-4 of the Direct Runoff Module if the DirRun feature class has not yet been created. The same model logic to account for simulation time is used.

2. For each polygon in DirRun, the model calculates the following equation for each month of the simulation, whose results are in pounds per month for each pollutant:

   Base Flow (inches) * Polygon Area (acres) * Base Flow Concentration (mg/L) * Conversion Factor

3. For each month the results are summed over each basin and reported to an output table. Results are also available in the units of pounds/acre/month.

5.3 REQUIRED DATA

User-Input Spatial Data

- Major drainage basin and bay boundaries (area) with Basin ID
- Soils (Hydrologic Soil Group, area)
- Time-stamped Land Use (FLUCCS Code, YR_BUILT, area)
- NEXRAD Rainfall Pixels (Pixel ID)

Reference Tables in Template Geodatabase

- Lookup_LandUseCompress: *relate* FLUCCS landuse *to* EMC landuse *for finding* EMC landuse
- Lookup_SoilCompress: *relate* hydrologic soil group *to* land use *for redefining* dual class hydrologic soil groups
- HydrologyTimeSeries: *relate* unique pixel/landuse/soil/BMP/Date combination *for finding* base flow volume
- Lookup_BaseflowConcentration: universal concentrations for 16 simulated constituents
- BaseflowLoad_lb_month: result table
- BaseflowLoad_lb_acre_month: result table

6.0 WET/DRYFALL MODULE

6.1 DATA AND MODEL DEVELOPMENT

As discussed in Section 2, NEXRAD-derived rainfall data are used with SIMPLE-Monthly. Direct pollutant loading from rainfall is restricted to bay segments, which have been included in the basin input layer, since loads from rainfall are implicit in the direct runoff loads. Based on availability of data, a single table of concentrations (i.e., non-time varying concentrations) was used for the rainfall. Concentrations were taken from several studies prepared for the Tampa Bay Estuary Program, including those by Poor (2002) and Janicki Environmental, Inc. (2005). Rainfall concentrations measured at the Verna Wellfield were also used for SIMPLE-Monthly (National Atmospheric Deposition Program, various years).

Average loading will be applied for dry atmospheric deposition based partly on data availability. Concentrations were collected as part of the Tampa Bay Atmospheric Deposition Study, which is described by Poor (2002). The 2005 study for the Tampa Bay Estuary Program also discussed calculation of dry deposition loading (Janicki Environmental, 2005), and was considered in the determination of loads. Dry deposition loads are only considered when rainfall is zero. As with rainfall, dry atmospheric deposition loading are applicable to direct loads on the bays since dry deposition loads are implicit in direct runoff load computations.

The land use and soils input layers were also amended to include data in the bay areas. The land use covering these areas will be unique: FLUCCS Code 5410 for Bays. This single FLUCCS code will compress to the EMC Land Use: Bays, and this will be the only EMC land use where direct runoff and base flow values will be set to zero, allowing for the only possible load to be wet or dryfall on these segments.

6.2 MODEL ACTION

The Wet/Dryfall Module is unique to SIMPLE-Monthly. Model operations are as follows:

1. Perform Steps 1-4 of the Direct Runoff Module if the DirRun feature class has not yet been created. The same model logic to account for simulation time is also used.

2. For each polygon in DirRun, the model calculates the following equation for each month of the simulation, whose results are in pounds per month for each pollutant:

   When Rainfall > 0

   Rainfall (inches) * Polygon Area (acres) * Rainfall Concentration (mg/L) * Conversion Factor

When Rainfall = 0

Dryfall (pounds/acre/month) * Polygon Area (acres)

3. For each month, the results are summed over each basin and reported to an output table. Results are also available in the units of pounds/acre/month.

6.3 REQUIRED DATA

User-Input Spatial Data

- Major drainage basin and bay boundaries (area) with Basin ID
- Soils (Hydrologic Soil Group, area)
- Time-stamped Land Use (FLUCCS Code, YR_BUILT, area)
- NEXRAD Rainfall Pixels (Pixel ID)

Reference Tables in Template Geodatabase

- Lookup_LandUseCompress: *relate* FLUCCS landuse *to* EMC landuse *for finding* EMC landuse
- Lookup_SoilCompress: *relate* hydrologic soil group *to* land use *for redefining* dual class hydrologic soil groups
- HydrologyTimeSeries: *relate* unique pixel/landuse/soil/BMP/Date combination *for finding* rainfall volume
- Lookup_WetDryfall: universal concentrations or loads for 16 simulated constituents for both rainfall and dryfall
- WetDryfallLoad_lb_month: result table
- WetDryfallLoad_lb_acre_month: result table

7.0 IRRIGATION MODULE

Earlier considerations for how to develop the irrigation module were discussed in the Draft Design Report and are referenced in Appendix A.

7.1 DATA AND MODEL DEVELOPMENT

Rather than assuming that irrigation inputs are mostly lost to evapotranspiration and handling irrigation by limiting how dry the pervious areas can get (as previously considered), SIMPLE-Monthly directly simulates flows and loads due to irrigation. The methodology of simulation has changed slightly from what was originally proposed in the draft model design memo, which is included as Appendix A. Jones Edmunds had previously proposed to simulate irrigation from two sources— groundwater/potable water and stormwater—and include the areal distribution of wastewater treatment plant effluent reuse spread in the Point Source Module.

To simplify modeling procedures and keep all irrigation sources in one module, Jones Edmunds moved effluent reuse into the irrigation module and added the ability to vary concentrations and rates. Therefore, the current module considers three sources of irrigation water: groundwater/potable, stormwater, and reclaimed water. Output tables exist for each of these sources. Stormwater is not used to irrigate in the County, but the module is equipped to handle this source for alternatives analysis and for other future needs. If stormwater is used for irrigation, we are assuming that there would be a loss in base flow volume (1:1 or a fraction of the volume) since we assume 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. For this model, volume output for this source type will show as negative and should be subtracted from the base flow volume to account for this loss.

Different concentrations are used for each source. Potable and reclaimed water concentrations are set to the standards required by FDEP. Stormwater reuse is not yet regulated, so it was assumed that concentrations would be similar to baseflow. During calibration these concentrations may be altered depending on monitoring data collected as part of this project.

A spatial representation of irrigated areas is a necessary input for this module. We have created a polygon coverage of irrigated areas based largely on land use and utilities infrastructure data. Each polygon is tagged with a coded source type and a coded application rate. The coded values used are Groundwater/potable source = 1, stormwater source = 2, reclaimed source = 3, low rate = 1, medium rate = 2, high rate = 3.

The first pass at determining irrigated areas was to assume that all residential, agricultural, commercial, and golf land uses were irrigated. Coverage of only those land uses was geoprocessed (intersected) with municipal and utility coverage areas provided by the County that denoted if reclaimed water was available. If reclaimed water was not available, the source was assumed to be groundwater/potable water. This analysis produced an irrigated portion of the County that was larger than that known by County staff. This layer was then refined by using

spatial data of the County's reclaimed water network and also groundwater well locations (both provided by the County). The resulting layer agreed more closely with the County staff's understanding.

To determine the rate at which each area was irrigated, data from the May 2006 field recon effort were used. This effort was described in detail in a memo dated June 8, 2006. Data collected included a measure of how green the lawns within the medium-density residential land use appeared. The greenest lawns were given a lawn health value of 10 and the brownest lawns a value of 0. Analysis later correlated lawn health with the average year of development per plat. The same logic was carried through to the irrigation module. The newest and healthiest residential areas were assumed to have the highest irrigation rate and the older and less healthy lawns were assumed to have a lower irrigation rate and so on. Similarly, the newest golf courses were assumed to have the highest irrigation rate, and so on. Agricultural areas were assumed to have a medium irrigation rate.

The low, medium, and high values vary by month, allowing for seasonal variation in irrigation. Irrigation rates vary depending on whether the land use is residential/commercial or agricultural/golf course. In total, 72 irrigation rates can be found in the module. Values for low, medium, and high rates were set by consulting residential irrigation restrictions established by Sarasota County, and commercial rates were assumed to be similar. For the agricultural and golf course land uses, values were calculated based on information in the SWFWMD Water Supply Plan for 2006 (SWFWMD, 2006). These reference values are stored in the AppliedDepth field. Since reported irrigation values are on a depth per area irrigated basis, the values needed to be reduced based on the actual irrigated area for a given landuse (i.e., only pervious areas are eligible for irrigation, with the exception of overspray). Irrigated areas for each irrigation rate were estimated as a fraction of the total landuse polygon by inspection of aerial imagery. These irrigated area fractions are stored in the Area_Fraction field. The irrigation depth used in model calculations is stored in the Value field and is the product of AppliedDepth and Area_Fraction.

Rates are given in units of inches and are converted to volume using the area irrigated. Not all of this water volume is considered in the total irrigation load. A fraction of the irrigation volume is typically inadvertently sprayed onto DCIA. This fraction was initially set as 5 percent based on various field observations. Similarly, some of the irrigated water infiltrates and is returned to the groundwater. This fraction was estimated to be 10 percent. Both volume fractions were considered calibration parameters.

7.2 MODEL ACTION

This module is unique to SIMPLE-Monthly. The modeling action is as follows:

1. Clip the land-use input layer to the selected basin and copy into the output geodatabase. Simplify this layer by compressing each land use polygon (for pre-development and developed land use) into one of 16 land use types where EMC

data are available. Use the Lookup_LandUseCompress table in the template geodatabase to do so.

2. Clip the Irrigation input layer to the selected basin.

3. Perform a GIS intersection between the Land Use, Irrigation, and Basin feature classes in the output geodatabase. This intersection results in a new feature class and is labeled Irrigation, each polygon carrying all attributes from the included layers. The same model logic to account for changes in land use with respect to simulation time is also used.

4. Determine whether the irrigation polygon should be specified as residential or agricultural/commercial/golf by using Lookup_LandUseCompress. Determine the source of the irrigation water by using Lookup_IrrigationSourceR (or –GW or –SW). Determine the irrigation rate by using Lookup_IrrigationRate.

5. For each polygon in Irrigation, the model calculates the following equation for each irrigation source. The results in pounds per month are written to the result tables pertinent to that source.

   [Area (acres) * Rate (inches/month) * DCIA-Concentration (mg/L)(unique to source) * Fraction returned to DCIA * Conversion Factor] +

   [Area (acres) * Rate (inches/month) * GW-Concentration (mg/L)(unique to source) * Fraction returned to GW * Conversion Factor]

6. For each month the results are summed over each basin and reported to an output table unique to that source. AppliedVolume represents the amount of water applied and Volume represents the fraction that reaches the downstream outfall. All loads are based on the Volume. Results are also available in the units of pounds/acre/month.

7.3 REQUIRED DATA

User-Input Spatial Data

- Major drainage basin and bay boundaries (area) with Basin ID
- Irrigation (Source, Rate)
- Time-stamped Land Use (FLUCCS Code, YR_BUILT, area)

Reference Tables in Template Geodatabase

- Lookup_LandUseCompress: *relate* FLUCCS landuse *to* irrigation landuse (LU_IRR) *for use in determining* Rate

- Lookup_IrrigationSourceR (or –GW or –SW): *relate* SOURCE *for determining* DCIA and GW return fractions, and all concentrations
- Lookup_IrrigationRate: *relate* RATE and LU_IRR *for finding* rate VALUE for each month of the simulation

8.0 POINT-SOURCE MODULE

The simulation methodology for the point source module did not change much from what was discussed in the Draft Design Report, except for how spatially applied effluent is loaded as discussed above. It was more consistent to include this, i.e., the method of loading spatially applied effluent, as an irrigation load--which is all applied over an area--and keep true point discharges in the point-source module.

8.1 DATA AND MODEL DEVELOPMENT

There are 38 non-delegated WWTPs with individual daily flows averaging less than 0.05 million gallons per day (MGD) in Sarasota County. These small package plants typically serve individual communities, campgrounds, parks, or even restaurants. Most use extended aeration and basic disinfection to treat their influent. The prevalent point sources in the County include 17 larger WWTPs serving municipalities and larger communities, treating between 0.1 and 6 MGD, on average. These delegated plants typically treat influent via extended aeration and high disinfection. Consistent with the methodology used in WMM, point-source loads are the product of flow and concentration. These flows and loads are subtotaled by basin and added to the total loads.

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 under operation in the County. Spatial location of the loads is based on effluent disposal location. SIMPLE-Monthly will handle regular point source discharges in a similar manner but more robustly by incorporating a monthly time step. Wherever possible, monthly average data reported by each treatment plant were incorporated into a timeseries of flows and concentrations within a lookup table (Lookup_PointSource) housed in the template geodatabase. This lookup table is related to a point-source coverage by an ID field, PS_ID. Treatment facilities going offline are handled by zeroing out flows and loads in the time series after the plant went offline.

Monthly flow and concentration data were obtained from Sarasota County (for non-delegated wastewater treatment plants) and FDEP (for delegated wastewater treatment plants) for all major sources in the County. Data were reported for each plant between 1998 and 2007. The data for 1998 were assumed to be representative for 1994 to1997. This does not account for small package plants coming on or offline within those 4 years. If more data become available for those particular years, the lookup table can easily be changed.

Typical effluent concentrations reported are BOD, TSS, NO_3, and fecal coliform. Other modeled constituents were calculated based on these values or assumptions about typical wastewater treatment plant effluent. For point sources where BOD was measured, COD was assumed to be 2.1*BOD, which is commonly applied for wastewater treatment plant (WWTP) effluent (Grady, Daigger, and Lim, 1999). Where monitoring data were not available, plants were assumed to be discharging at typical limits for secondary WWTP effluent. This methodology is similar to that applied in the WMM (CDM, 1993).

The ability to simulate untreated wastewater discharges (i.e., sewage spills) is a new addition to SIMPLE-Monthly. The required input to the model is in the form of a point coverage including the attributes of date, volume (in gallons) and type (raw sewage or reclaimed water). This point-source input will be joined to a lookup table of concentrations for each of those types (Lookup_NonCompliantEffluent) during point-source calculations. For this module this coverage will remain blank, meaning that no spills will be included in model simulations for this project, but mock data were created and loads hand-calculated to verify that the module is functioning correctly.

8.2 MODEL ACTION

The modeling action is as follows:

1. Clip the point source input layer to the selected basin and copy into the output geodatabase. Use the Lookup_PointSource table in the template geodatabase to determine concentrations and flows for each simulation month.

2. Clip the NonCompliantEffluent input layer to the selected basin and copy into the PointSource feature class in the output geodatabase. Use the Lookup_NonCompliantEffluent table to determine concentrations for the spill date.

3. For each regular point source, the model calculates the following equation for each simulation month:

   Flow (cfs) * Concentration (mg/L) * Conversion Factor

   This conversion factor is different from the ones previously used and may still be altered by the user if needed.

4. For each non-compliant effluent discharge, the model calculates the following equation for each date of spill:
   Volume (gal) * Concentration (mg/L)(unique to the type) * Conversion Factor

   This conversion factor is different from the ones previously used and may still be altered by the user if needed.

5. For each month the results are summed over each basin and reported to the output table. Results are also available in the units of pounds/acre/month.

8.3 REQUIRED DATA

User-Input Spatial Data

- PointSources (PS_ID)
- NonCompliantEffluent (Volume, Date)

Reference Tables in Template Geodatabase

- Lookup_PointSource: *relate* PS_ID) *for finding* Flow, concentrations
- Lookup_NonCompliantEffluent: *relate* type *for determining* concentrations

9.0 SEPTIC TANK MODULE

9.1 DATA AND MODEL DEVELOPMENT

Significant portions of Sarasota County are served by septic systems. Sarasota County provided spatial location of over 45,000 septic tanks during the development of SIMPLE-Seasonal. Although sewered areas of the County are growing, the actual number of septic tanks within the County is thought to be closer to 80,000. Since the roughly 35,000 or more undocumented septic tanks will create considerable load, it was necessary to develop a methodology to account for their spatial location.

To locate the potential undocumented septic tanks, the Sarasota County parcel coverage was used. If a building was located on a parcel (indicated by the YR_BUILT field), a point was created in that parcel. This information was rectified against the documented 45,000 tanks so that there were no duplicates. Finally, points representing the undocumented tanks were viewed against the most recent sanitary sewer coverage provided by the County, and all those points intersecting were deleted. This spatial analysis results in a new septic layer which includes nearly 90,000 tanks, which should give a more accurate representation of the septic tank presence. Jones Edmunds and Sarasota County will update this spatial layer as better information becomes available.

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. To include this information in the septic tank GIS feature class, the date of removal has been added to the input feature class. The model assumes that the septic tank is active after the construction year (YR_BUILT) and no longer used in and after the year designated in the OFFLINE field. This information may not be available for all of the tanks which have been discontinued. This field can easily be updated when better data become available. For now, the only offline data used pertain to tanks removed during the Phillippi Creek Septic Tank Replacement Program.

For SIMPLE-Monthly, average flow rates were assigned based on whether the tank intersected with a residential land use or non residential land use, such as would be the case for schools, institutions, or commercial areas. As for SIMPLE-Seasonal, flow rates throughout the County were assumed to be 100 gallons per day per capita, with an average of 2.5 people per household (resulting in 250 gallons per day for each tank) for residential units (Great Lakes-Upper Mississippi River Board of State Public Health and Environmental Managers, 1990). Non-residential flows vary by the type of land use they serve; however, a value representative of the entire County was calculated. Typical daily flow rates obtained from the Florida ASHI Seminar (1993) were used based on the capacity of the tank, which was known in most cases. A weighted average flow was then calculated based on the number of tanks located within each non-residential land use, commercial being the most prominent.

Rather than only employing a single set of concentrations for either working or failing septic tanks, SIMPLE-Monthly uses three sets of concentrations for each scenario. Which

concentration (between high, medium, and low) each tank is assigned depends on the type of soil it falls on, whether the area is being treated by a BMP, and its distance from the nearest conveyance. Each tank was assigned a concentration class (between 1 and 3 for high to low) based on GIS analysis using the latest NRCS soils coverage and the USGS's National Hydrography Dataset, and regardless of that tank's individual failure probability. The classification matrix is shown in Table 9-1. These classifications are based on analysis summarized in the October 20, 2006 memo from Jon Perry titled Phillippi Creek Septic System Replacement Program: GIS Analysis of Environmental Parameters for Reprioritization. If information were available to warrant further classification of concentrations, this would be easily updatable in the model by manipulating input data.

Table 9-1 Concentration Classification for Septic Tanks

Hydrologic Soil Group	Distance from Conveyance (feet)	BMP Presence	Concentration (1=High, 2=Medium, 3=Low)
A	< 165	BMP	1
A	< 165	No BMP	1
B	< 165	BMP	1
B	< 165	No BMP	1
C	< 165	BMP	1
C	< 165	No BMP	1
D	< 165	BMP	2
D	< 165	No BMP	1
A	165-900	BMP	1
A	165-900	No BMP	2
B	165-900	BMP	2
B	165-900	No BMP	2
C	165-900	BMP	2
C	165-900	No BMP	2
D	165-900	BMP	3
D	165-900	No BMP	2
A	> 900	BMP	2
A	> 900	No BMP	2
B	> 900	BMP	3
B	> 900	No BMP	3
C	> 900	BMP	3
C	> 900	No BMP	3
D	> 900	BMP	3
D	> 900	No BMP	3

Concentration values used are similar to those in SIMPLE-Seasonal. Raw effluent concentrations (immediately leaving the tank) are based on values reported in a case study in Onsite Wastewater Treatment Systems Manual (EPA, 2002) and supplemented by typical values listed in that document. These concentrations were reduced for functioning systems according to treatment by drain field or SWIS (subsurface wastewater infiltration system) (EPA, 2002). This was taken as the medium concentration for working tanks. The high and low concentrations were either raised or lowered from the medium values by 10%, as an initial estimate. Failing

drain fields with the highest concentration were conservatively assumed to not treat effluent at all. Similarly, medium and low failing concentrations were lowered each by 10%. All of the input concentrations are easily updated by the user in the geodatabase template as better data become available.

SIMPLE-Seasonal required a user-input average failure rate for septic tanks. For SIMPLE-Monthly, failure rate is an indirect input, which is calculated based on geoprocessing of GIS data unique to each tank. A matrix was developed for this project estimating individual failure probabilities based on property age and the type of soil the tank falls on. It was assumed that the construction year of the structure was the construction year of the tank. This was a necessary assumption since nearly half of the septic tanks were not actually inventoried in the County's database and therefore contain no data with regards to age, permitting, service, or capacity. It was also assumed that clay soils would tend to clog faster than sandy soils. Although it would have also been desirable to consider service dates in the estimation of failure, the attribute was too incomplete in the database to use as an estimator. Estimated failure rates for individual tanks range from 0.5% to 20%, and these values could easily be updated given better data.

This matrix was developed in an attempt to create a difference between the loading from older tanks on A soils versus a new tank constructed on D soils. The average failure rate per basin will be calculated as a straight average of all of the active tanks in that basin. For now, this average will be calibrated to roughly equal 8% by basin, which was used in SIMPLE-Seasonal as in WMM (CDM, 1993). Table 9-2 shows the preliminary matrix of septic tank failure rates.

Table 9-2 Failure Rate Classification for Septic Tanks

Year of Construction	Hydrologic Soil Group	Estimated Rate of Failure
> 1983	A	0.5%
1973-1982	A	1%
1963-1972	A	1.5%
1953-1962	A	2%
< 1952	A	2.5%
> 1983	B	3%
1973-1982	B	4%
1963-1972	B	5%
1953-1962	B	6%
< 1952	B	7%
> 1983	C	7%
1973-1982	C	8.5%
1963-1972	C	10%
1953-1962	C	11.5%
< 1952	C	13%
> 1983	D	13%
1973-1982	D	15%
1963-1972	D	17%
1953-1962	D	19%
< 1952	D	20%

9.2 MODEL ACTION

Model operations are as follows:

1. Clip the land use input layer to the selected basin and copy into the output geodatabase. Simplify this layer by compressing each land use polygon (for both pre-development and developed land use) into one of 16 land use types where EMC data are available. Use the Lookup_LandUseCompress table in the template geodatabase to do so.

2. Clip the Septic input layer to the selected basin.

3. Perform a GIS intersection between the Land Use, Septic, and Basin feature classes in the output geodatabase. This intersection results in a new feature class, and is labeled Septic, each point carrying all attributes from the included layers.

4. For each grouping of septic tanks in each concentration classification (either 1, 2, or 3, as designated by the field CONC_ID), the model will calculate the following equation:

   {[Number of Tanks * Flow (cfs) * Concentration for Working Tanks (unique to the classification)(mg/L) * Conversion Factor * (1-Average Failure Rate)] + [Number of Tanks * Flow (cfs) * Concentration for Failing Tanks (unique to the classification)(mg/L) * Conversion Factor * Average Failure Rate]} * ReturnFraction

   Flow will change depending on the LU_SEP field, which is determined after intersection with Land Use and designates the tank as either residential or non-residential. The failure rate is calculated based on an average of each tank's individual failure rate.

5. For each month the results are summed over each basin and reported to an output table. AppliedVolume represents the amount of water applied and Volume represents the fraction that reaches the downstream outfall. All loads are based on the Volume. Results are also available in the units of pounds/acre/month.

Each item in the above equation is found in lookup tables in the template geodatabase or the Septic feature class. The conversion factor is specific to this equation to create results in the units of pounds/month, but the user has the option to change this number in an editable xml file of settings.

9.3 REQUIRED DATA

User-Input Spatial Data

- Major drainage basin and bay boundaries (area) with Basin ID
- Soils (Hydrologic Soil Group, area)
- Time-stamped Land Use (FLUCCS Code, YR_BUILT, area)
- Septic Tanks (location, FAILURE, CONC_ID)

Reference Tables in Template Geodatabase

- Lookup_LandUseCompress: *relate* FLUCCS landuse *to* EMC landuse *for finding* EMC landuse
- Lookup_SoilCompress: *relate* hydrologic soil group *to* land use *for redefining* dual class hydrologic soil groups
- Lookup_SepticConcentration: *relate* CONC_ID *for finding* low, medium, and high concentrations for both working and failing tanks

10.0 ENHANCED OUTPUT REPORTING

In SIMPLE-Seasonal the model output consists of 31 tables (of seasonal or annual loads) and several feature classes. SIMPLE-Monthly provides 18 time-series output tables and additional feature classes such as Irrigation and NEXRAD pixels. Considerable amounts of spatial output data are 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.

During a project update meeting on December 14, 2007, outputs desired by the County and other potential users were discussed. The consensus was to output all monthly data to a spreadsheet program such as MS Excel so that the user could easily graph and manipulate the data. Spatial representation of output may only be necessary once per simulation for each module. Spatial representation may only be supplied for the constituents of greatest interest to the County such as TN and TP. This output would be in the form of pre-symbolized layers for each constituent that would display on command by the user.

Previous discussion concerning enhanced output reporting was covered in the Draft Design Report and can be found in Appendix A.

The HydrologyTimeSeries table, which was in the output geodatabase in draft versions, was removed from the output geodatabase for disk space considerations. The HydrologyTimeSeries table covering Sarasota County and additional monitored watershed areas outside of the County for the period of record occupied over 700 MB within the output geodatabase—often over 85% of the output geodatabase disk space requirement.

11.0 REFERENCES

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APPENDIX A

EXCERPTS FROM THE SARASOTA COUNTY POLLUTANT LOADING MODEL (W552) DRAFT DESIGN REPORT, JONES EDMUNDS & ASSOCIATES, JANUARY 2007

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).

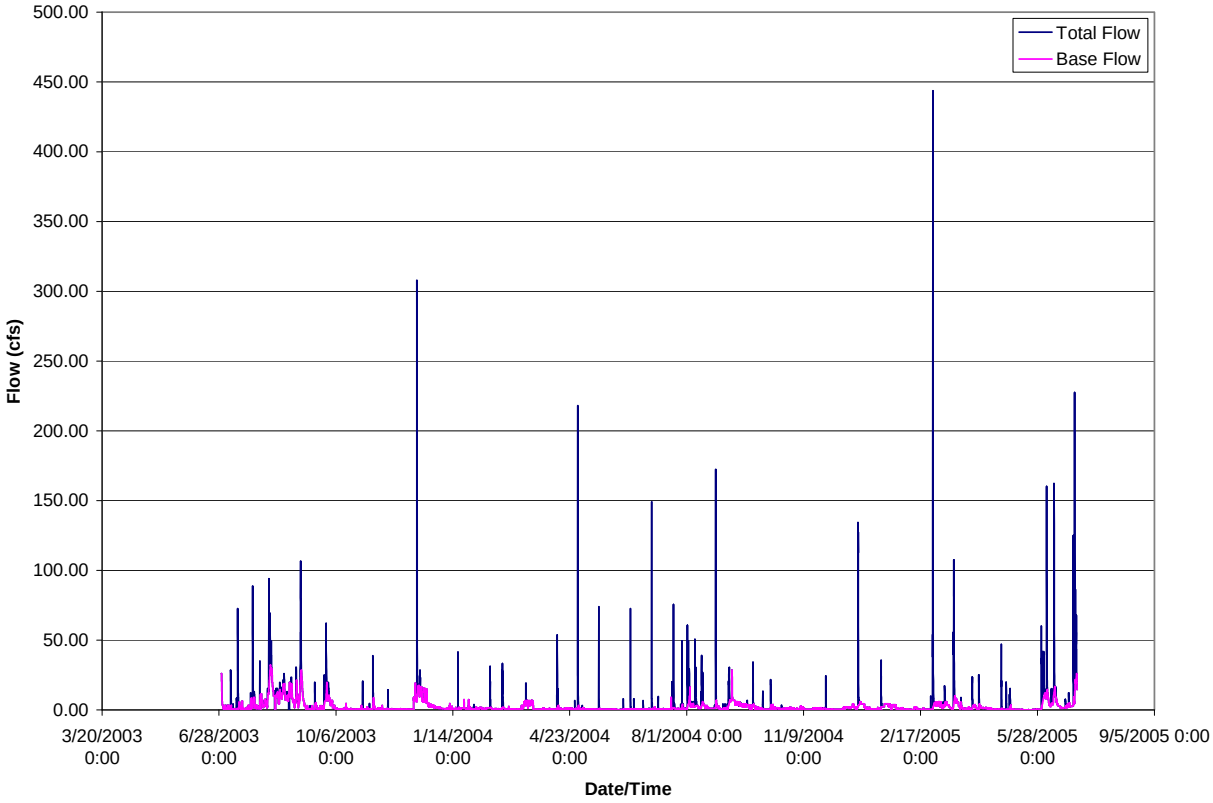

Figure 4-1 Total and Base Flow Hydrographs from MAT1

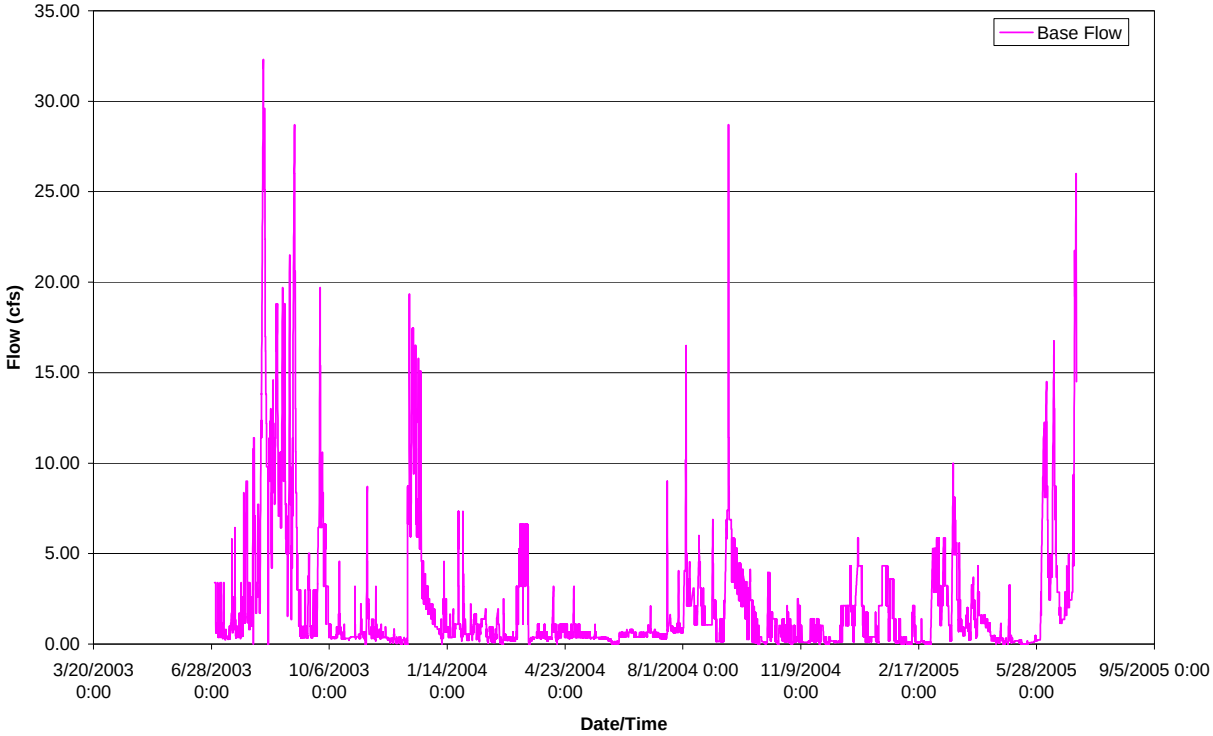

Figure 4-2 Base Flow Hydrograph from MAT1

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.

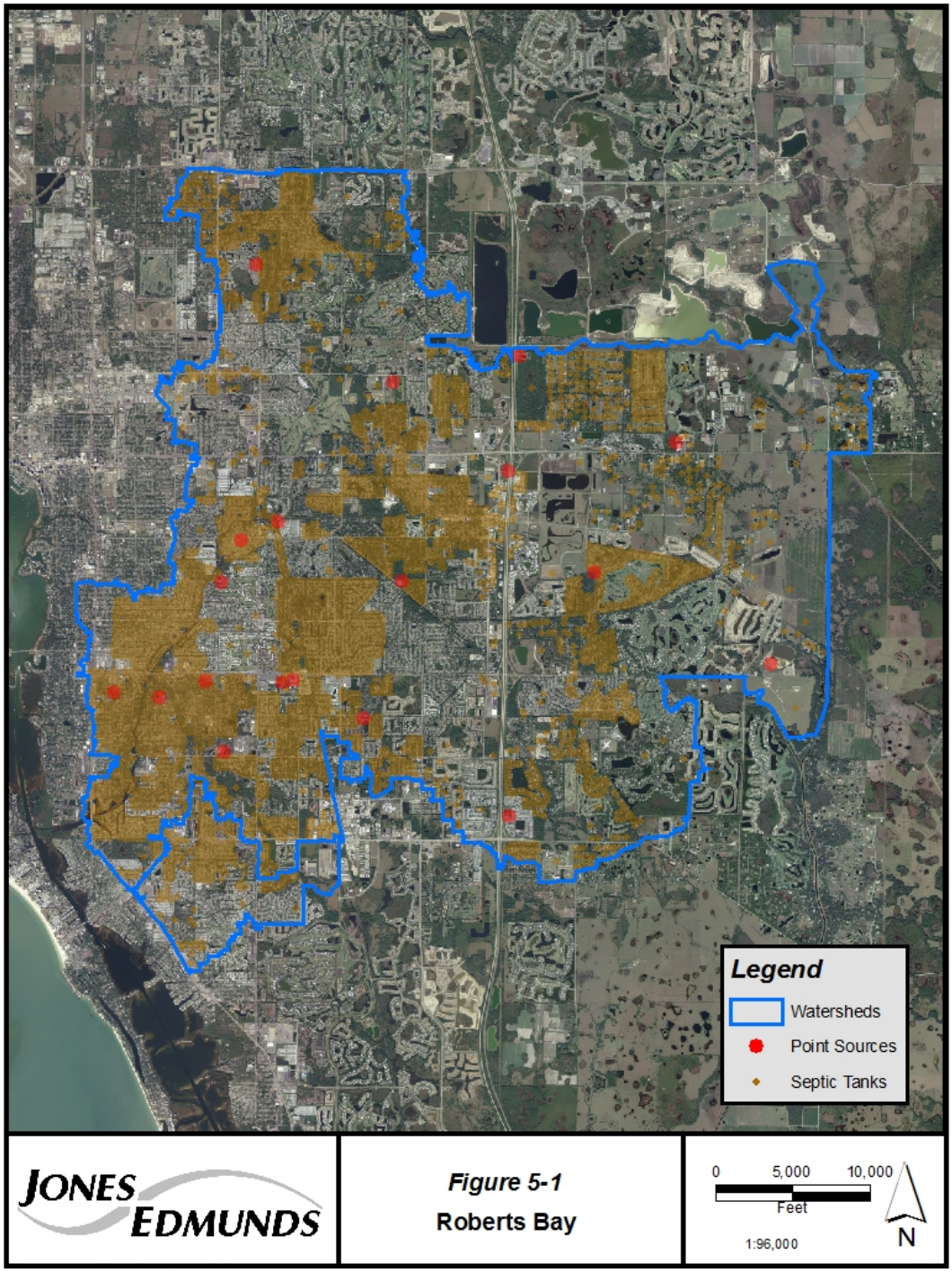

Figure 5-1 Example Map of Point Source and Septic Tank Input Data

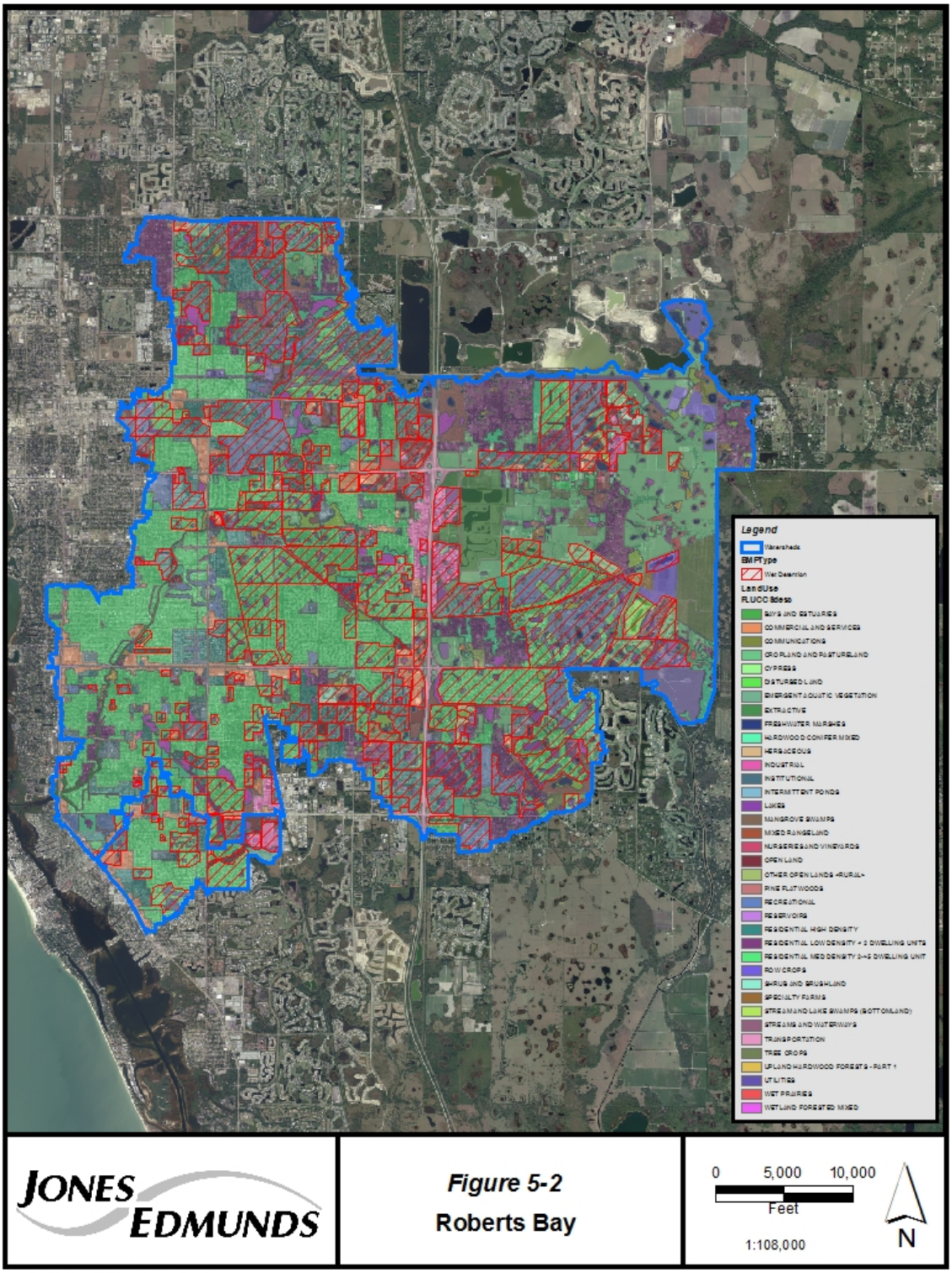

Figure 5-2 Example Map of Land Use and BMP Data

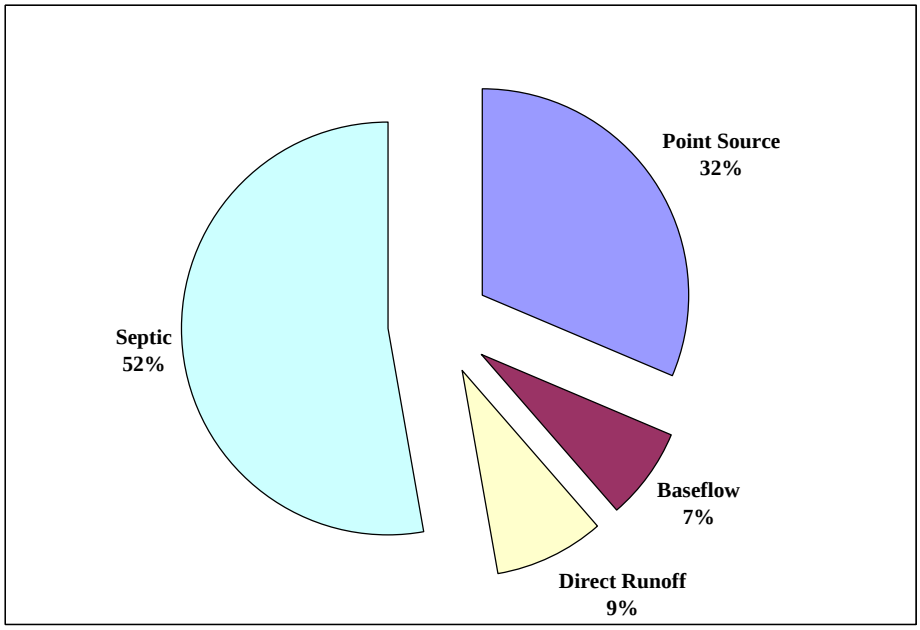

Figure 5-3 Distribution of TN Loading by Source for the Alligator Creek Basin

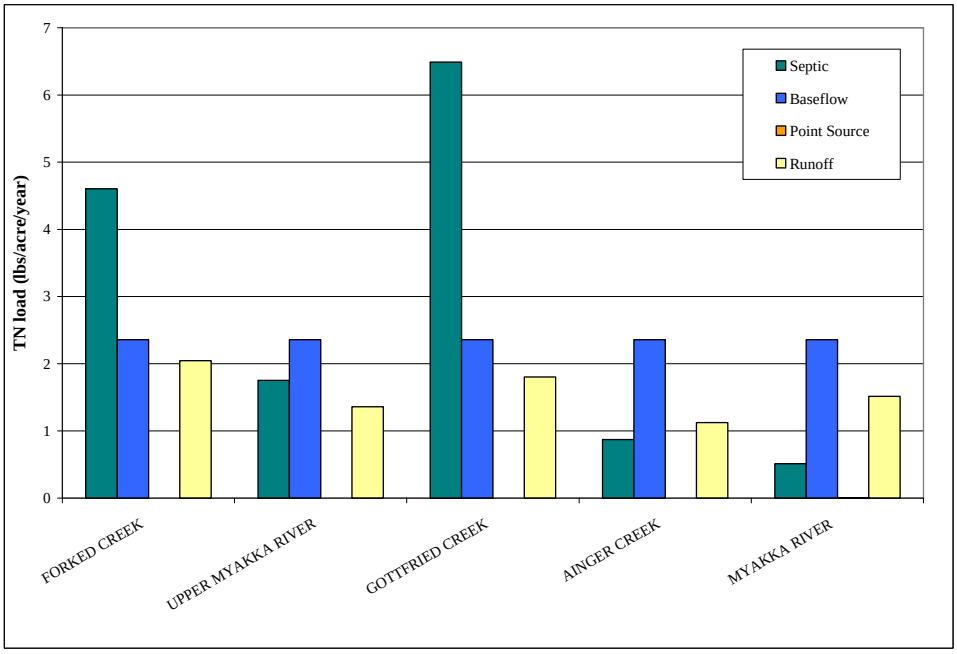

Figure 5-4 TN Loading by Source for Eastern Sarasota County

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.

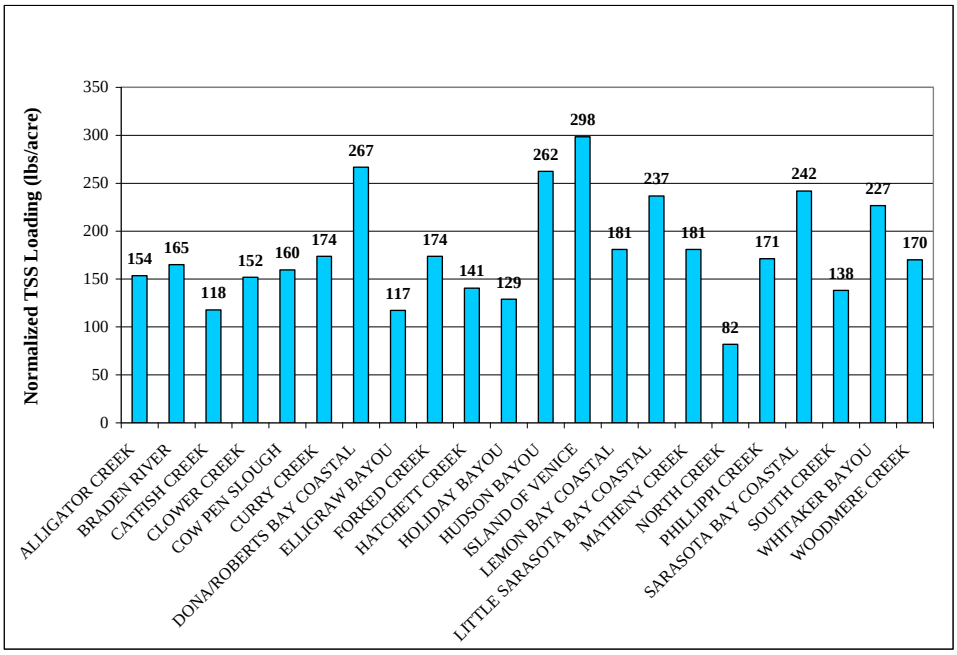

Figure 5-5 Normalized TSS Loading (lbs/acre/year) for Major Drainage Basins in Western Sarasota County

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.

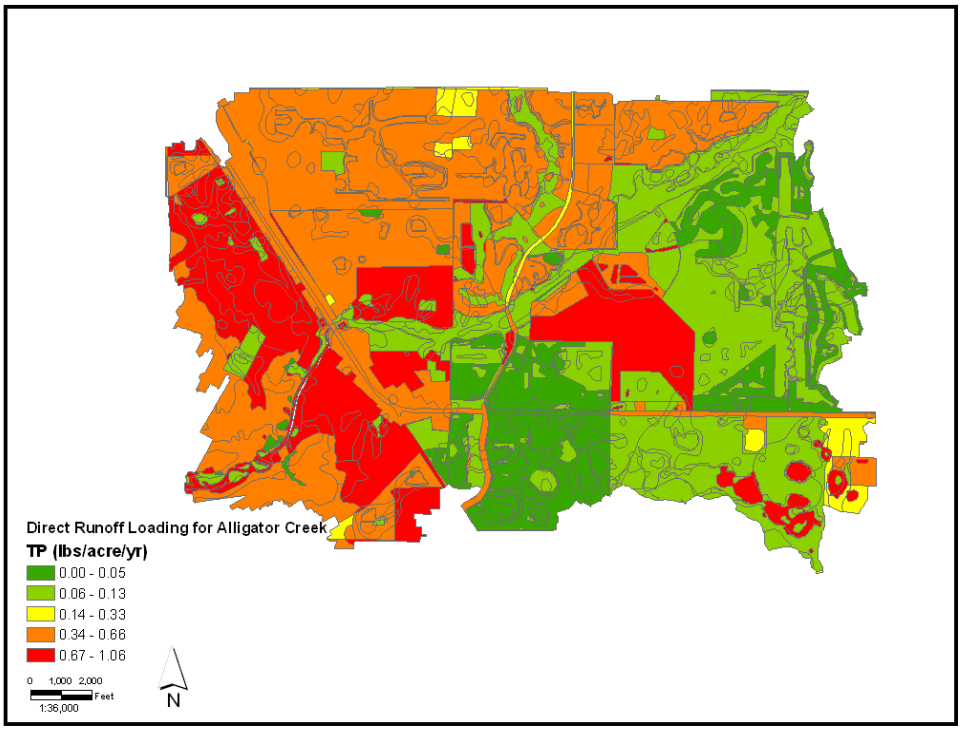

Figure 5-6 Direct Runoff TP Loading (lbs/acre/yr) for the Alligator Creek Basin

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.