User's Manual:
Watershed Management Model
Version 4.1

October 1998

DISCLAIMER

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1.0 INTRODUCTION

1.0 **INTRODUCTION**. The Watershed Management Model (WMM) supports development of watershed management plans and establishes an overall "framework" for assessing pollution control strategies within the watershed. A watershed management plan should address the following:

- Existing and projected future pollutant loads and the impacts of these pollutant loads on receiving water quality;
- Pollutant loading reduction goals required to attain a desired level of water quality;
- Watershed-specific best management practices (BMPs) that may include specific management policies, and facility siting and design criteria that will be implemented under the watershed plan; and,
- Methods for assessing the effectiveness of BMPs for reducing pollutant loadings.

To support watershed planning efforts, Camp Dresser & McKee developed a user-friendly database model has been developed to simulate the generation and fate of pollutant loads from a number of watershed pollutant sources. The model uses land use categories with associated event mean concentrations (EMCs), depending on the constituents of concern, to simulate annual or seasonal pollutant loads carried in storm water runoff. Additionally, the model estimates loads from other pollution sources such as wastewater treatment plant or industrial wastewater discharges, combined sewer overflows (CSOs) and failing septic systems. The model is also capable of analyzing the effects of pollutant controls for storm water and CSOs. This user's manual provides an overview of the Watershed Management Model for Windows and its application to watershed management planning.

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

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

Urban nonpoint pollution sources have become a growing concern over the past 10 to 20 years as areas throughout the U.S. have compiled monitoring data on the significant increase in pollution discharges which occur when an area becomes urbanized. For example, compared to undeveloped land uses (such as forested areas), annual runoff pollution (lbs/acre/yr) from urban development is as much as 10 to 20 times greater in the case of nutrients and as much as 10 to 50 times greater in the case of toxicants like heavy metals. Nonpoint pollution contributed by agricultural and other rural land uses can also be a significant concern, particularly for existing undeveloped areas in a watershed. Sediment and nutrients are of particular concern with rural land uses.

Local and nationwide studies have revealed extensive water quality impacts resulting from storm water runoff pollution, especially nutrients and suspended solids. Rapid urbanization, with its associated land clearing and paving of pervious area, has accelerated the problem of water quality pollution over the last several years. While runoff from rainfall is a natural occurrence, the problem lies in the nature of the land on which rain falls. As the amount of paved impervious surface area increases, the volume and rate of runoff (as well as the accompanying pollutant loads) increases. Storm water flowing over roofs, streets, lawns, commercial sites, industrial areas, and other permeable and impermeable surfaces transports many pollutants into surface and ground waters. Rain washes sediments from bare soil; transports heavy metals, oils, and greases deposited on streets and parking lots by motor vehicles; picks up nutrients from fertilized lawns and crops; and carries coliform bacteria from animal wastes into receiving waters (Livingston, 1985).

Experience has shown that the conservation of water resources, the level of tax expenditures, and the assurance of a high quality of life are intimately associated with a region's land use. As land is changed from its original state to more intensive uses, water quality tends to deteriorate. Transition periods between different uses (e.g., construction) are especially critical. Each progression toward more intensive land use disrupts the natural processes which protect and preserve water quality. While not all urban centers are predestined to poor water quality, as the intensity of land use increases, it becomes more important to manage resources effectively. Therefore, it is essential that the effects of alternative land uses be fully understood if local governments plan to protect their limited natural and financial resources (FDER, 1988).

1.2 LAND USE POLLUTION LOADING MODELS. Watershed pollution loading models are beneficial in local government planning because they can provide a forecast of the approximate impact of planned actions or alternatives on water quality and pollution loadings. Models can also be used to estimate and analyze trade-offs between planning objectives through the management of all watershed pollution sources. However, the modeling of water quality requires data for model input. Data can be obtained from existing studies or may require extensive field monitoring (Huber 1990).

Although water quality monitoring programs are typically required to support preparation and implementation of watershed management plans, only a limited amount of data are generally obtained under these monitoring programs. Short-term water quality monitoring data are usually insufficient for use in development of a comprehensive storm water management plan. Several years of water quality data are typically required to produce a database that reflects a sufficient range of hydrometeorologic conditions to permit definitive conclusions. For example, water quality data collected during drought conditions may support management decisions very different from decisions based on data collected during periods with normal or above normal precipitation.

Often a lack of local water quality monitoring data is cited as a reason to delay or ignore watershed management decisions. It is appropriate to apply a watershed pollution loading model in areas where a lack of local water quality monitoring data exists. Available literature values for pollution loading factors or results from the NPDES permit sampling programs can be used to develop a preliminary pollution loading evaluation for use in the preparation of a watershed management plan. Urban nonpoint pollution loading factors can also be transferred from one region to the next with considerable confidence, as long as regional differences in rainfall/runoff relationships are accounted for. The reason regional urban nonpoint pollution loading factors are transferable is that urban nonpoint pollution loadings tend to be governed by the amount of imperviousness and urban land use categories tend to exhibit similar levels and uses of imperviousness (e.g., roads, rooftops) throughout most of the U.S. Generally, water quality management decisions based on "regional" loading factors are not significantly different from those based on "local" loading factors.

Although a watershed pollution loading model can only be calibrated with local data, the model can still be used to analyze relative changes between various alternatives or scenarios. The model can provide municipalities with an indication of the relative direction (improvement vs. deterioration) and magnitude (10%, 50%, 100% increase/decrease) of water quality changes under various land use or BMP alternatives and will aid in the development of a comprehensive watershed management program.

1.3 THE STORM WATER PERMIT PROGRAM. Amendments to the Clean Water Act established a two-phased approach to addressing storm water discharges. Phase I, currently being implemented, requires permits for separate storm water systems serving large- and medium-sized communities (those with over 100,000 inhabitants), and for stormwater discharges associated with industrial and construction activity involving at least five acres. The Environmental Protection Agency (EPA) published regulations for Phase I in November 1990 requiring select municipalities to obtain a system wide permit for the discharge of storm water as part of the National Pollutant Discharge Elimination System (NPDES) program. The permit application must include an estimate of the quality and quantity of discharges from the municipal separate storm sewer system. This requirement is specified in the Code of Federal Regulations as:

> ***40 CFR 122.26(d) (2) (iii) (B)***
> *Estimates of the annual pollutant load of the cumulative discharges to waters of the United States from all identified municipal outfalls and the event mean concentration of the cumulative discharges to waters of the United States from all identified municipal outfalls during a storm event for* BOD_5*, COD, TSS, dissolved solids, total nitrogen, total ammonia plus organic nitrogen, total phosphorus, dissolved phosphorus, cadmium, copper, lead, and zinc. Estimates shall be accompanied by a description of the procedures for estimating constituent loads and concentrations, including any modeling, data analysis and calculation methods;*

EPA regulations also require estimates of the impact on these loads from proposed storm water management programs. A storm water management program typically consists of BMPs for controlling various constituents in storm water runoff. This important aspect of water quality improvement planning is required under the NPDES permit application.

The NPDES Storm Water regulations also require implementation of a long-term water quality monitoring program during the 5-year term of the permit to assess the impacts of the comprehensive storm water management plan. Monitoring will provide the additional data required to refine nonpoint pollution loading factors for local conditions. Monitoring will also help identify water quality changes within receiving waters and whether the trends are toward improving or deteriorating conditions. If several years of monitoring indicate that modifications of the original comprehensive storm water management plan are warranted, mid-course corrections can be implemented.

Phase II of the storm water program, which is currently under development, will address storm water discharges for additional municipalities that were not covered under Phase I of the storm water program. Ultimately, millions of potential permittees will be covered, including urban areas with populations under 100,000, smaller construction sites, and retail, commercial, and residential activities. EPA published it's draft Phase II Stormwater NPDES Permit Regulations in December of 1997 and has received public comment. The final rule is scheduled to be published by March 1, 1999, after EPA has responded to comments and revised the regulations. The draft rule proposes six minimum control measures including public education and outreach, public involvement/participation, an illicit discharge program, construction site controls, post-construction controls (BMPs) on new & redevelopment greater than one acre, and pollution prevention/good housekeeping for muncipal & govenment operations.

1.4 INTRODUCTION TO THE WATERSHED MANAGEMENT MODEL.

1.4 INTRODUCTION TO THE WATERSHED MANAGEMENT MODEL. WMM uses a database platform to estimate annual or seasonal pollutant loads from many sources within a watershed. Data required to use the WMM include storm water EMCs for each pollutant type, land use with the areas served by septic systems identified, average annual precipitation, annual baseflow and average baseflow concentrations, point source flows and pollutant concentrations, and average CSO flows and concentrations. The model is a stand alone application that runs in Microsoft Windows 3.1® or greater. The following summarizes some of the features of the WMM:

- Uses Microsoft Windows 3.1® or greater as the working system;
- Estimates annual storm water runoff pollution loads and concentrations for nutrients (total phosphorus, dissolved phosphorus, total nitrogen, ammonia plus organic nitrogen), heavy metals (lead, copper, zinc, cadmium), and oxygen demand and sediment (BOD_5, COD, total suspended solids, total dissolved solids) based upon EMCs, land use, percent impervious, and annual rainfall;
- Estimates storm water runoff pollution load reduction due to partial or full scale implementation of onsite or regional BMPs;
- Estimates annual pollution loads from stream baseflow;
- Estimates pollution loads from CSOs;
- Estimates CSO pollution load reduction due to implementation of CSO Controls;
- Estimates point source loads for comparison with relative magnitude of other watershed pollution loads;
- Estimates pollution loads from failing septic tanks;
- Applies a delivery ratio to account for reduction in runoff pollution load due to uptake or removal in stream courses; and
- Imports data sets from land use data files from the spreadsheet version of WMM 3.30 into the data base version of WMM for Windows, Version 1.0.

Pollution control strategies that may be identified and evaluated using the Watershed Management Model include:

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

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

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

The WMM consists of three major computational modules, the import utility, and numerous related database records. WMM was developed using Visual Basic® and MS Access® and runs under MS Windows® 3.1 or greater. Table 1.1 lists hardware and software requirements to run WMM. Figure 1-3 depicts the interactions among the main computational modules, supporting data files and supplemental program files.

1.5 OUTLINE OF USER'S MANUAL. This User's Manual describes the theory and formulation of the WMM and provides instructions for its application. Section 2 presents the theory and formulation of the data required to use WMM for Windows. Section 3 presents the structure and operation of the WMM. Appendix A presents default data inputs for the WMM which may be used when local data are not available. Appendix B contains an index of variables. Appendix C provides a sample data set to use as a test run for WMM. Appendix D contains sample output reports.

Table 1.1
System Requirements

- IBM compatible 8048b or higher PC.
- VGA Display or better
- RAM of 16 Megabyte or higher
- Available disk space of 15 Megabyte or higher
- Mouse
- MS Windows® 3.1 or greater

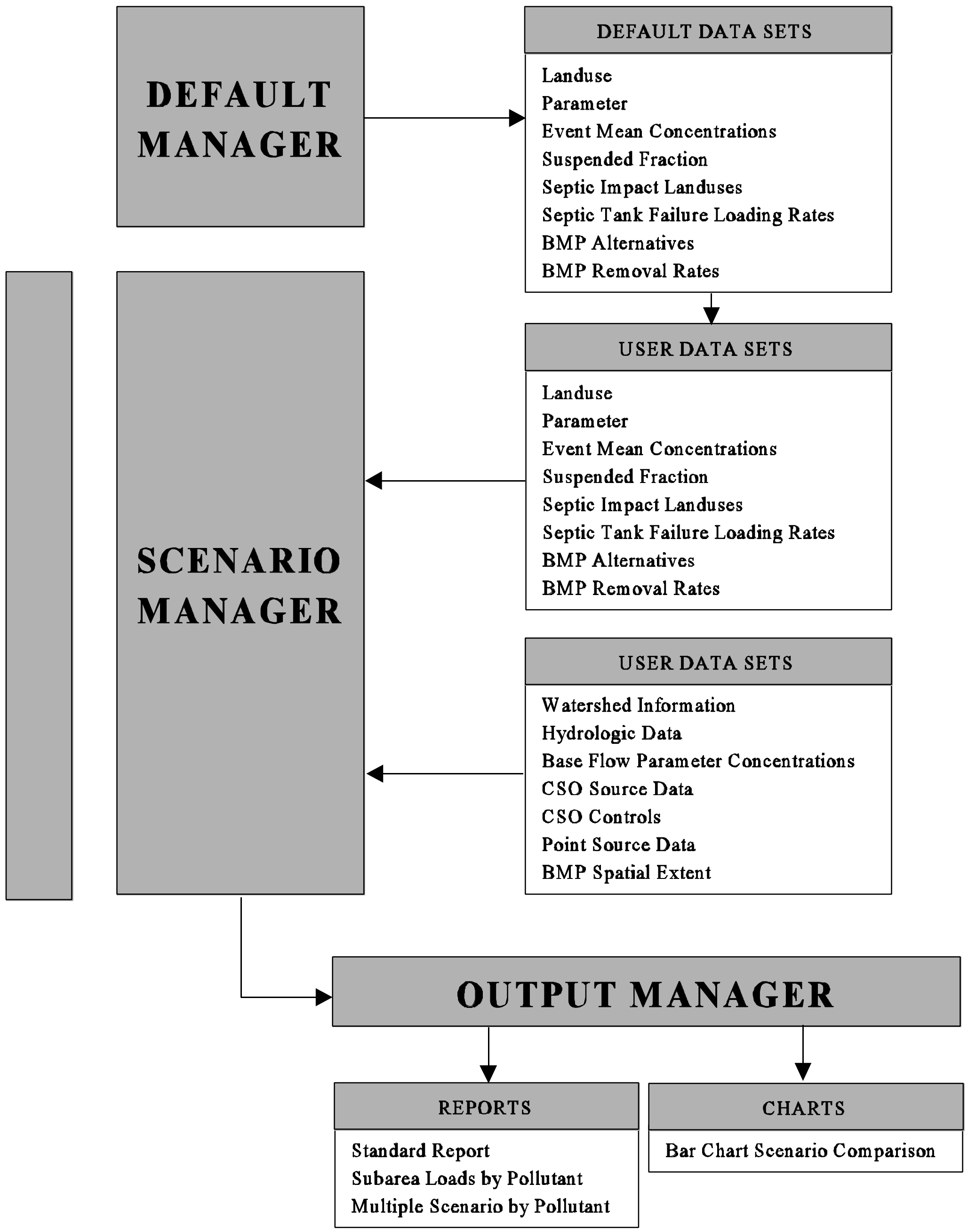


Figure 1-1

Schematic of Watershed Management Model

2.0 WATERSHED MANAGEMENT MODEL PRINCIPLES.

The Watershed Management Model (WMM) is a database model that was developed to estimate annual/seasonal pollutant loads on watersheds and subbasins and specifically to address watershed management needs for nonpoint source pollution. The WMM estimates loads based on local hydrology and non-point loading factors (EMCs) which relate land use patterns and percent imperviousness in a watershed to “per-acre” pollutant loadings. The EMCs, percent imperviousness, and hydrologic parameter values can be easily changed for a particular local application. This section describes the conceptual model framework and basic concepts for the application of WMM.

2.1 CONCEPTUAL MODEL FRAMEWORK.

Application of WMM requires that watershed data be compiled and analyzed. Table 2.1 presents a summary of the types of watershed data required for application of the model and potential data sources. The data available for each particular watershed under study will be different. In all cases, it is advantageous to collect as much local data as possible and to perform field investigations within the watershed to determine site specific conditions. In some cases, data from adjacent or neighboring watersheds may be applicable to the study watershed.

The conceptual framework for WMM is presented in Figures 2-1 through 2-3. These figures show schematically the outline or delineation of a hypothetical watershed with a stream and three smaller tributaries discharging to a receiving water (e.g., lake, reservoir, major river). Figure 2-1 illustrates the types of data required to setup the model and how a watershed might be subdivided into smaller subbasins. Figure 2-1(A) shows initial delineation of the watershed and potential data sources. Note that meteorological data should be obtained from stations in the region. All available water quality monitoring data from river/tributary stations, WWTPs and other dischargers, and water quality stations located within a lake or other receiving water should be collected. Water quality data from similar watersheds in the region should also be considered. Figure 2-1(B) illustrates how the watershed might be subdivided into subbasins. Note that subbasins can be delineated by drainage area as well as jurisdiction. As shown in the example, subbasins #6 and #7 are both within the drainage area of tributary #3 but represent different jurisdictions.

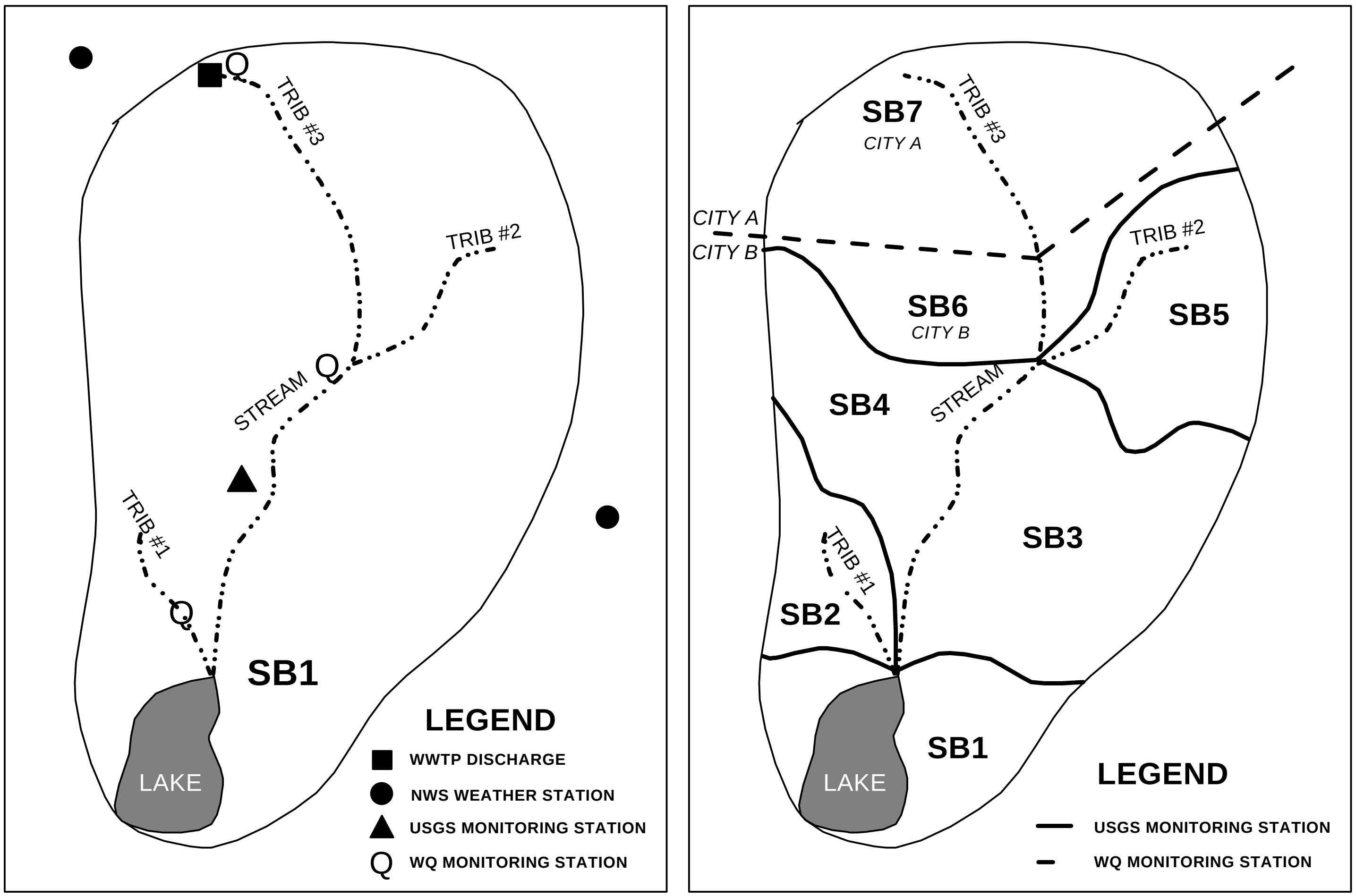
In Figure 2-2 land use information has been overlaid on the watershed schematic. Figure 2-2(A) represents "existing" land use. In many cases existing land use data will be obtained from the most recent aerial photography or other land use maps. Future land use, conceptually shown in Figure 2-2(B), will typically represent a long term "build-out" condition that can be obtained from available land use plans or zoning maps.

Figures 2-3 illustrates two simple cases of evaluating watershed management alternatives. Figure 2-3(A) represents a hypothetical application of source control BMPs throughout the watershed. The source control BMPs might include buffer zones, lower density development, and locational restrictions on commercial/industrial land uses. Figure 2-3(B) represents use of treatment control BMPs. In this example, detention pond BMPs have been sited throughout the watershed to control about 85% of the watershed area. Actual watershed management plans are likely to involve a mix of both source control and treatment control BMPs based upon local needs and preferences. A watershed management plan for a multi-jurisdictional watershed will typically involve devising alternatives that leave the choice of source or treatment controls up to the individual jurisdictions.

Table 2.1
Summary of Watershed Management Model Data Requirements and Potential Data Sources

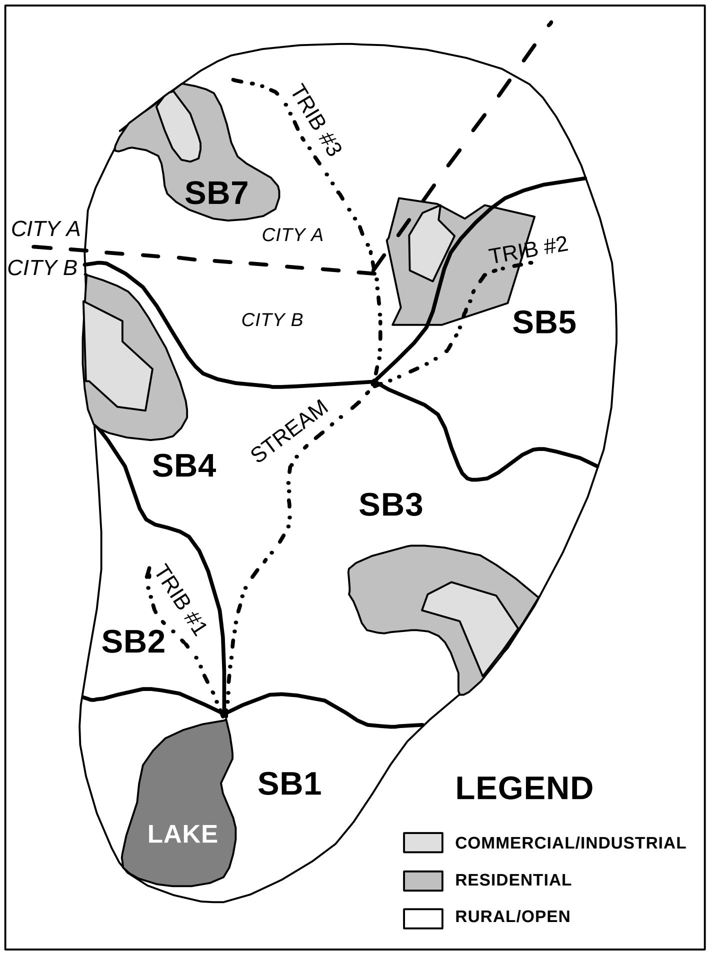
Data Type	Data	Generic Source
Watershed Characteristics	Drainage Area	USGS Quadrangle Maps; Local Topographic Maps; Local GIS
	Existing Land Use	Aerial Photography; Land Use Maps; LandSat Imagery; Comprehensive Land Use Plans; Large Development Plans; Zoning Maps
	Topography / Soils	USGS Quadrangle Maps; SCS Soil Surveys
Rainfall / Runoff	Long Term Average Annual Precipitation	NWS Weather Stations
	Annual Streamflow	USGS Monitoring Gages
	Impervious Cover	Aerial Photos; (large scale) "Typical" Site Plans
Watershed Water Quality Data	Storm Event Mean Concentrations	NPDES Permit Applications; USEPA NURP Study (1983); FHWA (1990); NURP Project Final Reports; State, Local Pollution Control Dept.
	Baseflow Concentrations (Ambient Water Quality)	USEPA STORET WQ database; State, Local Pollution Control Dept.
	Monitoring Data	Local WWTP/Utility; State Agency; USEPA
	Inventory of Package Plants, Industrial Dischargers	Utility Location Maps; Local WWTP/Utility; State Agency; USEPA
Data Type	**Data**	**Generic Source**
Combined Sewer Overflows	Overflow Concentrations	Literature Values; Local WWTP/Utility; USEPA
Failing Septic Tanks	Septic Tank Service Area	Local Utility Maps; Local Health Department
	Annual Septic Tank Failure Rate	Sanitary Surveys EPA, 1986
Delivery Ratio / Travel Time	Channel Geometry	FEMA Flood Studies; Field Surveys
	Mean Storm Event	NOAA National Climatic Center

Figure 2-1
Watershed Management Model Conceptual Framework:
Drainage Area and Subbasin Delineation

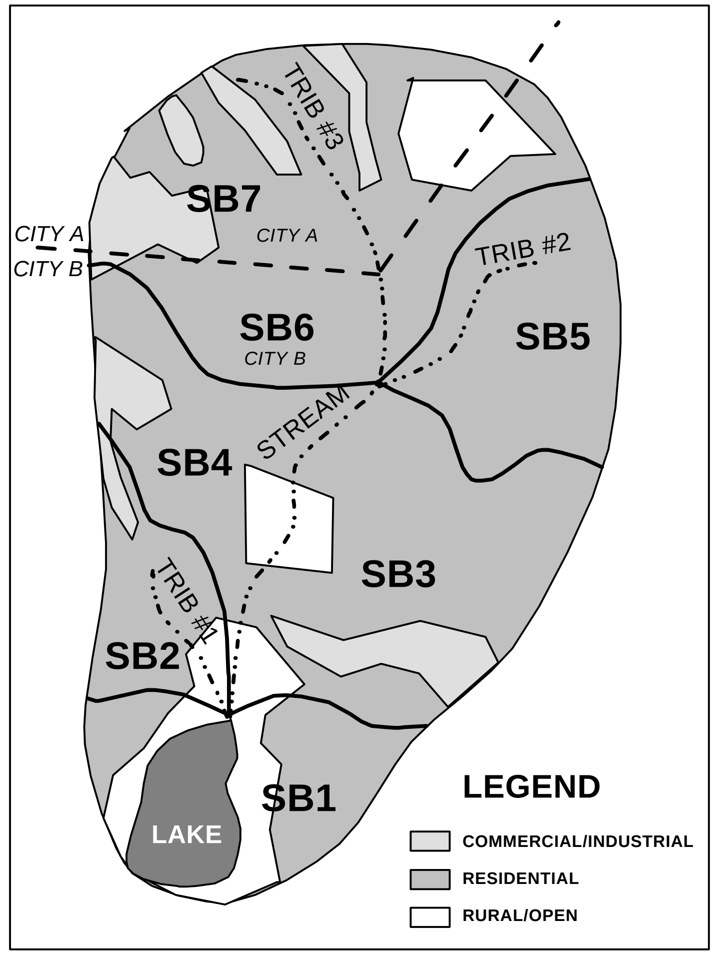


A. Map of Watershed and Location of Potential Data Sources **B. Delineation of Subbasins by Drainage and Jurisdiction**

Figure 2-2
Watershed Management Model Conceptual Framework:
Land Use Delineation

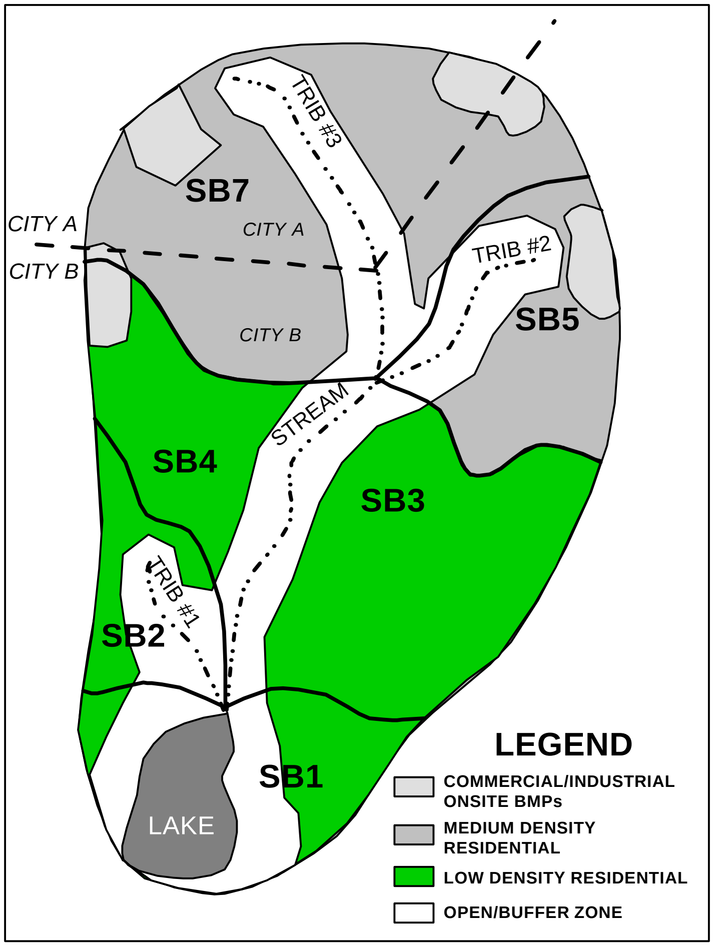


A. Land Use: YEAR 1992 (<15% Urban Development)

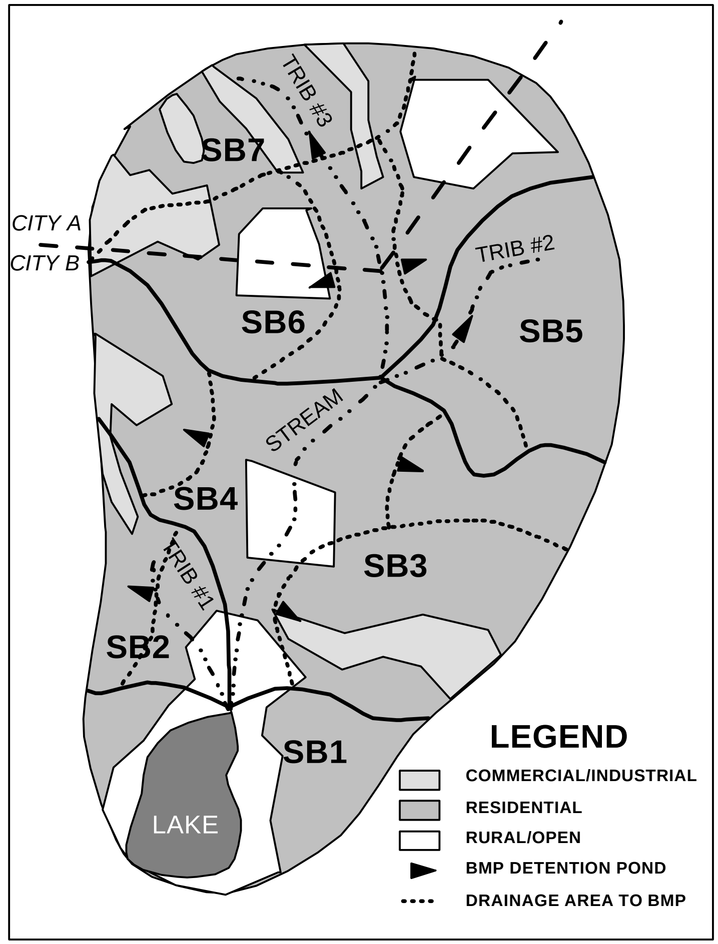


B. Land Use: YEAR 2020 (>85% Urban Development)

Figure 2-3
Watershed Management Model Conceptual Framework:
Alternatives Evaluation



A. YEAR 2020 Nonstructural BMPs (Land Use Controls, Buffer Zones)



B. YEAR 2020 Structural BMPS (80% Coverage of Watershed)

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

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

$$R_L = [C_p + (C_I - C_P)\ IMP_L] * I \qquad \textit{(Equation 2-1)}$$

Where:

R_L = total average annual surface runoff from land use L (in/yr);
IMP_L = fractional imperviousness of land use L;
I = long-term average annual precipitation (in/yr);
C_P = pervious area runoff coefficient; and
C_I = impervious area runoff coefficient.

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

Table 2-1 presents typical impervious area percentages based on CDM experience and on literature values. These factors can be refined based upon analysis on several "typical" development site plans, aerial photos, local ordinances, or previous hydrologic studies.

It should be noted that the impervious area percentages do not necessarily represent directly connected impervious area (DCIA). Using a single family residence as an example, rain falls on rooftops, sidewalks, and driveways. The sum of these areas may represent 30 percent of the total lot. However, much of the rain that falls on the roof drains to the grass and infiltrates to the ground or runs off the property and thus does not run directly to the street. Thus, not all of the 30 percent impervious area actually contributes as impervious area and the DCIA percentage is less than the total impervious area percentage. The DCIA percentage is typically on the order of one half the total impervious area percentage.

TABLE 2.2
DEFAULT EVENT MEAN CONCENTRATIONS AND IMPERVIOUS PERCENTAGES ASSIGNED FOR THE WATERSHED MANAGEMENT MODEL

Land Use Category	Percent Impervious	Oxygen Demand & Sediment (mg/L)				Nutrients (mg/L)				Heavy Metals (mg/L)			
		BOD	COD	TSS	TDS	TP	SP	TKN	NO23	Pb	Cu	Zn	Cd
Forest/Open	0.5%	8.0	51	216	100	0.23	0.06	1.36	0.73	0.00	0.00	0.00	0.00
Agricultural/Pasture	0.5%	8.0	51	216	100	0.23	0.06	1.36	0.73	0.00	0.00	0.00	0.00
Urban Open	0.5%	8.0	51	216	100	0.23	0.06	1.36	0.73	0.00	0.00	0.00	0.00
Low Density Single Family	10.0%	10.8	83	140	100	0.47	0.16	2.35	0.96	0.18	0.05	0.18	0.002
Medium Density Single	30.0%	10.8	83	140	100	0.47	0.16	2.35	0.96	0.18	0.05	0.18	0.002
Family	50.0%	10.8	83	140	100	0.47	0.16	2.35	0.96	0.18	0.05	0.18	0.002
Commercial	90.0%	9.7	61	91	100	0.24	0.10	1.28	0.63	0.13	0.04	0.33	0.002
Office/Light Industrial	70.0%	9.7	61	91	100	0.24	0.10	1.28	0.63	0.13	0.04	0.33	0.002
Heavy Industrial	80.0%	9.7	61	91	100	0.24	0.01	1.28	0.63	0.13	0.04	0.33	0.002
Water	100.0%	3.3	17	7	100	0.03	0.01	0.60	0.60	0.00	0.00	0.11	0.000
Wetlands	100.0%	3.3	17	7	100	0.03	0.01	0.60	0.60	0.00	0.00	0.11	0.000
Major Roads	90.0%	9.7	103	142	100	0.44	1.78	1.78	0.83	0.53	0.05	0.37	0.002

2.3 NONPOINT POLLUTION EVENT MEAN CONCENTRATIONS. The Watershed Management Model estimates loads from pollutants which are most frequently associated with nonpoint pollution sources, including, but not limited to:

- Oxygen Demand
  - Biochemical Oxygen Demand (BOD)

- Sediment
  - Total Suspended Solids (TSS)

- Nutrients
  - Total Phosphorus (TP)
  - Dissolved Phosphorus (DP)
  - Total Kjeldahl Nitrogen (TKN)
  - Nitrate+Nitrite (NO_3+NO_2)

- Heavy Metals
  - Lead (Pb)
  - Copper (Cu)
  - Zinc (Zn)
  - Cadmium (Cd)

- Bacteria
  - Fecal Coliform (F Coli)

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

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

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

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

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

Bacteria: Bacteria such as Fecal coliform are indicators of human or other animal waste contamination. Pathogenic organisms found in feces pose a threat to human health because they carry bacteria, viruses, and protozoa which may have been excreted by diseased persons or animals. The presence of bacteria in a stream may be an indication of failing septic tanks, illicit connections to the storm sewer, combined sewer overflows or sanitary sewer overflows within the watershed.

2.3.1 Event Mean Concentrations. Nonpoint pollution monitoring studies throughout the U.S. over the past 15 years have shown that annual "per acre" discharges of urban storm water pollution (e.g., nutrients, metals, BOD, fecal coliform) are positively related to the amount of imperviousness in the land use (i.e., the more imperviousness the greater the nonpoint pollution load) and that the EMC is fairly consistent for a given land use. The EMC is a flow-weighted average concentration for a storm event and is defined as the sum of individual measurements of storm water pollution loads divided by the storm runoff volume. The EMC is widely used as the primary statistic for evaluations of storm water quality data and as the storm water pollutant loading factor in analyses of pollutant loadings to receiving waters.

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

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

Table 2.2 presents recommended "default" storm water event mean concentrations for use in the WMM when local data are not available. Event mean concentrations for all land uses except major highways are based on the pooled USEPA NURP study national median EMC statistics (USEPA, 1983b) and EMC data reported by the Northern Virginia Planning District Commission (NVPDC 1979, 1983b). Highway runoff data reported by the Federal Highway Administration (FHWA, 1990) are applied to major highways. The median EMC NURP data are presented in Table 2.3. There were only four land use groups considered in the NURP study final report: residential (RES), commercial (COMM), mixed commercial/residential (MIXED), and open/nonurban (OPEN). Only four monitoring sites under NURP were characterized as industrial and these sites did not represent heavy industrial land uses, but rather light industrial park land use. The industrial sites were combined with the commercial sites for the evaluation of national statistics. The FHWA highway runoff data are treated as a separate land use category (ROAD).

TABLE 2.3
MEDIAN EVENT MEAN CONCENTRATIONS
FOR ALL NURP SITES BY LAND USE CATEGORY

		Oxygen Demand & Sediment (mg/L)				Nutrients (mg/L)				Heavy Metals (mg/L)			
Land Use Category (Source)	Statistic	BOD	COD	TSS	TDS	TP	SP	TKN	NO23	Pb	Cu	Zn	Cd
Residential (USEPA NURP Table 6-12	Median CV	10.0 0.41	73 0.55	101 0.96	- -	0.383 0.69	0.143 0.46	1.900 0.73	0.736 0.83	0.144 0.75	0.033 0.99	0.135 0.84	- -
Mixed (USEPA NURP Table 6-12	Median CV	7.8 0.52	65 0.58	67 1.14	- -	0.263 0.75	0.056 0.75	1.288 0.50	0.558 0.67	0.114 1.35	0.027 1.32	0.154 0.78	- -
Commercial (USEPA NURP Table 6-12	Median CV	9.3 0.31	57 0.39	69 0.85	- -	0.201 0.67	0.080 0.71	1.179 0.43	0.572 0.48	0.104 0.68	0.029 0.81	0.226 1.07	- -
Open/Nonurban (USEPA NURP Table 6-12	Median CV	- -	40 0.78	70 2.92	- -	0.121 1.66	0.026 2.11	0.965 1.00	0.543 0.91	0.030 1.52	- -	0.195 0.66	- -
Highway	Median CV	- -	84 0.71	93 1.16	- -	0.293 1.10	- -	1.480 0.67	0.660 0.77	0.234 2.01	0.039 0.87	0.217 1.37	- -

Another primary source of loading factor data is the *Guidebook for Screening Urban Nonpoint Pollution Management Practices* developed for northern Virginia (NVPDC, 1979). To derive these loading factors, nonpoint pollution loading parameters were calibrated to single land use monitoring data using the Environmental Protection Agency Nonpoint Source (EPA NPS) model, a continuous simulation nonpoint pollution loading model (Hartigan, *et al.*, 1978, 1983). The EPA NPS model was then applied with an hourly precipitation record for a year of average rainfall to generate annual loading projections for individual land uses, which were further refined to include loading factors for different ranges of imperviousness and soil textures. With the exception of the 5-acre lot single family residential category, the NPS model projections for residential land uses assumed that all pervious area was covered with fertilized lawn surfaces. For the 5-acre lot category, it was assumed that about 2 acres was covered with fertilized lawns and about 3 acres was maintained with tree cover.

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

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

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

Where:
- M = arithmetic mean;
- T = median; and
- CV= coefficient of variation = standard deviation/mean.

Table 2.4 presents the calculated mean EMCs. The mean EMCs are allocated to the 12 land use categories as follows:

Forest/Open	OPEN
Agriculture/Pasture	OPEN
Urban Open	OPEN
Low Density Single Family Residential	RES
Medium Density SF/Institutional	RES
High Density Residential	RES
Commercial	COMM
Office/Light Industrial	COMM
Heavy Industrial	COMM
Water	WETFALL
Wetlands	WETFALL
Major Roads	ROAD

If the study area includes large portions of agricultural or wetland land use, caution should be used in applying the default EMCs since pollutant loads from agricultural or wetland areas tend to be more variable from one region to another. If local or regional agricultural or wetland EMC data are available, these data should be carefully scrutinized before applying the default values.

TABLE 2.4
MEAN CONCENTRATIONS
FOR ALL NURP SITES BY LAND USE CATEGORY

	Oxygen Demand & Sediment (mg/L)				Nutrients (mg/L)				Heavy Metals (mg/L)			
Land Use Category	BOD	COD	TSS	TDS	TP	SP	TKN	NO23	Pb	Cu	Zn	Cd
Residential	10.8	83	140	-	0.47	0.16	2.35	0.96	0.18	0.05	0.18	-
Mixed	8.8	75	102	-	0.33	0.07	1.44	0.67	0.19	0.04	0.20	-
Commercial	9.7	61	91	-	0.24	0.10	1.28	0.63	0.13	0.04	0.33	-
Open/Nonurban	-	51	216	-	0.23	0.06	1.36	0.73	0.05	-	0.23	-
Highway	9.7	103	142	-	0.44	-	1.78	0.83	0.53	0.05	0.37	-
Wetfall (Priede-Sedgwick 1983a Tbls 4-6 to 4-9; NVPDC 1983b tbl 24)	3.3	17	7	-	0.03	0.01	0.60	0.60	0.00	0.00	0.11	-

EMC data for cadmium were not analyzed in the final NURP report (USEPA, 1983b) although these constituents were routinely analyzed at several of the NURP sites and reported for local NURP projects. Cadmium was analyzed during part of the priority pollutant scans performed on 121 samples of the more than 2,300 runoff samples analyzed as part of the NURP. The priority pollutant scans were performed at 61 sites (two storm events per site) at 20 of the NURP project sites. Cadmium was detected in 48% of the limited number of NURP priority pollutant samples. Cadmium concentrations detected as part of the priority pollutant scan ranged from 0.1 to 14 ug/L. Under the Knoxville NURP project, cadmium was routinely analyzed for all storm water samples and the following geometric mean EMCs were reported:

Monitoring Site	Cadmium (ug/L)
Residential (R1)	1.5
Residential (R2)	0.6
Central Business District	1.0
Strip Commercial	0.9.

The Tampa NURP study reported mean cadmium concentrations in pooled runoff data of 2.5 ug/L (Metcalf & Eddy, 1983). The Long Island NURP study reported storm water concentrations of cadmium ranging from 0.0 to 1.0 ug/L at the NURP monitoring sites (Long Island Regional Planning Board, 1982). Monitoring data collected during 1976 and 1977 in Northern Virginia for single land use watersheds reported mean cadmium concentrations of 1.4 ug/L to 5.0 ug/L (NVPDC, 1978). Note that the Northern Virginia cadmium concentrations were not EMCs but arithmetic means of samples collected during storm events. Based on this information, a default EMC for cadmium was set at 2.0 ug/L. This EMC is assumed to apply to all urban land uses. The coefficient of variation for cadmium was assumed equal to lead.

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

$$M_L = EMC_L * R_L * K \qquad \textit{(Equation 2-3)}$$

Where:

- M_L = loading factor for land use L (lbs/ac/yr);
- EMC_L = event mean concentration of runoff from land use L (mg/l); EMC_L varies by land use and by pollutant;
- R_L = total average annual surface runoff from land use L computed from Equation 2-1 (in/yr); and
- K = 0.2266, a unit conversion constant.

By multiplying the pollutant loading factor by the acreage in each land use and summing for all land uses, the total annual pollution load from a subbasin can be computed. The EMC coverage is typically not changed for various land use scenarios within a given study watershed, but any number of land use data sets can be created to examine and compare different land use scenarios (e.g., existing versus future) or land use management scenarios. For fecal coliform, the annual load is also calculated using Equation 2-3. The conversion multiplier of 4,535,000 allows a annual load with units of counts per year to be calculated.

2.5 BEST MANAGEMENT PRACTICES. Best Management Practices (BMPs) are techniques, approaches, or designs which promote sound use and protection of natural resources. Types of BMPs include:

- ***Source Controls:*** Practices that are intended to improve runoff quality by reducing the generation and accumulation of potential storm water runoff contaminants at or near their sources. Nonstructural controls that can be analyzed by the model include: development density restrictions, restrictions on industrial/commercial land uses (or other highly impervious uses), land acquisition, and buffer zones. Other source controls such as public education programs that reduce the EMC of the runoff can also be simulated by reducing the EMC in the data file. However, presently there is nothing available in the literature to assist the user to relate source controls to reduced EMCs.

- ***Treatment Controls:*** Practices that are aimed at controlling the volume and discharge rate of runoff from urban areas as well as reducing the magnitude of pollutants in the discharge water through physical containment or flow restrictions designed to allow settling, physical removal through filtration, percolation, chemical precipitation or flocculation, and/or biological uptake. (FDER, 1988)

2.5.1 Best Management Practice Treatment Controls. The use of a specific BMP depends on the site conditions and the needs such as water quality protection, flood control, aquifer recharge, or volume control. Source controls may be analyzed with WMM by modifying land use types and impervious areas. The following comparative discussion of BMPs concentrates on <u>treatment</u> controls such as retention, swales, wet detention, and extended dry detention that can be analyzed by WMM.

<u>Retention</u>. Retention controls are typically best suited for onsite applications where the water table is low, soils are highly permeable, and the contributing area is limited to a single development site or subdivision (e.g., 1 to 50 acres). These devices include retention ponds, exfiltration trenches, infiltration pipes (underdrains) and swales. To be effective, retention controls must be an integral part of the initial design and construction of a site. Retention controls are generally difficult to retrofit to highly urban areas. Compared to detention pond BMPs, exfiltration trenches and underdrains require greater maintenance costs in the form of more frequent major cleanouts (CDM, 1985). In the absence of a continuing maintenance program, these BMPs will tend to fail within a few years after start-up. In light of these constraints, these types of retention BMPs are not recommended for regional applications. However in certain cases, retention pond BMPs may be suitable for use in regional applications where soils, water table, and available space allow.

Swales are very versatile because they can treat and convey storm water in Group A, B, or C soils. They can be used for pre-treatment or conveyance in a regional facility concept. It is important to note that often swales are designed and constructed to be deep with steep side slopes. This sours public acceptance because they take on the appearance of a ditch with standing water. Flat (or nearly flat) bottomed swales with maximum depths of 1-2 feet, and 4:1 or flatter side slopes overcome this problem. Swales are recommended for use with new development or re-development efforts in conjunction with green space or park for recreational uses.

<u>Detention</u>. Detention ponds are the most practical and effective storm water runoff management measure for flood attenuation/control and pollution abatement within most watersheds because of the physical constraints, soil conditions, and high water table. Two general categories of detention pond BMPs are currently used for runoff pollution control: wet detention and extended dry detention. Both wet and extended dry detention facilities can be designed not only for water quality control but also for flood and erosion control. The major difference between the performance of wet and dry detention ponds is the greater removal of nutrients for wet detention. Therefore, wet detention ponds are most appropriate for areas where the receiving water quality problems are caused by nutrient loadings and where metals loadings also need to be reduced.

In wet detention ponds, pollutant removal occurs primarily during the period of time between storm events within a permanent pool typically sized to provide a two-week hydraulic residence time during the wet season. The primary mechanism for the removal of particulate forms of pollutants in wet detention ponds is sedimentation. Wet detention ponds can also achieve substantial reductions in soluble nutrients due to biological and physical/chemical processes within the permanent pool. These facilities consist of a permanent storage pool (i.e., section of the pond which holds water at all times), and for new developments or where site conditions allow, an overlying zone of temporary storage to accommodate increases in the depth of water resulting from runoff. Pollutant removal within the wet detention pond can be attributed to the following important processes which occur within the permanent pool: uptake of nutrients by algae and rooted aquatic plants; adsorption of nutrients and heavy metals onto bottom sediments; biological oxidation of organic materials; and sedimentation of suspended solids and attached pollutants.

Extended dry detention ponds provide increased detention times to provide treatment for the captured first-flush runoff in order to enhance solids settling and the removal of suspended pollutants. Extended detention facilities are drawn down through a control structure at a rate which is slow enough to achieve maximum pollutant removal by sedimentation. These types of detention ponds can be designed to achieve heavy metal loading reductions which are similar to wet detention ponds (e.g., 75 percent for lead and 40 percent for zinc), since heavy metals in urban runoff tend to be primarily in suspended form. However, wet detention pond BMPs can achieve greater loading reductions for nutrients which tend to appear primarily in dissolved form in urban runoff. Extended dry detention ponds require much less storage and are less expensive than wet detention ponds because they rely upon sedimentation processes without the permanent pool expense.

2.5.2 BMP Pollutant Removal Efficiencies. The Watershed Management Model applies a constant removal efficiency for each pollutant to all land use types to simulate treatment BMPs. Recommended pollutant removal efficiencies for retention, extended dry and wet detention ponds are discussed below.

Retention Ponds. The design of retention systems is generally based on a specified diversion volume. Based on extensive field investigations and simulations using 20 years of rainfall data, average yearly pollutant removal efficiencies were estimated for fixed diversion volumes for on site (small) watersheds as presented in Table 2.6. The diversion depth is the depth of runoff water which must be stored and percolated from the total upstream drainage area that discharges to the retention pond (FDER, 1988).

Wet Detention Ponds. The USEPA NURP study monitored several wet detention ponds serving small urban watersheds in different locations throughout the U.S. (USEPA, 1983b). For wet detention ponds with significant average hydraulic residence times (e.g., 2 weeks or greater), average pollutant removal rates were on the order of 40 to 50 percent for total-P and 20 to 40 percent for total-N. For other pollutants which are removed primarily by sedimentation processes, the average removal rates were as follows: 80 to 90 percent for TSS; 70 to 80 percent for lead; 40 to 50 percent for zinc; and 20 to 40 percent for BOD. Based upon efficiencies reported by the USEPA NURP study the average pollutant removal rates shown in Table 2.6 are recommended for wet detention ponds which achieve an average hydraulic residence time of 2 weeks or greater.

Extended Dry Detention Ponds. Pollutant removal efficiencies for dry extended detention ponds are based on settling behavior of the particulate pollutants. Table 2.5 summarizes average pollutant removal efficiencies for extended dry detention ponds based on settling column data and field monitoring data. Settling column data from NURP studies and from the FHWA study were evaluated to establish the removal efficiencies for TSS and metals (USEPA, 1983b; FHWA, 1990). Removal efficiencies for the nutrients were determined by evaluating the results of two field monitoring studies of dry extended detention ponds in the metropolitan Washington, D.C. region (MWCOG, 1987). These efficiencies are applied to the percentage of total annual pollutant washoff captured for treatment in the extended dry detention pond BMP.

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

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

where:

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

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

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

Table 2.5
Average Annual Pollutant Removal Rates for Select BMPs

POLLUTANT	RANGE OF POLLUTANT REMOVAL RATES (%)			
	EXTENDED DRY DETENTION[1]	WET DETENTION[2]	RETENTION[3]	SWALES[4]
BOD5	20%-30%	20%-40%	80%-99%	20%-40%
TSS	80%-90%	80%-90%	80%-99%	70%-90%
F-COLI	10-30%	60-80%	80%-99%	0%
Total-P	20%-30%	40%-50%	80%-99%	30%-50%
Dissolved-P	0%	60%-70%	80%-99%	0%-20%
TKN	10%-20%	20%-30%	80%-99%	30%-50%
NO_2+NO_3	0%	30%-40%	80%-99%	30%-50%
Lead	70%-80%	70%-80%	80%-99%	60%-90%
Copper	50%-60%	60%-70%	80%-99%	40%-60%
Zinc	40%-50%	40%-50%	80%-99%	40%-50%
Cadmium	70%-80%	70%-80%	80%-99%	50%-80%

NOTES:
1. Extended dry detention basin efficiencies assumes that the storage capacity of the extended detention pool is adequately sized to achieve the design detention time for at least 80% of the annual runoff volume. For most areas of the U.S. extended dry detention basin efficiencies assume a storage volume of at least 0.5 inches per impervious acre.
2. Wet detention basin efficiencies assume a permanent pool storage volume which achieves hydraulic residence time of at least two weeks.
3. Retention removal rates assume that the retention BMP inadequately sized to capture at least

80% of the annual runoff volume from the BMP drainage area. For most areas of the U.S., the required minimum storage capacity of the retention BMP will be in the range of 0.50 to 1.0 inch of runoff from the BMP drainage area, but the required minimum storage capacity should be determined for each location.

4. Source: California Storm Water Best Management Practices Manual (CDM, et al, 1993).

Equation 2-4 enables the user to examine the effectiveness of various BMPs and the degree of BMP coverage within a watershed. Coverage might vary depending upon whether the BMP is applied to new development only, existing plus new development, etc. Also, topography may limit the areal coverage of some BMPs.

The nonpoint pollution load from a watershed is thus computed by combining Equations 2-3 and 2-4 and summing over all land uses and all subbasins, i.e.

$$MASS = \sum_{SB=1}^{N} \sum_{L=1}^{15} M_{L,SB} \, (1 - P_{L,SB}) \qquad (Equation\ 2-5)$$

Where:

MASS = annual nonpoint pollution load washed off the watershed in lbs/yr.

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

2.6 BASEFLOW LOADING FACTORS. Some watersheds exhibit dry weather flow due to baseflow or interflow. To determine whether baseflow discharges are a significant component of the average annual flow volume discharged from a watershed, an estimate of baseflow rate and quality should be included in the watershed pollution loading modeling analyses. The baseflow loading analysis also provides a reasonable basis for comparison of the relative magnitude of pollutant loadings during dry weather periods versus storm events. Typically, baseflow discharges are fairly constant and do not exhibit wide ranges of pollutant concentrations. Baseflow pollutant loading factors must be specified for the watershed and can be developed based upon available ambient water quality monitoring data. Annual or monthly baseflow discharge rates (cfs/sq-mi) can be estimated from daily flow records at local USGS gages.

2.6.1 Annual Baseflow Volume. Average annual baseflow (i.e., dry weather flow) for rural-agricultural areas and pervious areas in urban land uses can be estimated using simple hydrograph separation techniques. Baseflow can be computed by subtracting the annual surface runoff from the total annual stream flow measured at the stream gages located in the watershed (e.g., USGS stations).

Monthly baseflow volumes can be estimated from daily flow records at local USGS gages, however, it should be noted that the daily flows reported by USGS represent averaged data and do not provide a detailed representation of storm event hydrographs. For small tributary areas (e.g., less than 40 sq mi), the USGS records typically do not provide sufficient information to define the recession limb of the storm event hydrograph. Shorter storms are represented as simple triangular shapes. Therefore, simple hydrograph separation techniques (a straight horizontal line drawn from the point of runoff initiation to the intersection with the hydrograph recession limb), are used to identify baseflow contributions. Baseflow volumes are totaled by month for a period (1 to 5 years) characterized by average rainfall and runoff. By subtracting out the cfs-days that are clearly responses to rainfall events, this method provides an estimate of cfs-days that are between storm events which are summed to compute baseflow volume. Regional values of average monthly baseflow in cfs per square mile of contributing area can be developed for the study area. If site specific data are not available for a study watershed, the regional average monthly flow data provides a reasonable approximation of relative baseflow contributions.

2.6.2 Baseflow Concentrations. Ambient water quality monitoring data collected within the watershed or nearby watersheds are used to represent baseflow (dry weather) concentrations of nutrients and heavy metals. The locations of ambient water quality sampling stations monitored by local, state or federal agencies should be identified within the region. Statistical summaries of the available water quality monitoring data for sampling stations should be prepared.

For monitoring stations which were not influenced by WWTP or other point source discharges or other influences such as CSOs, illicit connections and failing septic tanks, mean concentrations of nutrients and heavy metals can be used to characterize baseflow water quality in the watershed for the model. If water quality monitoring data are not available within the study watershed, baseflow can be assumed to exhibit the characteristics from stream monitoring stations in the vicinity.

Baseflow concentrations are assumed to be representative of baseflow water quality which is not impacted by other pollutant sources such as point sources, CSOs or failing septic tanks. For each subbasin and land use scenario, baseflow volumes are multiplied by the appropriate concentrations described above to derive baseflow pollutant loadings discharged from the study watershed.

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

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

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

2.8 COMBINED SEWER OVERFLOWS. Within some watersheds, combined sewer overflows (CSOs) may be a pollutant source contributing to degraded water quality within a river system. In many cities throughout the United States, storm water runoff and sanitary wastewater are collected in the same sewer (combined sewers.) In dry weather conditions, all sewer flows are conveyed to and treated at the local or regional wastewater treatment plant. During wet weather events, the combined sewage flow may become too large for the sewer system and may overflow into the nearest receiving water system. These events are referred to as CSOs. These discharges produce high concentrations of pollutants such as oxygen demand, solids, nitrogen, phosphorus, and heavy metals. Pollutant loadings from combined sewer overflows can be estimated in the pollution loading modeling analysis to compare the impacts of CSOs to other pollution loading sources in the watershed.

2.8.1 CSO Flow Estimates and Pollutant Loading Factors. Combined sewer overflow water quality monitoring data collected within the watershed or nearby watersheds are used to represent CSO concentrations in the pollution loading modeling analysis. Event mean concentrations (EMCs), rather than discrete sampling data, are required to give a composite representation of overflow events. Because of the variability of CSO pollutant concentrations from system to system it is inappropriate for default CSO pollutant concentrations to be recommended.

2.8.2 CSO Controls. Several types of controls are available for the elimination or reduction of combined sewer overflows. Sewer separation, in which a new sewer is constructed so that storm water may be conveyed directly to the receiving water (lake, stream, etc.), allows for elimination of CSOs and their pollutant loads. However, storm water pollution contribution of select pollutants may increase with use of this type of control. For example, heavy metals pollutant load concentrations are often higher than the metals concentrations found in CSOs.

An alternative method of CSO control involves the use of CSO detention facilities. The effectiveness of these CSO controls may be for each CSO control option modeled. The WMM applies a constant removal percentage associated with each of the treatment control alternatives for each of the modeled constituents in the following manner:

$$CSOMASS_{Scenario} = \sum CSO_{SB} * (1 - CSOREM_{SB,\ Scenario}) \qquad \textit{(Equation 2-6)}$$

Where:

CSOMASS = annual CSO pollution load discharged from the CSO subarea;

CSO = annual CSO pollution load generated from the CSO subarea;

CSOREM = percent of annual pollution load captured by the control alternative; and

Scenario = CSO pollution loading control scenario.

CSO removal rates should be determined based upon detention time, basin dimensions and configuration.

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

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

Therefore, during an average year, 5 to 15 percent of the septic tanks systems in the watershed are assumed to be failing.

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

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

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

The low, medium, and high concentrations are used in the model sensitivity analysis described in the uncertainty analysis section of this manual. Annual "per acre" loading rates for septic tank failures from low density residential land uses were then estimated assuming 50 gallons per capita per day wastewater flows. The loading rates can be applied to the percentage of all non-sewered residential land uses with failing septic tanks. The septic tank loading factors are included in the runoff pollution loading factors. The range of percent increases in annual per acre loadings attributed to failing septic tanks is:

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

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

2.10 DELIVERY RATIO/TRAVEL TIME. The nonpoint pollution loading factors represent estimates of loadings which have been discharged into a storm sewer, swale, or stream channel. Therefore, these loading factors represent discharges into the smaller tributary stream channels throughout the watershed. Pollutant loadings to these small tributary stream channels may be of interest in some studies. In most cases, the model is applied to provide an estimate of the loads delivered to a downstream receiving water such as a lake or reservoir. In large watersheds, where maximum instream travel times during storm events are one day or greater, the storm event loadings discharged to a downstream receiving water are likely to be reduced due to sediment deposition or biological decay en route to the point of discharge. Since large infrequent flood events can scour out stream beds and transport deposited pollutant loads downstream, some studies make the assumption that 100 percent of the nonpoint pollution loadings discharged into a stream will ultimately be delivered to the receiving water. But if the user wants to simulate average delivery between those very large events, the Watershed Management Model incorporates a pollutant delivery ratio into annual pollution loading evaluations to account for instream sedimentation and decay.

The pollutant delivery ratio method used in the model is consistent with the nonpoint pollution loading factors in that it accounts for pollutant sedimentation and decay only during instream transport. Locational differences in the discharge of pollutants into streams are not accounted for, although land areas that adjoin a stream are likely to deliver a higher loading than land areas that are farther from the stream channel. Because there is insufficient monitoring data available in the literature on relative differences in pollutant loadings for "onstream" and "offstream" sites, it is generally assumed that the available monitored loading factors reflect an average of the two. In other words, within the single land use test watersheds monitored to develop these loading factors (e.g., NVPDC, 1979; USEPA, 1983b), it is assumed that the areas adjoining the drainage way produced a higher pollutant delivery ratio and that the upland areas produced a lower delivery ratio, with the loading factors representative of the composite loadings.

One approach used to estimate the pollutant delivery ratio is described below and other methods for estimating delivery ratio are presented in the literature (Novotny and Chesters, 1981). The method for estimating delivery ratio is based on travel time from the mouth of a watershed or subbasin to the point of runoff discharge. This method assumes that suspended pollutants settle out in a stream channel while being transported to a downstream receiving water. The methodology applies to suspended pollutants only, with dissolved pollutants assumed to exhibit 100 percent delivery to the receiving water. In addition to being useful for evaluations of water quality impacts of nonpoint pollution loadings, the pollutant delivery ratios can be used to identify the most critical sections of a watershed in terms of pollutant delivery potential. The suspended fraction data input into the model are used in the deliver ratio calculation.

Ideally, the delivery ratio method should be applied to the range of storm events which occur over the course of one or more years for determinations of travel time contours and long-term pollutant deposition rates. The selected approach approximates long-term impacts by using regional statistics on "average" rainstorm conditions. Based on statistics on the mean duration and mean volume for regional rainfall events, travel times and pollutant delivery ratios can be estimated using sedimentation calculations for channel transport periods.

Since settling velocities for specified particle sizes apply only under quiescent flow conditions, the duration of turbulent flow resulting from rainfall runoff is an important assumption. For approximate delivery ratio calculations based on triangular hydrograph approximations, it is reasonable to assume that the maximum duration of turbulent flow in the major stream channel system is about 1.5 to 2.0 times the rainstorm duration (Reckow, et al., 1988). For example, since storm events in the southeastern U.S. have a mean duration of 4 to 8 hours, the maximum duration of turbulent stream flow conditions which may preclude settling of suspended pollutants is 12 to 16 hours.

Channel slopes and cross-section characteristics should be estimated for the main stem channel system within a watershed. Based on rational formula calculations for existing land use conditions, flow rates for the mean storm event can be estimated for stream channels in the watershed. Using the Manning equation, stream channel velocities can be calculated for specified reaches, and cumulative travel times can be calculated for the watershed. Maximum travel times to the tributary mouth from headwater areas are calculated by summing the cumulative travel time within each subbasin. Settling velocities for suspended pollutants are approximately about 0.1 ft/hr (fine/very fine silt particles) (FHWA, 1990). Under the assumption that turbulent stream flow conditions (i.e., periods of no sedimentation) occurred for 12 to 16 hours after the start of rainfall, sedimentation rates can be calculated for transport from different sections of the watershed. The sedimentation calculations were based on the ratio of depth settled by a particle following the turbulent flow period to the total depth of flow. In subbasins where mean instream travel times are less than 24 hours, 100 percent delivery of suspended pollutants is likely. For watersheds where travel times are difficult to estimate, the delivery ratio can be set at 100% to conservatively estimate pollutant loadings to the receiving waters. The delivery ratio can also be used as a model calibration parameter if sufficient water quality monitoring data are available.

2.11 MODEL CALIBRATION. If sufficient monitoring data are available for the study watershed, the model should be calibrated to both runoff quantity and quality. This is a two-step procedure since the water quality calibration is a function of the predicted runoff volumes. It is therefore essential to properly calibrate the runoff quantity section before attempting to calibrate the water quality section.

2.11.1 Runoff Calibration. The runoff quantity model should be calibrated to the same period that the water quality monitoring data were collected. The model is designed to use annual or seasonal flow volumes and nutrient loads, so the model's runoff section should be calibrated to match the average annual seasonal or runoff during the calibration period, using Equation 2-1.

The available gaged flow volumes used in the calibration should be tabulated for the long term period, as well as the calibration period, to determine whether hydrometerologic conditions were wet, dry or normal. The pervious and impervious areas runoff coefficients can be adjusted to match available data. Those coefficients can be used to account for surface runoff, initial abstractions, and evapotranspiration. Typical ranges of the runoff coefficients are:

Pervious	0.05 - 0.30 (FDOT Drainage Manual, 1987)
Impervious	0.85 - 1.0 (Linsley and Franziani, 1979)

2.11.2 Water Quality Calibration. It is necessary to use professional judgement about the appropriate values of the water quality calibration coefficients. Each of the land use categories has three coefficients which can be varied to change the predicted pollutant load:

1) the assigned fraction of impervious area,
2) the pollutant EMC, and
3) the pollutant delivery ratio.

The impervious area values will impact the runoff calibration process and should not be varied if the runoff coefficient derived from them appears reasonable. Therefore, only the pollutant EMC and the pollutant delivery ratio should be used for calibration. These two coefficients are independent of each other because each of the 12 land use categories has EMC values for each pollutant that can be varied independently of the other land use EMCs. While the model has this capacity, the available data are not typically sufficient to support such a detailed calibration. Model calibration typically will involve varying the pollutant delivery ratio so that the EMC values for each land use category remain at their mean literature values. This is the same as varying all the land use EMCs by the same pollutant delivery ratio. This will simplify the water quality calibration process to the variation of the pollutant delivery ratio assigned to each subbasin. Pollutant delivery ratios can be initially estimated using the travel time technique described in the Delivery Ratio/Travel Time Section. This procedure will yield a lower delivery ratio for subbasins located in the headwaters of the watershed. Subbasins located near the mouth of the watershed are likely to discharge 100 percent of the pollutant loading into the receiving water.

Water quality calibration will involve comparison of the annual pollutant loads predicted by the model to actual annual pollutant loads based on monitoring data. Water quality calibration typically will require 3 to 5 years of monitoring data. The monitoring data should be evaluated carefully to ensure that it includes samples collected over a range of storm events. Water quality sampling is often performed only during ambient (dry weather) conditions. However, the majority of the pollutant load is transported during storm events. The monitoring data used for calibration should report storm event EMCs for a statistically representative number of storms (e.g., greater than 10).

2.12 UNCERTAINTY ANALYSIS. Because the nonpoint pollution loading factors used in the Watershed Management Model were derived from national statistics, the model includes the capability to perform an uncertainty analysis with a range of literature values for each land use category. The calculated from the loading factors (lbs/acre/year) EMCs (mg/L) based on the average annual runoff estimates are assumed to be representative of a "medium" or "most probable" estimate of the nonpoint pollution loading factor for each specific land use. The purpose of the uncertainty analysis is to develop estimates of the extremes, high and low values of pollutant loadings and to assess whether these estimates would result in different management decisions.

A statistical approach is used to estimate the "high" and "low" loading factors for each pollutant. Based on a review of monitoring study data, a Coefficient of Variation (CV) is applied to for EMCs specific to each pollutant and each land use. The CV is calculated as the standard deviation divided by the mean and provides an indication of the relative degree of uncertainty associated with the EMC estimates.

Based upon the NURP study results (USEPA, 1983b), the CVs assigned to each pollutant and to each land use category are summarized in Table 2.13 for total-P, total-N, lead and zinc. Forest and open land uses have CVs of zero since the available monitoring data suggest that there is very little variability among rural watersheds. The CVs for nutrient loading factors from cropland are highly variable, and monitoring studies indicate that there is much uncertainty about nonpoint pollution loading factors from this type of land use. This uncertainty is a result of the wide range of tillage practices, fertilizer application rates, cropping practices, etc. which are represented by a single loading factor. For urban land uses, the CVs range from 0.5 to 1.0 (USEPA, 1983b), which reflects a degree of uncertainty in the EMC estimates.

"High" and "low" EMCs are computed from the mean EMC and CV estimated for each pollutant and land use category based on a specified probability of exceedance. An EMC in the 90th percentile will be exceeded during only 10% of storm events, whereas an EMC in the 10th percentile will be exceeded during 90% of storm events. The following relationship is used to calculate "high" and "low" EMCs:

$$EMC_{(HIGH,LOW)} = e^{(U + Z + W)} \qquad \textit{(Equation 2-7)}$$

Where:

EMC = "High" or "low" EMC;
U = log mean;
U = LN (M/SQRT(1+CV^2));
Z = standardized normal deviate:
  Z = 1.645 for 95% percentile,
  Z = 1.282 for 90% percentile,
  Z = -1.645 for 5% percentile, and
  Z = -1.282 for 10% percentile;
W = log standard deviation; and
W = SQRT(LN(1 + CV^2)).

By changing the standardized normal deviate (Z), any pair of percentiles can be used to generate "high" and "low" EMC values. The range of EMCs generated by the "high" and "low" reflects the effects of the coefficient of variation on the EMCs. Table 2.14 and 2.15 present "high" and "low" EMCs based on the 95% and 5% percentile. As may be seen, a higher coefficient of variation results in a greater spread of the "high" and "low" EMC estimates.

The model user may select a single EMC estimate (e.g., low, medium or high) or all three EMC estimates. If all three EMC estimates are selected, the annual loadings discharged from a watershed are automatically computed in the WMM for the medium EMC estimates and for both the high and low EMC estimates for each land use scenario.

2.13 MODEL LIMITATIONS. The Watershed Management Model projects average annual or seasonal pollutant loadings discharged from the watershed. The model may also be used to predict the cumulative effects of alternative watershed management decisions (e.g. treatment BMPs or CSO controls). The models should be applied to appropriate spatial (watershed wide) and temporal (average annual) scales. It is not appropriate to use these input/output models for analysis of short-term (i.e., daily, weekly) water quality impacts, nor for incremental area (i.e., development of several hundred acres) water quality impacts. For example, it is not appropriate to use this model to evaluate the downstream water quality impacts of development projects that are only a small percentage (e.g., less than 10%) of a watershed drainage area.

Table 2.6
COEFFICIENT OF VARIATION
ASSIGNED FOR THE WATERSHED MANAGEMENT MODEL

		Oxygen Demand & Sediment				Nutrients				Heavy Metals			
Land Use Category	Percent Impervious	BOD CV	COD CV	TSS CV	TDS CV	TP CV	SP CV	TKN CV	NO23 CV	Pb CV	Cu CV	Zn CV	Cd CV
Forest/Open	0.5%	0.5	0.5	0.5	0.5	0.7	0.7	0.5	0.5	0.0	0.0	0.0	0.0
Agriculture/Pasture	0.5%	0.5	0.5	0.5	0.5	0.7	0.7	0.5	0.5	0.0	0.0	0.0	0.0
Cropland	0.5%	0.5	0.5	0.5	0.5	0.7	0.7	0.5	0.5	0.0	0.0	0.0	0.0
Low Density Single Family	10.0%	0.4	0.6	1.0	1.0	0.7	0.5	0.7	0.8	0.8	1.0	0.8	0.8
Medium Density Single Family	30.0%	0.4	0.6	1.0	1.0	0.7	0.5	0.7	0.8	0.8	1.0	0.8	0.8
High Density Single Family	50.0%	0.4	0.6	1.0	1.0	0.7	0.5	0.7	0.8	0.8	1.0	0.8	0.8
Commercial	90.0%	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Office/Light industrial	70.0%	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Heavy Industrial	80.0%	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Water	100.0%	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Wetlands	100.0%	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Major Roads	90.0%	0.7	0.7	1.2	1.2	1.1	2.0	0.7	0.8	2.0	0.9	1.4	1.4

TABLE 2.7
"HIGH" EVENT MEAN CONCENTRATIONS (95TH PERCENTILE)
BY LAND USE CATEGORY

		Oxygen Demand & Sediment				Nutrients				Heavy Metals			
Land Use Category	Percent Impervious	BOD CV	COD CV	TSS CV	TDS CV	TP CV	SP CV	TKN CV	NO23 CV	Pb CV	Cu CV	Zn CV	Cd CV
Forest/Open	0.5%	15.6	99	420	195	0.54	0.14	2.65	1.43	0.00	0.00	0.00	0.000
Agriculture/Pasture	0.5%	15.6	99	420	195	0.54	0.14	2.65	1.43	0.00	0.00	0.00	0.000
Cropland	0.5%	15.6	99	420	195	0.54	0.14	2.65	1.43	0.00	0.00	0.00	0.000
Low Density Single Family	10.0%	19.1	170	382	273	1.07	0.29	5.57	2.42	0.43	0.13	0.43	0.005
Medium Density Single Family	30.0%	19.1	170	382	273	1.07	0.29	5.57	2.42	0.43	0.13	0.43	0.005
High Density Single Family	50.0%	19.1	170	382	273	1.07	0.29	5.57	2.42	0.43	0.13	0.43	0.005
Commercial	90.0%	15.3	106	232	256	0.55	0.23	2.32	1.21	0.29	0.09	0.95	0.006
Office/Light industrial	70.0%	15.3	106	232	256	0.55	0.23	2.32	1.21	0.29	0.09	0.95	0.006
Heavy Industrial	80.0%	15.3	106	232	256	0.55	0.23	2.32	1.21	0.29	0.09	0.95	0.006
Water	100.0%	6.3	33	13	195	0.07	0.02	1.09	1.14	0.00	0.00	0.32	0.000
Wetlands	100.0%	6.3	33	13	195	0.07	0.02	1.09	1.14	0.00	0.00	0.32	0.000
Major Roads	90.0%	22.5	240	425	298	1.28	0.49	4.03	2.03	1.90	0.13	1.18	0.006

TABLE 2.8
"LOW" EVENT MEAN CONCENTRATIONS (5TH PERCENTILE)
BY LAND USE CATEGORY

		Oxygen Demand & Sediment				Nutrients				Heavy Metals			
Land Use Category	Percent Impervious	BOD CV	COD CV	TSS CV	TDS CV	TP CV	SP CV	TKN CV	NO23 CV	Pb CV	Cu CV	Zn CV	Cd CV
Forest/Open	0.5%	3.3	21	89	41	0.07	0.02	0.56	0.30	0.00	0.00	0.00	0.0000
Agriculture/Pasture	0.5%	3.3	21	89	41	0.07	0.02	0.56	0.30	0.00	0.00	0.00	0.0000
Cropland	0.5%	3.3	21	89	41	0.07	0.02	0.56	0.30	0.00	0.00	0.00	0.0000
Low Density Single Family	10.0%	5.2	31	27	19	0.14	0.07	0.65	0.22	0.05	0.01	0.04	0.0005
Medium Density Single Family	30.0%	5.2	31	27	19	0.14	0.07	0.65	0.22	0.05	0.01	0.04	0.0005
High Density Single Family	50.0%	5.2	31	27	19	0.14	0.07	0.65	0.22	0.05	0.01	0.04	0.0005
Commercial	90.0%	5.7	31	21	23	0.07	0.03	0.60	0.27	0.04	0.01	0.05	0.0003
Office/Light Industrial	70.0%	5.7	31	21	23	0.07	0.03	0.60	0.27	0.04	0.01	0.05	0.0003
Heavy Industrial	80.0%	5.7	31	21	23	0.07	0.03	0.60	0.27	0.04	0.01	0.05	0.0003
Water	100.0%	1.3	7	3	41	0.01	0.00	0.25	0.25	0.00	0.00	0.02	0.0000
Wetlands	100.0%	1.3	7	3	41	0.01	0.00	0.25	0.25	0.00	0.00	0.02	0.0000
Major Roads	90.0%	2.8	29	20	14	0.07	0.03	0.54	0.21	0.03	0.01	0.04	0.0002

3.0 STRUCTURE AND OPERATION OF THE WATERSHED MANAGEMENT MODEL.

The Watershed Management Model (WMM) for Windows is based on model run scenarios with each scenario consisting of a user defined set of data input files. (Note: Technically they are not files but a collection of related database records, however it is easier to think of them as files.) WMM assists the user in creating, managing and associating these input files in preparation for a model run. Once a scenario has been established, the model is run and the resultant output is both displayed to the user and stored for later use. This section describes the structure of the Watershed Management Model (WMM) and how the model may be applied.

WMM for Windows is composed of three modules described as follows and shown in Figure 3-1:

- The **Default Manger** allows the user to create default files for each of the main data input areas (e.g. landuse, parameters, EMC values, etc.). The default files allow the user to have a starting point when creating new input files.

- **Output Manger** manages the model output data sets created when the model is run. Here the user can display output from any of the previous model runs in a variety of different formats. This is also the module where the user can delete unwanted model output.

- The **Scenario Manager** is the heart of WMM. This is where data input files are created and managed, model scenarios are assembled and model execution takes place. This is also where data from the non-Windows based WMM Version 3.30 may be imported.

3.1 INSTALLATION AND STARTUP OF THE WATERSHED MANAGEMENT MODEL.

To install WMM for Windows, insert the CD or diskette into the appropriate drive. In File Manager or Windows Explorer, double click on **Setup.exe**. To initiate the WMM for Windows application, double click on the **WINWMM** icon in Windows. Click on **Continue** after reading the information/disclaimer screen to reach the main WMM screen (Figure 3-2). You are now ready to begin setting up the model of your watershed.

Figure 3-2 shows the introductory screen of the model, providing three options allowing the user to enter the Default Manager, Output Manager or Scenario Manager modules of the model by selecting the appropriate button. File management also takes place through this screen, by selecting the **File** pull down menu. A new project file can be created by selecting the **New Project** button and entering a new file name when prompted. When a new project is created, the base project data set may be selected by highlighting the desired data set in the pull down menu on the right of the pop up screen. This option allows data for individual clients and projects to be stored in separate data base files, and for old data sets to be used to build new data sets under different project names. An existing project may be opened by clicking on the **Open Project** button and selecting the project you wish to use for your modeling session.

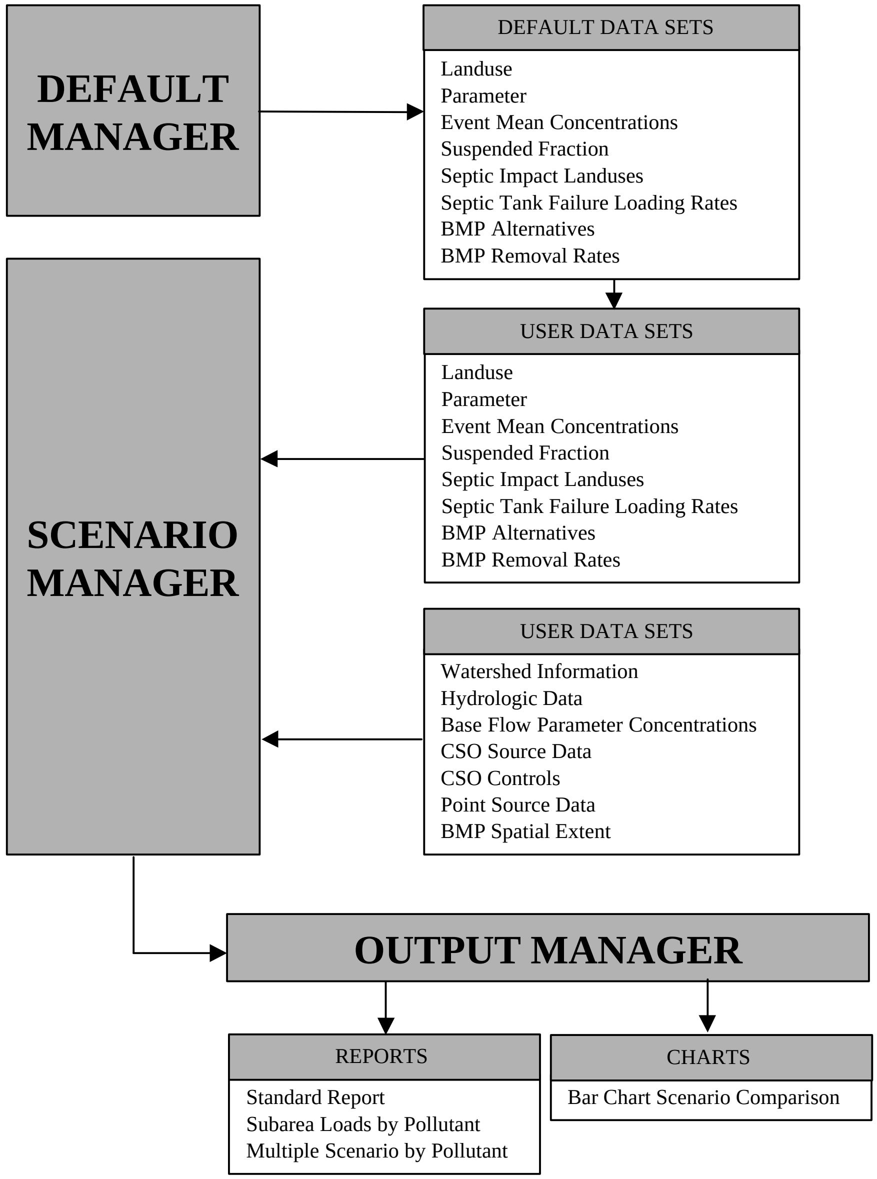


Figure 3-1
Schematic of Watershed Management Model

Figure 3-2
Main Menu

3.2 DEFAULT MANAGER. From the Default Manager window (shown in Figure 3-3) the user selects the category for the default file they wish to modify, by clicking on the appropriate button. Upon selection, a new window opens with the selected file ready for editing. To exit the Default Manager window and return to the main menu, click the **OK** button. Because default files are interrelated (e.g. Event Mean Concentration Files are dependent upon both landuse types and parameters) **modifications should be made to default files from the top to the bottom of the menu**. Additionally, it is important to note that all new land use types, parameters, and best management practices **must** first be entered into the Default Manager before they can be used in the Scenario Manager.

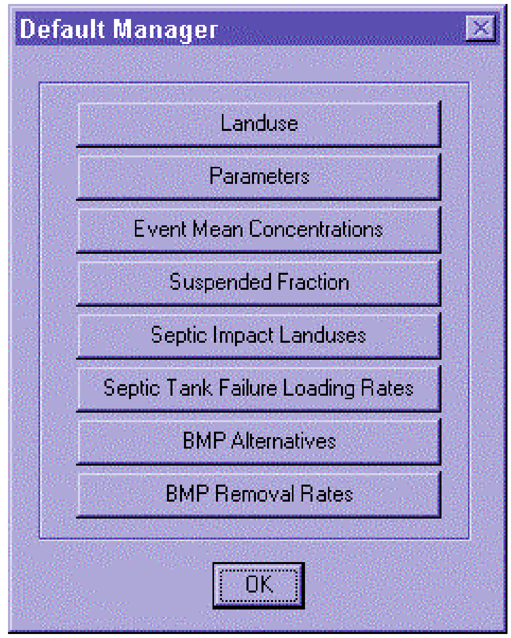


Figure 3-3
Default Manager Menu

3.2.1 Default Landuse. To add a new landuse category click the **Add** button, as shown in Figure 3-4. You will be prompted with a message notifying you that adding a new landuse type to the Default Landuse File will also result in the new landuse type being added to the Default EMC and Suspended Fraction files. Additionally, it is important to remember that all land use types need for use in the scenario manager must be included in the default land use types. Click **OK** and enter the new landuse type and the % impervious in decimal format. Click **Save** to save your change or **Cancel** to quit without saving the change.

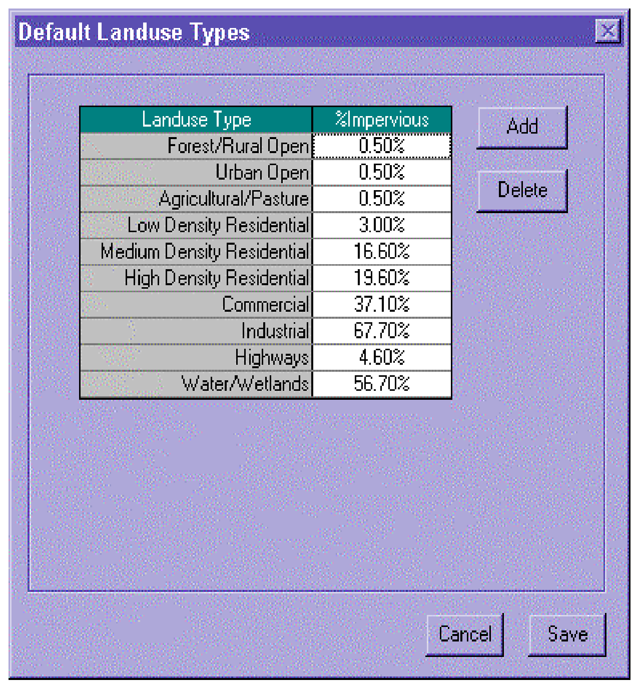


Figure 3-4
Default Land Use Types

To delete a landuse type, click the landuse type you wish to delete and then click the delete button. Similar to above, you will be prompted with a message notifying you that deleting a landuse type from the Default Landuse File will also result in the landuse type being deleted from the Default EMC and Suspended Fraction files. When done modifying the file, click **Save** to save your changes or **Cancel** to cancel your changes and restore the original values.

3.2.2 Default Parameters. To add a new parameter click the **Add** button in the Default Parameters Screen, as shown in Figure 3-5. You will be prompted with a message notifying you that adding a new parameter to the Default Parameter File will also result in the new parameter being added to the Default BMP Removal Rate, EMC, Suspended Fraction and Septic Tank Failure Loading Rate files. Click OK and enter the new parameter and description. Click **Save** to save your change or **Cancel** to quit without saving the change.

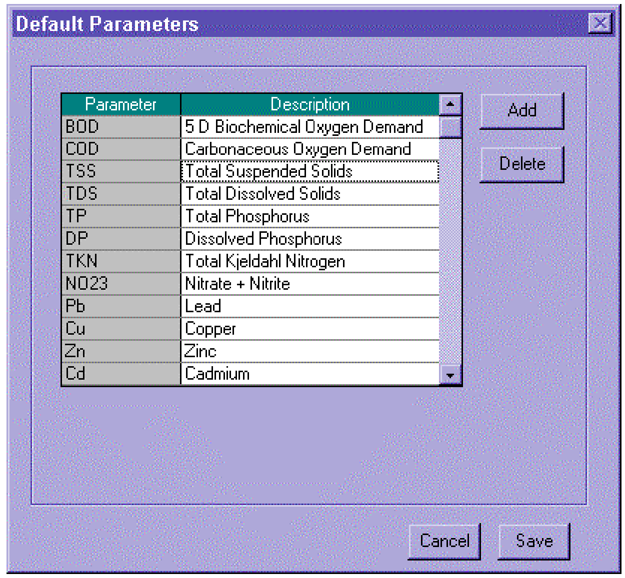


Figure 3-5
Default Parameters

To delete a parameter type, click the parameter you wish to delete and then click the **Delete** button. Similar to above, you will be prompted with a message notifying you that deleting a parameter from the Default Parameter File will also result in the new parameter being deleted from the Default BMP Removal Rate, EMC, Suspended Fraction and Septic Tank Failure Loading Rate files. When done modifying the file, click **Save** to save your changes or **Cancel** to restore the original default parameters and return to the Default Manager Menu.

3.2.3 Default EMC Values. To edit EMC values and associated coefficients of variation for each landuse type, click on the landuse type you wish to edit and enter the new values in the table, as shown in Figure 3-6. Note that all EMC values need to be entered in concentrations of mg/L. Click **Save** to save the changes or **Cancel** to undo changes and restore the original default EMC values. If a parameter or landuse was added to the default manager, new EMC values will need to be entered into this data set.

3.2.4 Default Suspended Fraction Values. To edit suspended fraction percentages for each parameter and land use, click on the landuse type you wish to edit and enter the new values in the table, as shown in Figure 3-7. These percentages are used in the travel times and delivery ratio calculations, when travel time and delivery ratio are taken into account. For the Rouge modeling purposes, travel time and delivery ratios were not taken into account. Again, note that the values should be entered as decimals (e.g. 0.25 equals 25%). Click **Save** to save all changes, **Cancel** to undo changes and return to the previous default suspended fraction values. If a parameter or landuse was added to the default manager, new suspended fraction values will need to be entered into this data set.

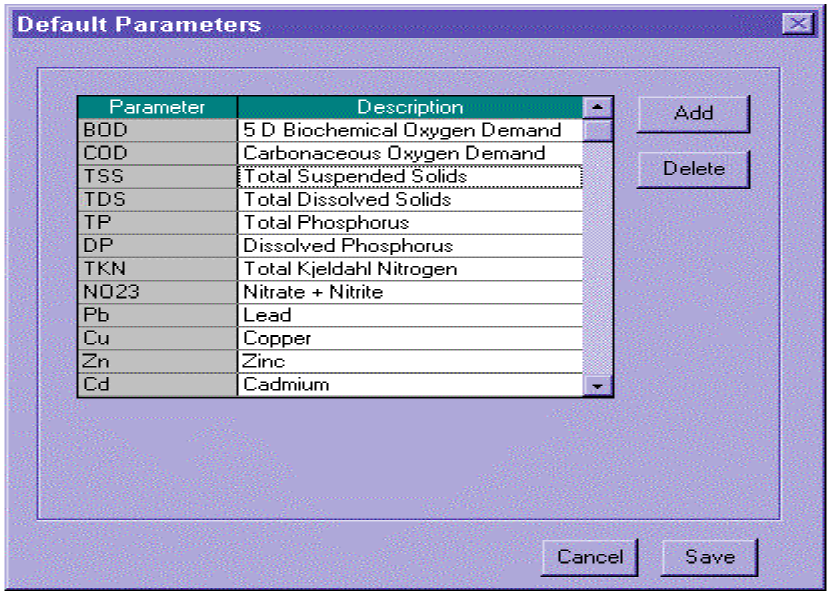


Figure 3-6
Default EMC Values

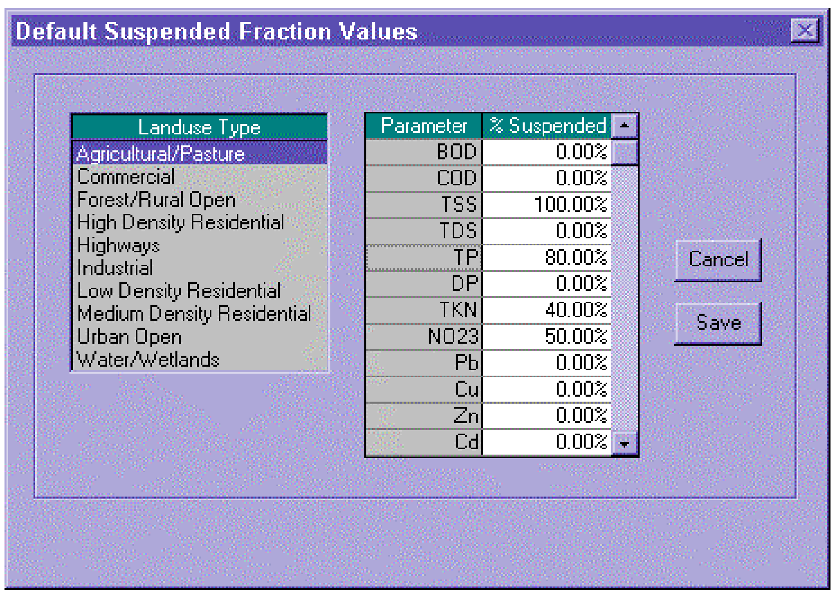


Figure 3-7
Default Suspended Fraction Values

3.2.5 Default Septic Impact Landuse Types. Figure 3-8 shows the screen obtained by clicking on the **Septic Impact Landuses** button in the Default Manager screen. By clicking on the **Add/Delete** button, a new window opens (shown in Figure 3-9) which allows the user to add or delete landuse types. By using the >, >>, <**,** and << buttons, landuse types can be moved from the available list on the left to the selected list on the right. Click **Save** to save all changes, **Cancel** to undo changes and return to the previous values.

3.2.6 Default Septic Failure Loading Rates. Modify septic tank failure loading rates by first selecting the landuse type and then the concentration level for which you wish to modify values, as shown in Figure 3-10. Enter the new multiplier values for each parameter into the table. These multipliers are used to increase the storm water pollutant load in the

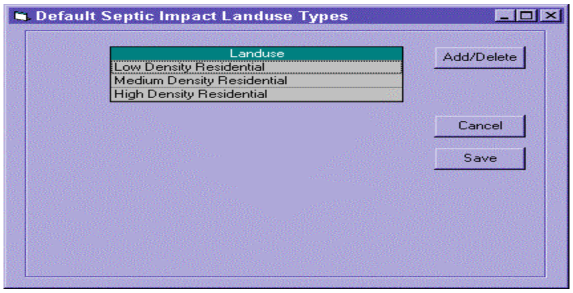


Figure 3-8
Default Septic Impact Landuse Types

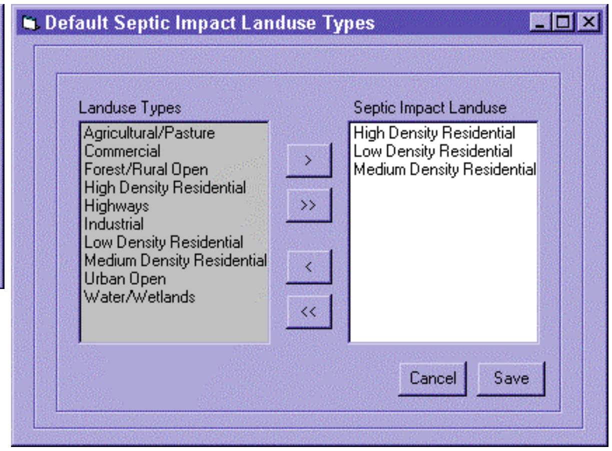


Table 3-9
Default Septic Impact Landuse Types - Modify Landuses

areas affected by failing septic tank impacts. If new parameters were added to the default manager, septic impact multipliers must be entered for new parameters. Click **Save** to save all changes, **Cancel** to undo and return the previous values.

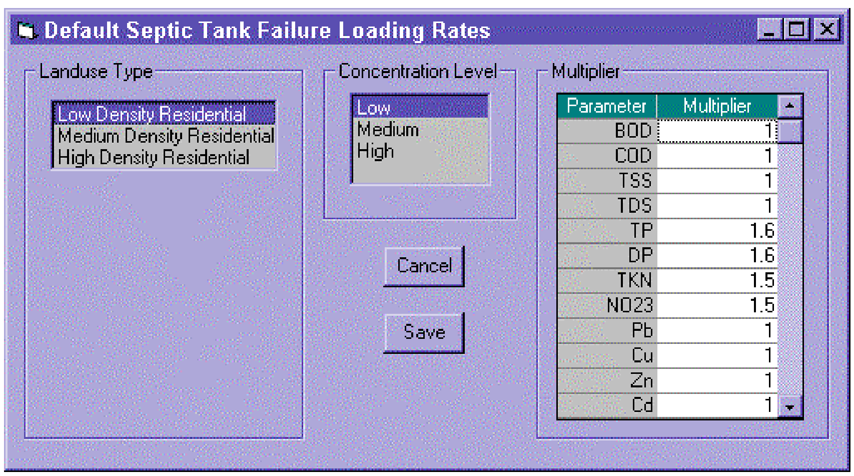


Figure 3-10
Default Septic Tank Failure Loading Rates

3.2.7 **Default BMP Alternatives**. Add BMP alternatives by clicking the **Add** button and typing the new BMP and a description in the table, as shown in Figure 3-11. You will be notified that adding a new BMP will result in it being added to the BMP Removal Rate default file. To delete a BMP, select the BMP by clicking on it and then click the **Delete** button. As described above, you will be notified that deleting a BMP will result in it being deleted from the BMP Removal Rate default file. Click **Save** to save all changes, **Cancel** to undo changes and return to the previous values.

3.2.8 Default BMP Removal Rates. As shown in Figure 3-12, pollutant load reductions for each best management practice may be assigned for each pollutant parameter by clicking on the BMP type and then entering new removal rate values in the table. Values should be entered as decimal percent (e.g. 0.25 equals 25%). Click **Save** to save all changes, **Cancel** to undo changes and return to the previous default values. Again, note that if a new parameter was added to the default manager, BMP pollutant removal efficiencies will need to be entered for the new parameter.

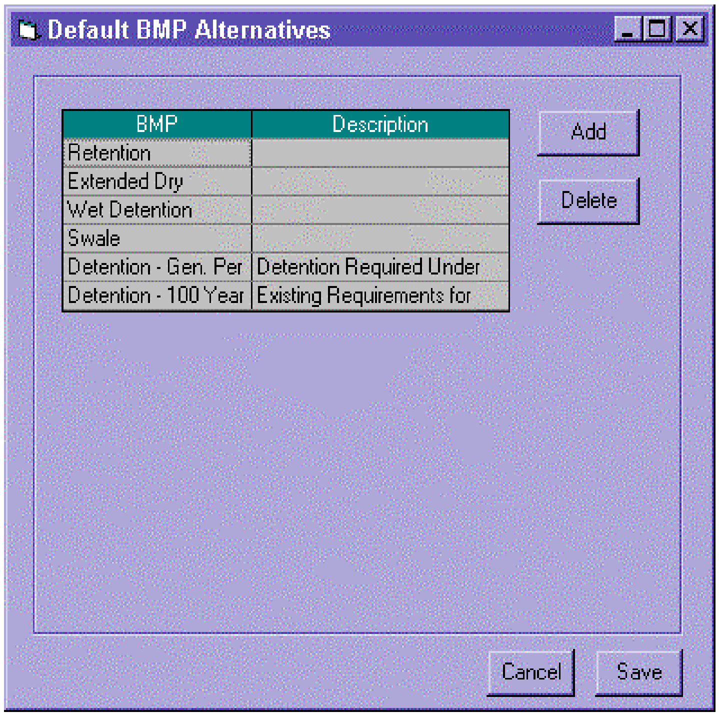


Figure 3-11
Default BMP Alternatives

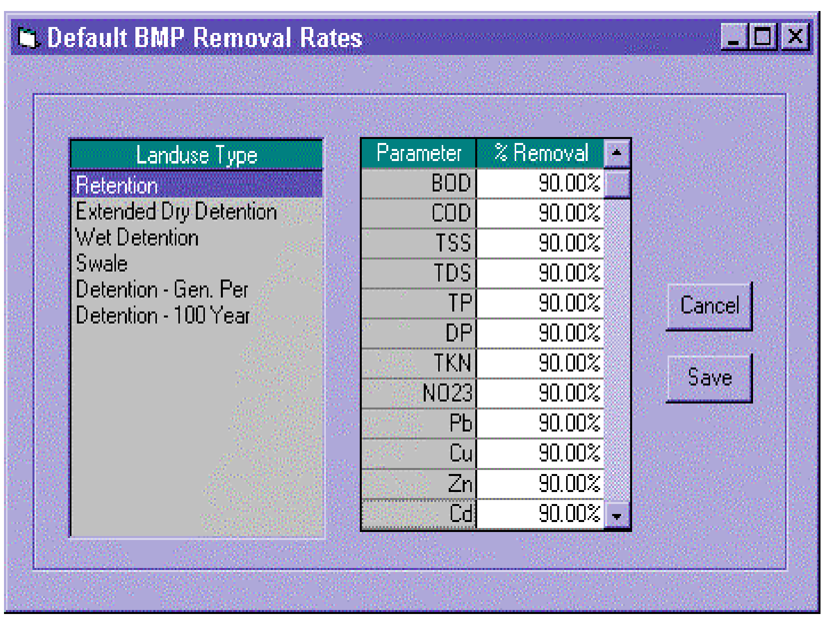


Figure 3-12
Default BMP Removal Rates

3.3 SCENARIO MANAGER 1. The Scenario Manager is the heart of WMM and is where data input files are created and managed, model scenarios are assembled and where model execution takes place. The user builds scenarios by creating new input files, selecting existing files accessed through the two main windows of this module and/or importing old data files from the non-Windows based version of WMM, release 3.30. It is important for the user to remember, however, that all new land use types, pollutant parameters, and best management practices must be entered in the default manager before they may be used in the Scenario Manager module of WMM for Windows.

The Scenario Manager module is accessed by clicking on the **Scenario Manager** button in the main menu screen of WMM. There are several file management operations that are universal for data set management within Scenario Manager. These options are shown Figure 3-13, Page One of the Scenario Manager, and are described as follows:

- By clicking the list drop down button the user can obtain a list of all existing files. To select a file for use, click on the file name in the list.
- Clicking anywhere in the file list box will cause the action buttons for that input set to be displayed. These buttons are used to view/edit existing files, create new files, delete existing files or import files from WMM Version 3.30.
  To view/edit an existing file, select the desired file from the list box and click the **View/Edit** button. A new window will open, displaying the selected file.
- Create a new file by clicking on the **New** button and then selecting the Default Set option. If the new file being created is one for which default values exist, a new file will be created with the appropriate default values. The default values can then be edited as necessary. If a new file is being created for a category where default values do not exist, a blank form for entering data is displayed. Each file has an associated name and description field that must be filled.
- Spreadsheet files from WMM Version 3.30 may be imported for all data sets required to run WMM for Windows by clicking on the **New** button and selecting the Import from Version 3.30 button. See Appendix E for additional information on the import functionality of this modeling software.
- Delete a file by selecting the file you wish to delete in the file list box and then click the **Delete** button. You will be prompted with a question asking if you really want to delete the file.
- Clicking the **Next** button takes you to the Scenario Manager 2 screen, clicking the **Before** button returns you to the main WMM screen.

It is important to note that data files should be created, imported and/or modified in the order they are listed in Scenario Managers 1 and 2. For example, changes to the parameter set for the current scenario impacts EMC mean values, base flow parameters and concentrations, etc. If changes are not made in the order the data sets are listed, data incompatibility flags may appear next to the incompatible data sets. These flags disappear as these related data sets are updated to reflect any changes made to the land use, parameter or watershed data sets. The incompatible data sets will automatically be updated when they are opened using the **View/Edit** button. The user must allow these data sets to be updated (by selecting **Yes** when prompted) in order for the selected files to be used for watershed modeling.

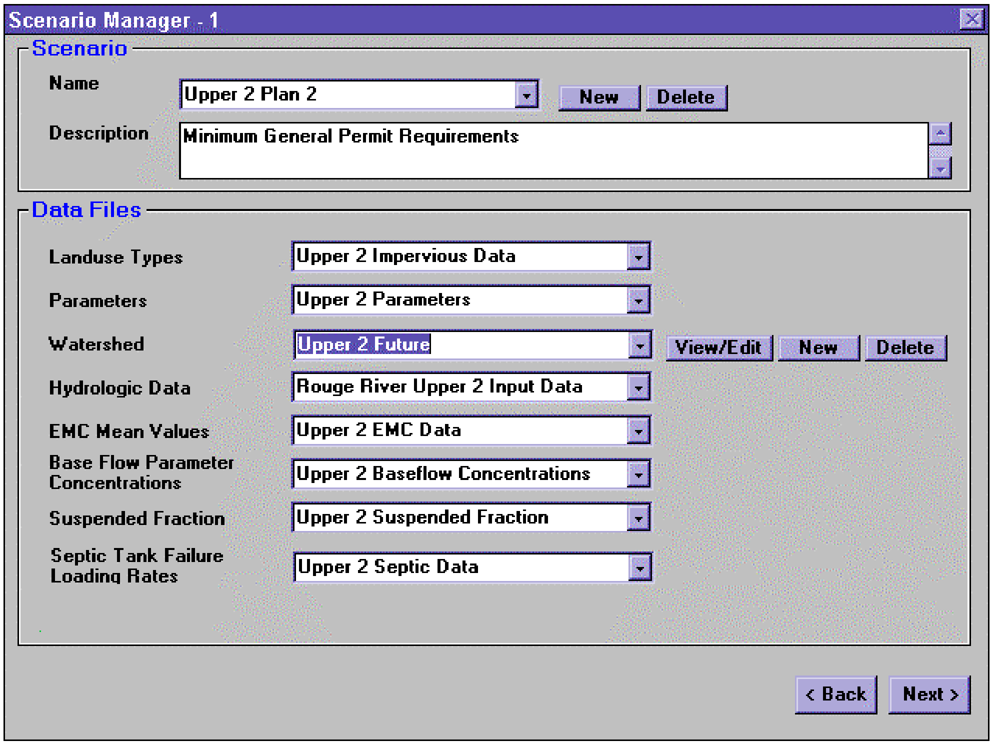


Figure 3-13
Scenario Manager 1

3.3.1 Landuse Types. To modify an existing land use coverage or create a new coverage, click on the **View/Edit** or **New** buttons. To edit the percent impervious values, type the new values in decimal format in the % impervious column, as shown in Figure 3-14. To add or delete land uses click on **Add/Delete** to obtain the screen shown in Figure 3-15. By using the >, >>, <, and << buttons, landuse types can be moved from the available list on the left to the selected list on the right. Click **Save** to save all changes, **Cancel** to undo changes and return to the previous values. It is important to remember that any new land uses

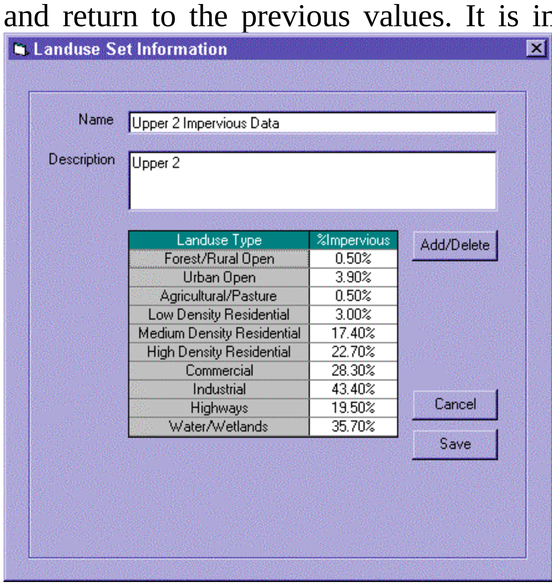


Figure 3-14
Scenario Manager 1 - Land Use Set Information

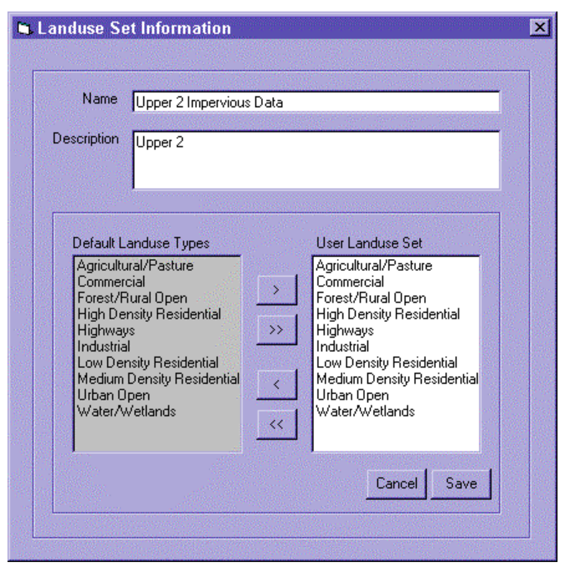


Figure 3-15
Land Use Set Information - Add/Delete

desired for use in the Scenario Manager must first be entered in the Default Manager.

3.3.2 **<u>Scenario Manager 1 - Parameters</u>**. To modify an existing parameter set of or create a new parameter data set, click on the **View/Edit** or **New** buttons. To add or delete parameters click on the **Add/Delete** button, as shown in Figure 3-16, to obtain the screen shown in Figure 3-17. By using the >, >>, <**,** and << buttons, parameters can be moved from the available list on the left to the selected list on the right. Click **Save** to save all changes, **Cancel** to undo changes and return to the previous values. Again, remember that any new parameters desired for use in the Scenario Manager must first be entered in the Default Manager.

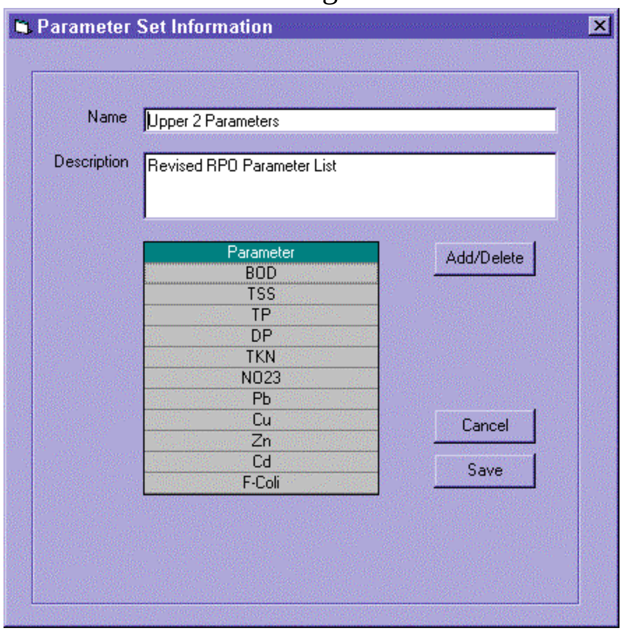


Figure 3-16
Scenario Manager 1 - Parameter Set Information

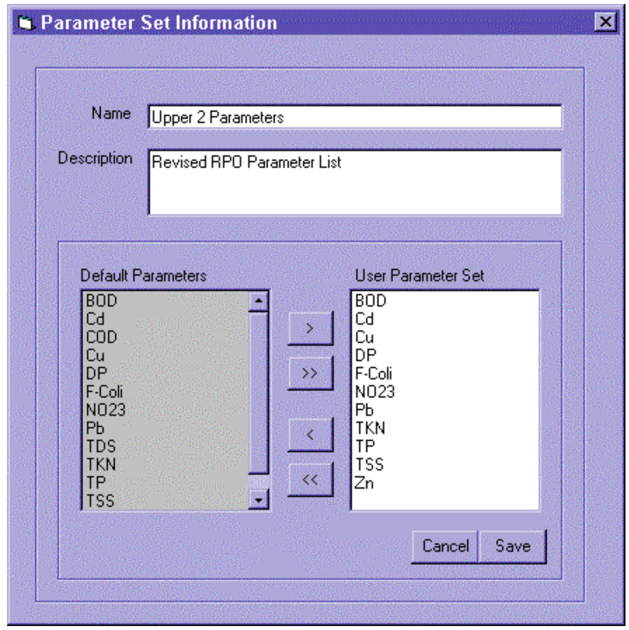


Figure 3-17
Parameter Set Information - Add/Delete

3.3.3 **Watershed**. The Watershed file is where the subbasin information for the watershed to be modeled is entered. This file contains the subbasin name and description, a breakdown of land acreage within each subbasin including a total acreage calculated from the sum of the breakdown, the pollutant load delivery ratio, and septic impact zones and failure rates. A set of information is generated for each unique subbasin name and jurisdiction, which **must** be unique for each subbasin. A sample input screen is shown in Figure 3-18.

There are several data fields shown on the input screen which do not require entry from the user. The **number of subbasins** and **acres** of fields are calculated automatically for each subbasin. The remainder of the fields requires input from the user.

The pollutant load **Delivery Ratio** should be entered as decimal percent. For each **Landuse Type**, enter the number of acres that exist within the given subbasin. To include effects of septic systems within the subbasin, click the box to the left of **Septic Impact**, which will cause the default Septic Impact Landuse Types to be displayed in the table. Enter the decimal percent, each of the septic impacted landuse types are effected by septic systems. The value for **Septic Tank Failure Rate** must also be entered as a decimal percent . (e.g. 0.25 equals 25%)

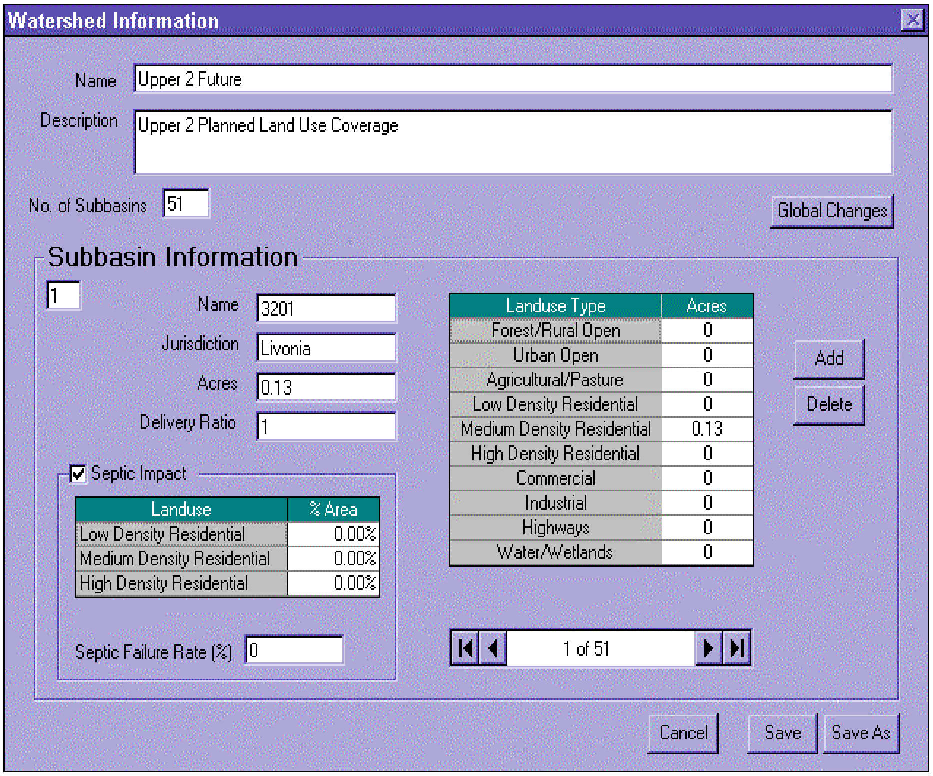


Figure 3-18
Scenario Manager 1 - Watershed Information

To add a new subbasin, click the **Add** button. To delete a subbasin, click the **Delete** button. In each case the user will be asked if they really want to add/delete a subbasin. Use the navigation bar to move between the subbasins, as shown in Figure 3-19. Click on the **Cancel** button to cancel all changes and restore previous values. Click on the **Save** button to save all changes and exit form. The **Save As** button prompts the user for a new file name and description, saves all changes with the new file name, and exits the form.

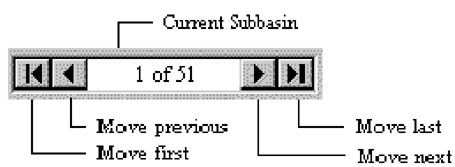


Figure 3-19
Navigation Bar

Clicking the **Global Changes** button brings up a window that allows the user to make changes to all subbasins in the watershed for delivery ratio, septic impact and/or septic failure rates. To select an item to change, click on the empty box to the left of the item of interest. Values for delivery ratio and septic impact rates should be entered as decimal percents. Septic impact is **Yes** to take in account septic systems impact on loadings or **No** for no septic impact.

3.3.4 Hydrologic Data. An existing Hydrologic data file may be modified or a new one created by clicking on the appropriate button in the main screen of Scenario Manager 1. The following data are entered in the screen shown in Figure 3-20:

- **Annual Precipitation** as (in/yr).
- **Annual Base Flow** as (MGD).
- **Pervious Runoff Coefficient** as decimal percent (e.g. 0.25 equals 25%).
- **Impervious Runoff Coefficient** as decimal percent (e.g. 0.25 equals 25%).

Click **Cancel** to cancel all changes and exit, Save to **Save** all changes and exit.

3.3.5 EMC Values. To create a new or edit an existing EMC value file, click on the appropriate button in the EMC Mean Values menu in Scenario Manager 1. The default EMC and Coefficient of Variation values from the default manager will automatically show up when a new file is created, as shown in Figure 3-21. Scenario specific values may be created by overwriting the default values. Click **Cancel** to cancel all changes and exit, Save to **Save** all changes and exit.

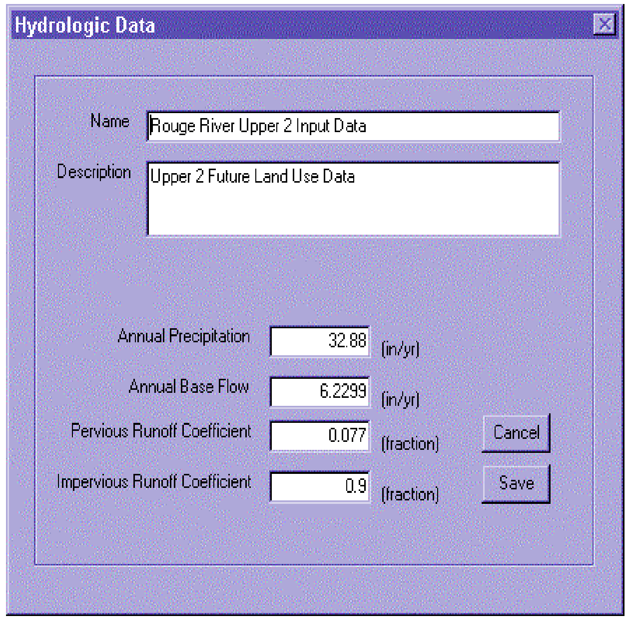


Figure 3-20
Hydrologic Data

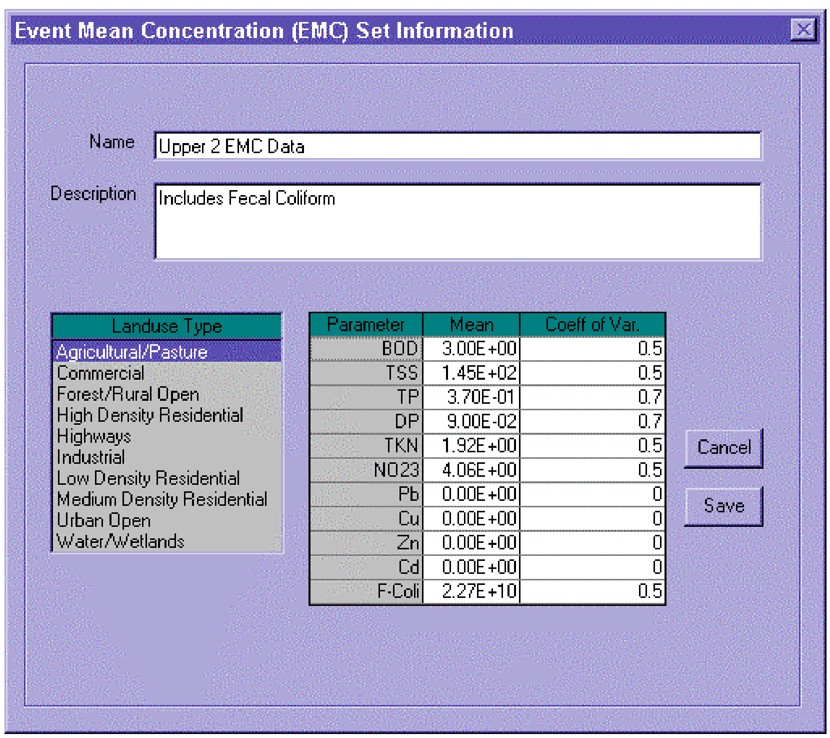


Figure 3-21
Scenario Manager 1 - EMC Set Information

3.3.6 Base Flow Concentration Values. To create a new or edit an existing baseflow concentration file, click on the appropriate button in the Base Flow Parameter Concentrations menu in Scenario Manager 1. Enter the base flow concentrations in units of mg / L, as shown in Figure 3-22. Click **Cancel** to cancel all changes and exit, save to **Save** all changes and exit.

3.3.7 Suspended Fraction. To create new or edit existing suspended fraction value files, click on the appropriate button in the Suspended Fraction menu in Scenario Manager 1. Enter the suspended fraction for a parameter as a decimal percent, as shown in Figure 3-23.

Click **Cancel** to cancel all changes and exit, save to **Save** all changes and exit.

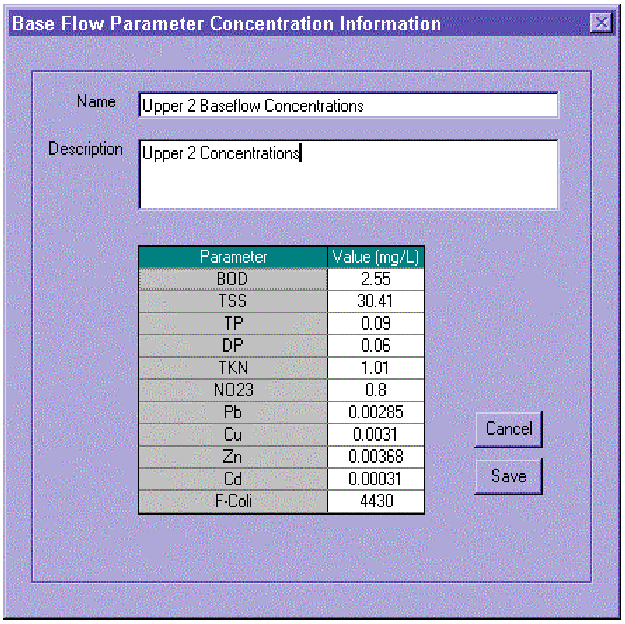


Figure 3-22
Scenario Manager 1 - Base Flow Concentration Values

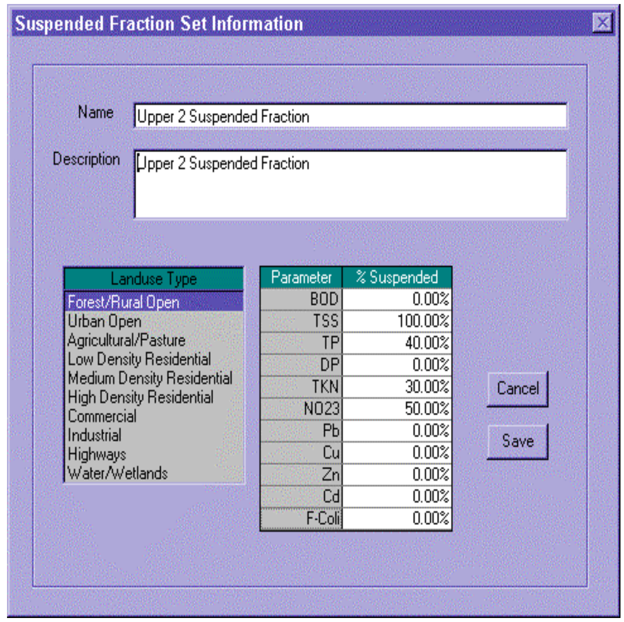


Figure 3-23
Scenario Manager 1
Suspended Fraction Set Information

3.3.8 Septic Failure Loading Rates.

To create new or edit existing septic tank failure loading rate files, click on the appropriate button in the Septic Tank Failure Loading Rate menu in Scenario Manager 1. Click on a land use type and enter the loading rate percentages in decimal format for the desired parameter, as shown in Figure 3-24. Click **Cancel** to cancel all changes and exit, save to **Save** all changes and exit.

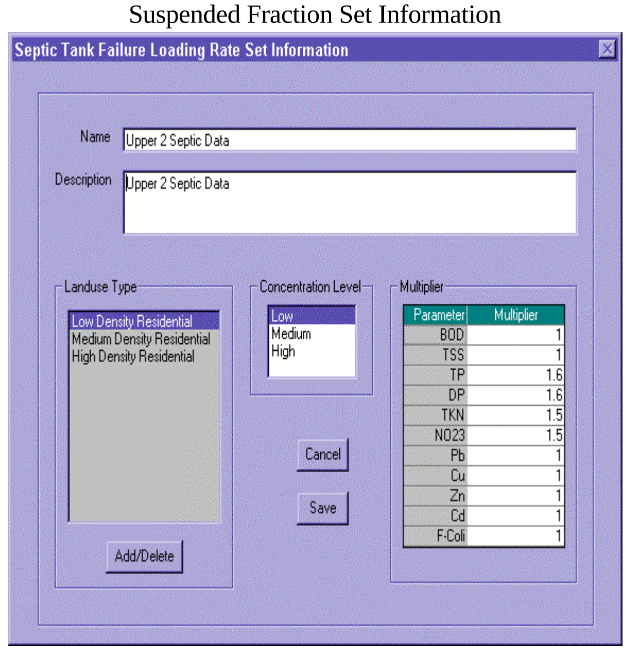


Figure 3-24
Scenario Manager 1 - Septic Tank
Failure Loading Rate Set Information

3.4 SCENARIO MANAGER 2.

The Scenario Manager 2 screen, as shown in Figure 3-25, allows modifications to the degree of uncertainty in calculating loads and the options to include CSOs, BMPs, Point Sources and CSO controls in load calculations. In addition, model execution is initiated from this screen. Clicking **the Save Scenario** button will save the current scenario configuration under the existing name. Clicking the **Back** button will return you to the Scenario Manager 1 screen.

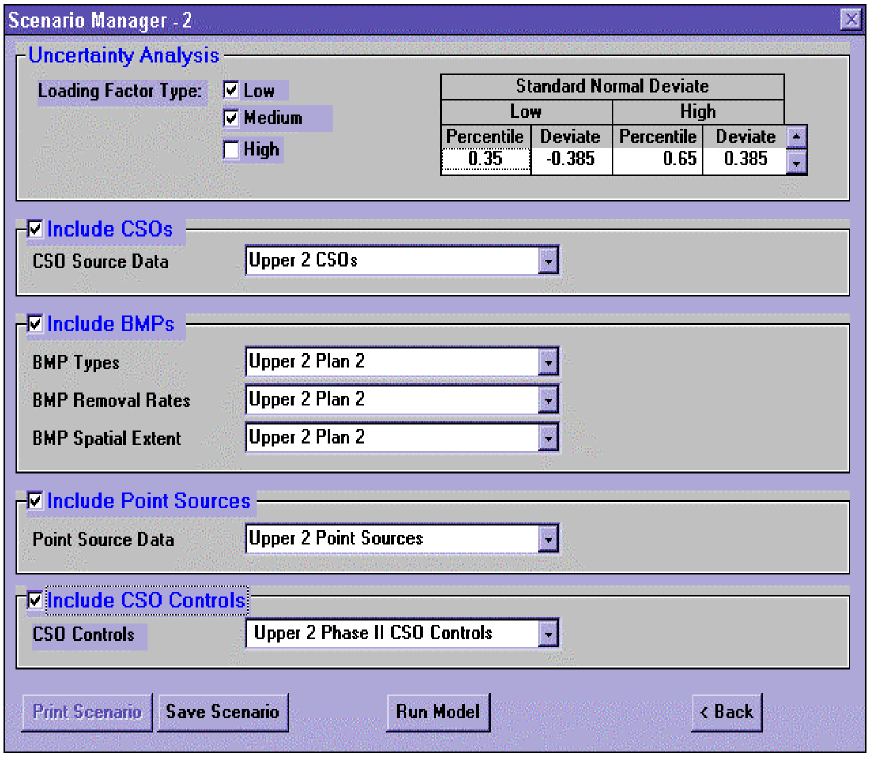


Figure 3-25
Scenario Manager 2

3.4.1 Uncertainty Analysis. The Uncertainty Analysis option allows the user to select the desired EMC estimate (low, medium or high). Selecting a low and/or high estimate will cause the Standardized Normal Deviate table to be displayed. To select the desired deviate, use the arrow up/down buttons, as shown in Figure 3-26.

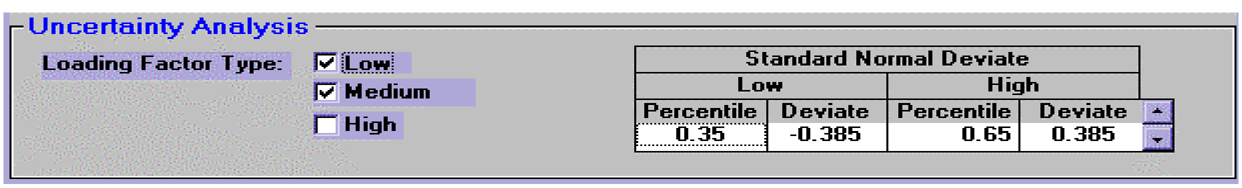


Figure 3-26
Scenario Manager 2 - Uncertainty Analysis

3.4.2 Include CSOs. Click the box next to **Include CSOs** to activate this option. Once selected, the file list box and action buttons become enabled.

To create a new CSO Concentration Set file, click the **New** action button which displays the CSO concentration set window, Figure 3-27. Enter a name and description for the new file. To add or delete subbasins, click on the **Add/Delete** key. Using the <, <<, > and >> buttons, move the subbasins for which CSOs exist from the available list to the selected list, as shown in Figure 3-28. Click **Save** to save the list. For each subbasin, click on the subbasin name in the Subbasin Table and enter values for each parameter and a CSO flow in MGD. Use the **Add/Delete** button to add or delete subbasins.

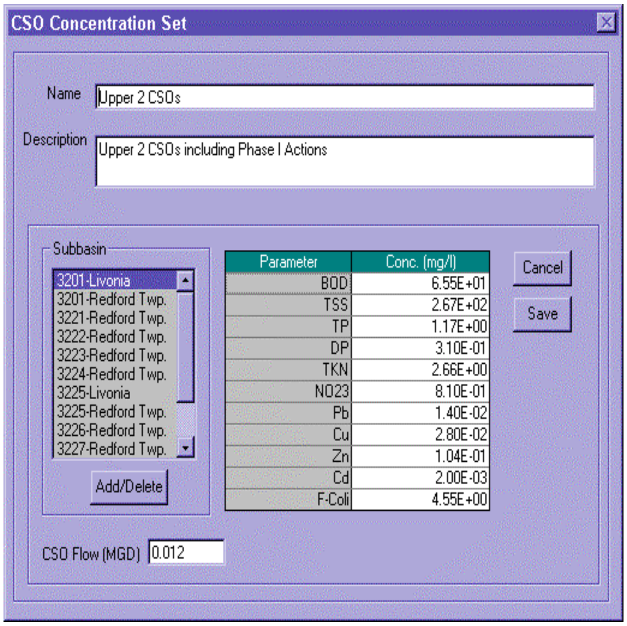


Figure 3-27
Scenario Manager 2 - CSO Concentration Set

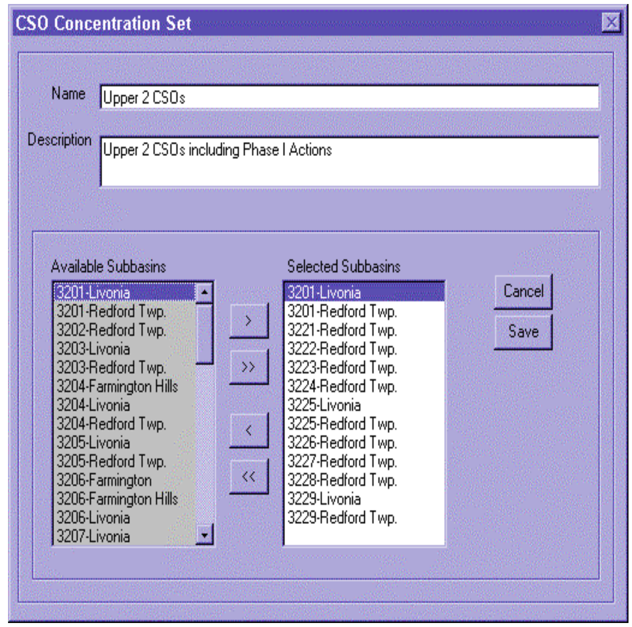


Figure 3-28
CSO Concentration Set - Add Subbasins

3.4.3 Include BMPs. Click the box next to **Include BMPs** to activate this option. Once selected the file list boxes and action buttons become enabled. This option allows BMP types, pollutant removal rates and coverages to be created or modified for each scenario.

<u>BMP Types</u>. The BMP Types file contains the types of BMPS available for use in the model. Figure 3-29 shows the screen that is accessed by clicking the **View/Edit** button. Upon creation of a new file the available types of BMPs will consist of those from the default BMP Alternatives. Click the **Add/Delete** button access the screen shown in Figure 3-30. Using the <, <<, > and >> buttons, move the BMPs back and forth between the lists to add or delete BMP types. Click the **Save** button to save your changes and exit or the **Cancel** button to undo your changes and exit.

<u>BMP Removal Rates</u>. Scenario specific pollutant load reductions for each best management practice may be created or modified by clicking on the **View/Edit** or **New** button in the BMP removal rates pull down menu. For help on editing BMP pollutant removal rates, see the Default Manager - BMP Removal Rates description found in Section 2.3.1.

<u>BMP Spatial Extent</u>. To create a new BMP Spatial Extent file, click the New action button and select Default Set as the data type. In the BMP Area Set Information window (shown in Figure 3-31), enter a name and description for the new file. Using the arrow keys, select the subbasins you wish to apply BMP coverage to. Next click on the add/delete button to select the BMPs you wish to apply to these subbasins. Enter the percent coverage of the BMPs for each landuse type for the selected basin. Continue adding information as necessary by selecting new BMPs and subbasins. Click the **Save** button to save your changes or the **Cancel** button to undo your changes.

To edit an existing BMP Spatial Extent file, click the **View/Edit** action tool. Click the subbasin and landuse type of interest and edit as was done when a new coverage was entered.. (Shown in Figure 3-32.) Click the **Save** button to save your changes and exit or the **Cancel** button to undo your changes and exit.

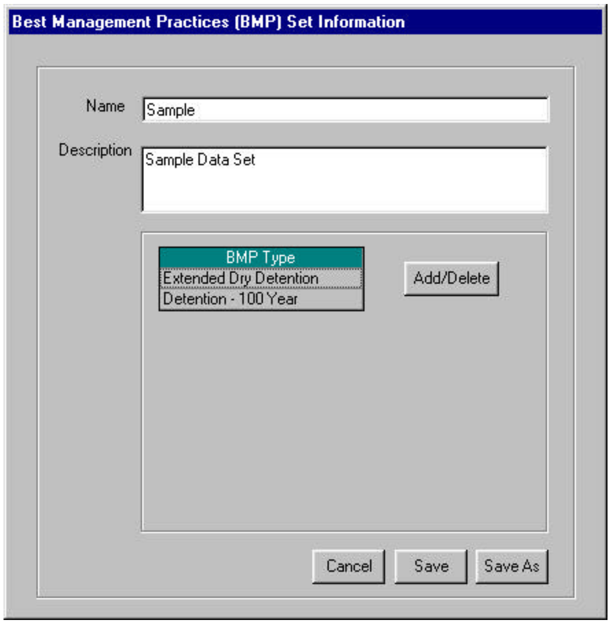


Figure 3-29
Scenario Manager 2 – BMP Set Information

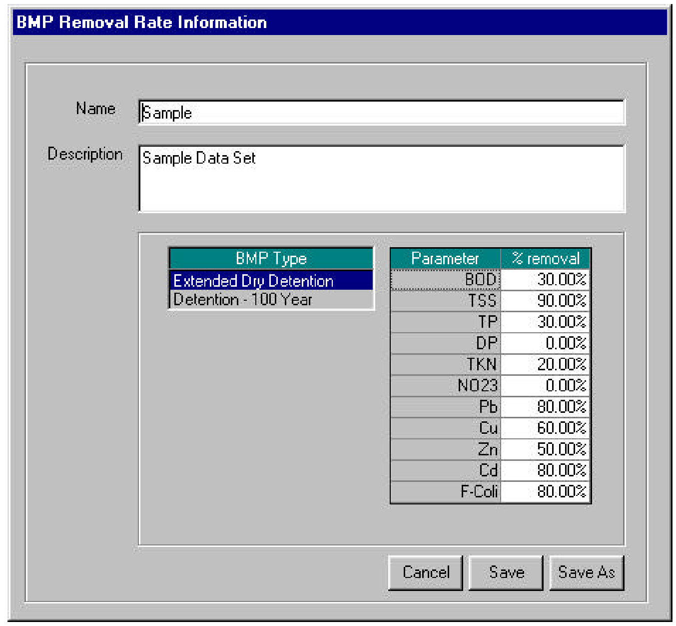


Figure 3-30
BMP Removal Rates

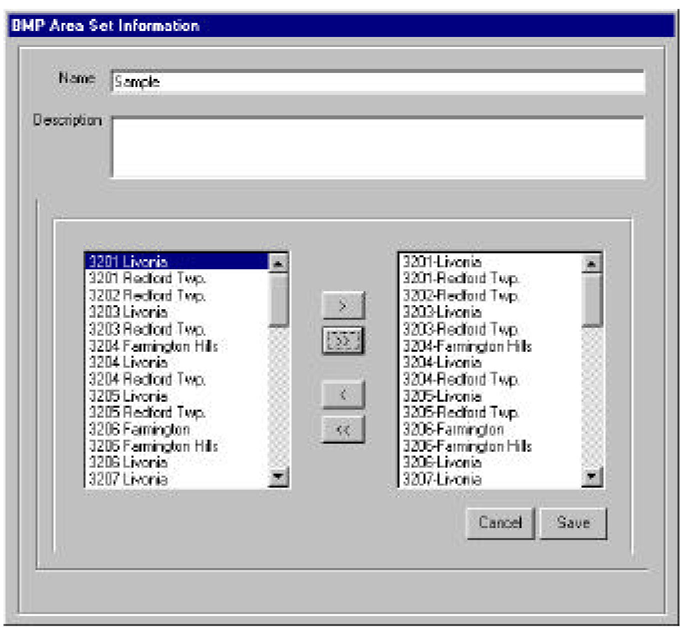


Figure 3-31
Scenario Manager 2 – Create New BMP Area Set

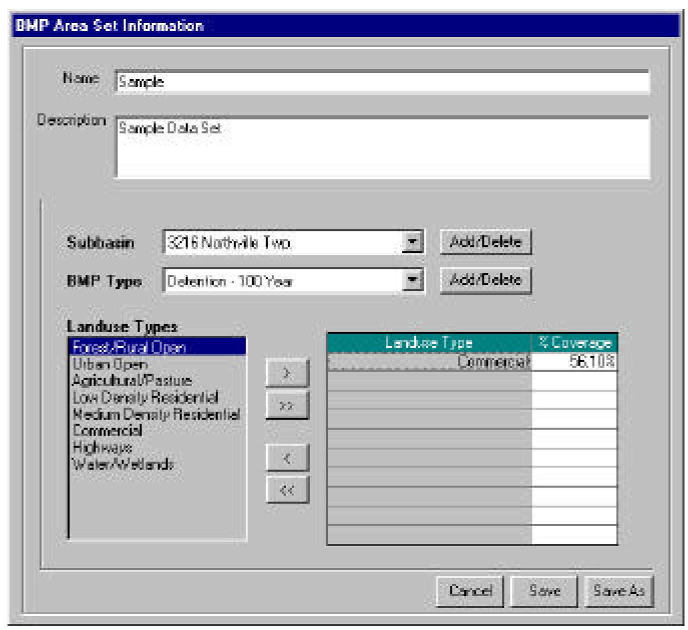


Figure 3-32
Scenario Manager 2 – **View/Edit** BMP Area Set

3.4.4 Include Point Sources. Click the box next to **Include Point Sources** to activate this option. Once selected, the file list box and action buttons become enabled. To create a new Point Sources file, click the **New** action button. Enter a name and description for the new file, as shown in Figure 3-33. To add or delete subbasins, click on the **Add/Delete** key. Using the <, <<, > and >> buttons, move the subbasins for which point sources exist from the available list to the selected list, as shown in Figure 3-34. Click **Save** to save the

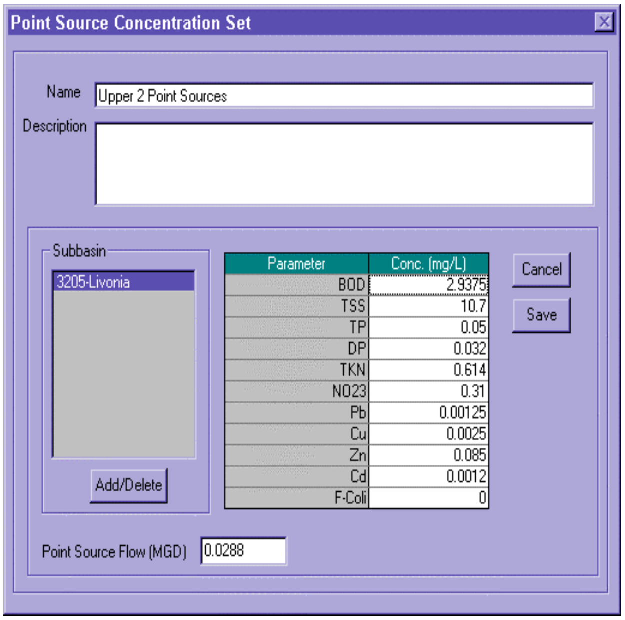


Figure 3-33
Scenario Manager 2 - Point Sources

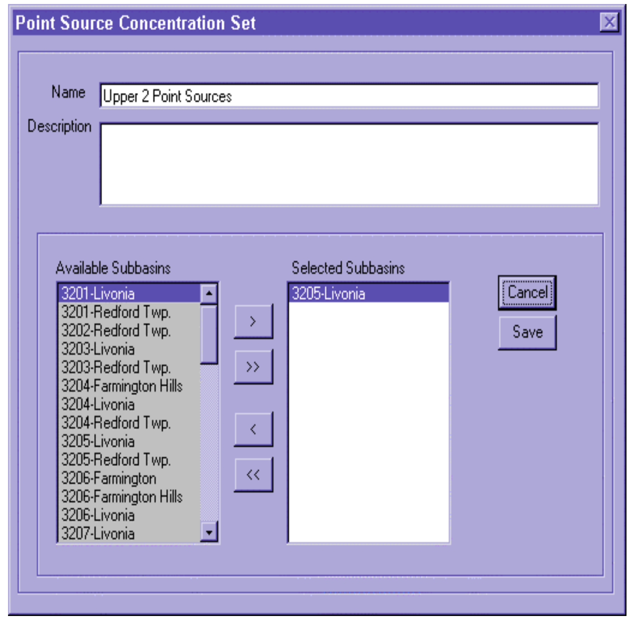


Figure 3-34
Add/Delete Point Sources

list. For each subbasin, click on the subbasin name in the Subbasin Table and enter point source pollutant loading concentrations in mg/L for each parameter, and a flow in MGD.

3.4.5 Include CSO Controls. Click the box next to **Include CSO Controls** to activate this option and access the screen shown in Figure 3-35. Once selected the file list box and action buttons become enabled. To create a new CSO Controls Set file click the **New** action button. If necessary, use the **Add/Delete** buttons to add or delete CSO controls. Note that the Sewer Separation control is a default CSO control and cannot be removed. Click the **Save** button to save your changes and exit or the **Cancel** button to undo your changes and exit.

For each CSO control, click on the control in the CSO Controls list box and enter percent reduction values for each parameter. Also enter a % Flow Reduction value (as decimal percent) for each CSO control. To assign subbasins to a CSO control, click on the **Add/Delete** button in the subbasins box and use the <, << , > and >> buttons to move subbasins from the available list to the selected list, similar to the method used to add subbasins for point sources. Click the **Save** button to save the selected subbasin list, **Cancel** to undo changes. The **Save** button saves all changes using the current file name and exits the form. To save with a different name, change the name and description in the text boxes before using the **Save As** button

3.4.6 Running the Model. Once all data files are updated with scenario specific information, the model may be run by clicking the **Run Model** button. You will be prompted for a model run output name and description. After entering the required information, click **OK** to run the model or **Cancel** to return to page 2 of the Scenario Manager. The model will take several minutes to run, with the calculation time dependant upon the number of subbasins, point sources, CSOs and BMPs.

Upon completion of a model run, the results of the run are displayed to the user in a display window, as shown in Figure 3-36. Within the display window, you may scroll

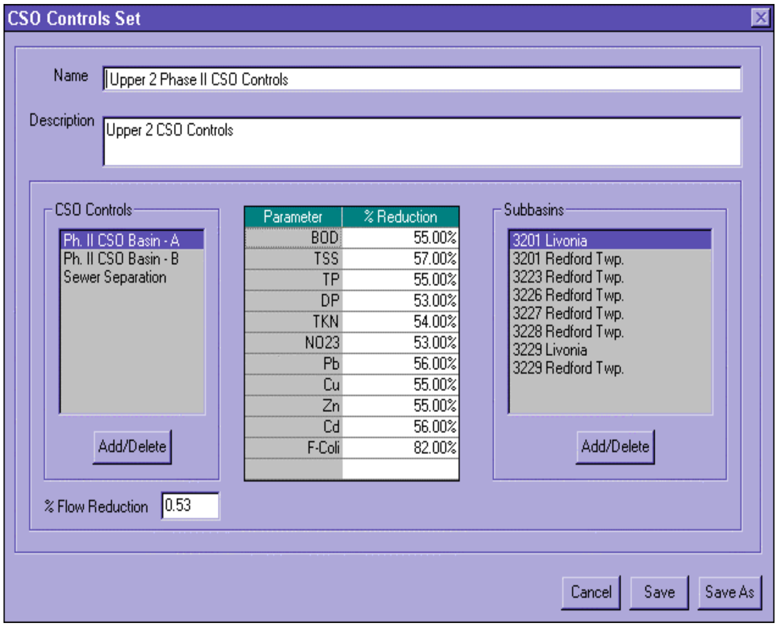


Figure 3-35
Scenario Manager 2 - CSO Controls Set

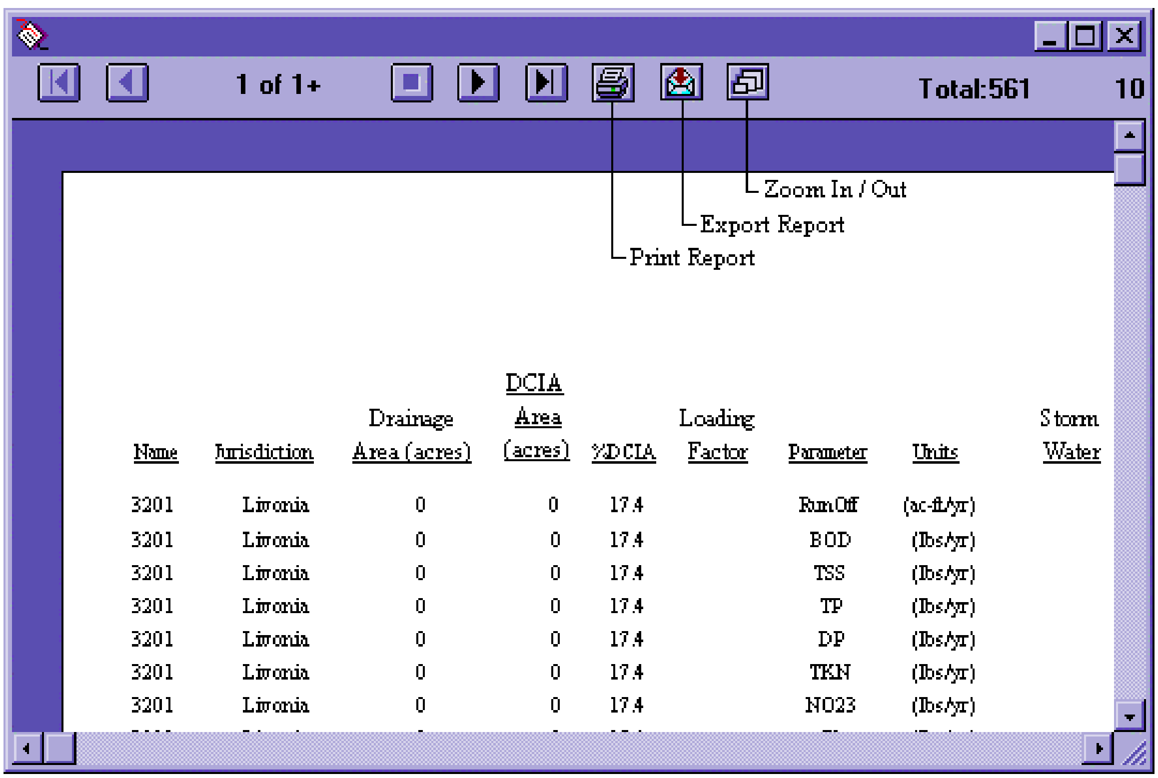


Figure 3-36
Model Output Window

through the data pages using the arrow keys, zoom in or out, print the output data, or export the data to a new file. It is not necessary to export the data from this window in order to save it. The data are automatically saved and can be accessed through the Output Manager module of the program.

3.5 OUTPUT MANAGER. The Output Manager allows the user to display output from previous model runs in a variety of different styles and formats. Additionally, the Output Manager also supports the comparison of different model output sets. Output Manager also allows the user to delete data from previous model runs. The output manager menu may be accessed by clicking on the **Output Manager** button from the main menu of WMM, and is shown in Figure 3-37.

3.5.1 Standard Report. The Standard Report format is designed to closely resemble the output from the spreadsheet version of WMM's NPL module. Clicking the **Standard Report** button displays the Model Output Display selection screen (see Figure 3-38). This screen is used to select the output to be displayed. Using the navigation bar (see Figure 3-39), the user can select the output set to display. Once selected, the user may enter a title for the report in the report title box. The user clicks the **Display** button to display the results. The report may be printed or exported from the display screen. Sample reports of this standard report and all other reports can be found in Appendix D.

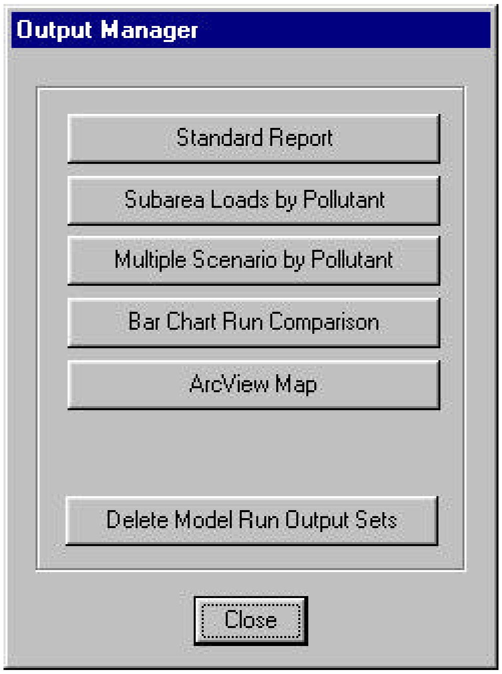


Figure 3-37
Output Manager

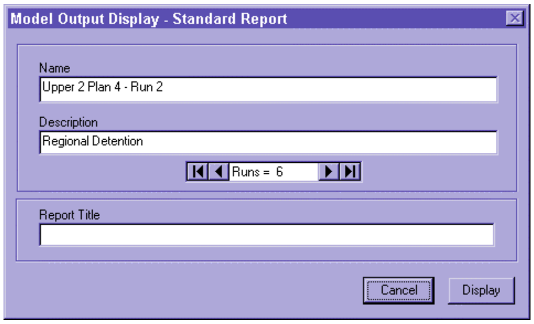


Figure 3-38
Model Output Display - Standard Report

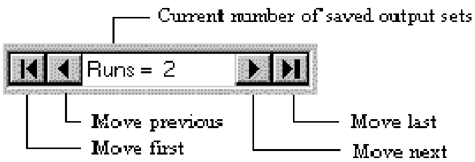


Figure 3-39
Output Navigation Bar

3.5.2 Subarea Loads by Pollutant. Clicking the **Subarea Loads by Pollutant** allows the user to display modeling results grouped by pollutant parameter. This report also provides the opportunity to compare one scenario to another by calculating a percent change between two defined sets of results. The user selects a primary run, for which pollutant loads by subarea will be displayed by parameter. The user also selects a comparison run to as a basis for the percent change. The user is also given the opportunity to create a report title, as shown in Figure 3-40.

3.5.3 Multiple Scenario by Pollutant. The multiple scenario by pollutant output option allows the user to display output summarizing total pollutant load totals for up to five scenarios in one table. This option may be accessed by clicking on the **Multiple Scenario by Pollutant** button, which accesses the screen shown in Figure 3-41.

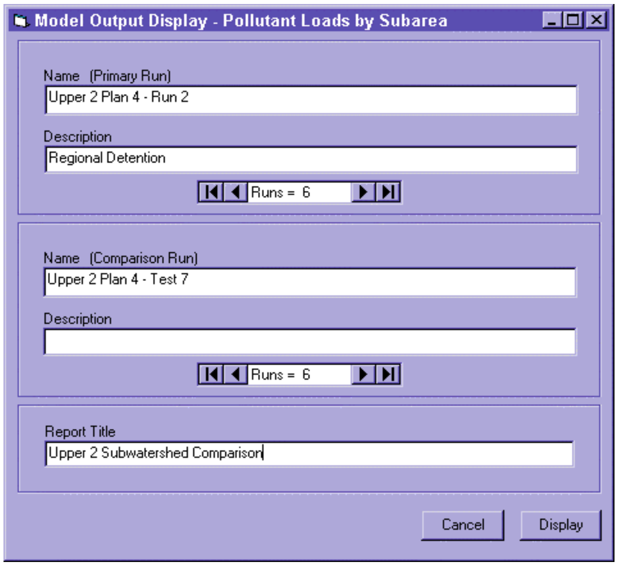


Figure 3-40
Model Output Display - Pollutant Load by Subarea

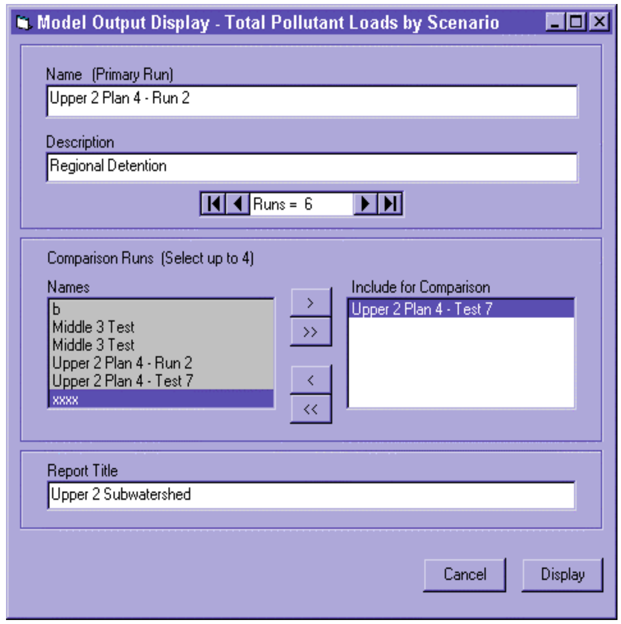


Figure 3-41
Model Output Display - Total Pollutant Load by Scenario

3.5.4 Bar Chart Run Comparison. Clicking the **Bar Chart Run Comparison** allows the user to display modeling results in a graphical format, comparing pollutant loads by parameter for up to five scenarios. The user is prompted to select the scenarios desired for comparison, as shown in Figure 3-42. After clicking **next** to continue, the user must select the parameter they wish to display and may create a graphic title, as shown in Figure 3-43. To create the graphic, click on **Display**.

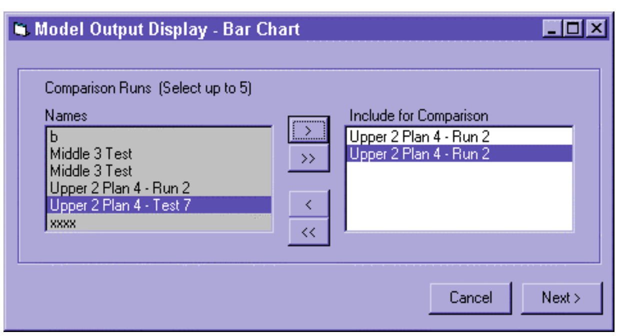


Figure 3-42
Model Output Display - Bar Chart

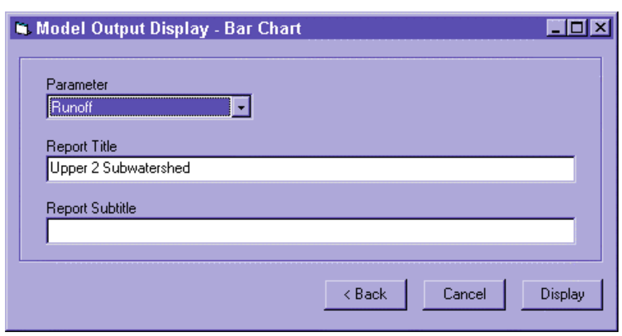


Figure 3-43
Bar Chart Parameter and Title Selection

3.5.5 ArcView Map. Selecting the **ArcView Map** button allows the user to spatially display data generated by the WMM for Windows model. ArcView Version 3.1 is required to utilize this capability of WMM for Windows. After clicking the **ArcView Map** button, the user will be prompted to enter the location of their ArcView 3.1 executable file (ArcView.exe). Once this location has been identified, ArcView will automatically initialize and the user may proceed with mapping their model results. See Appendix E for details on the development of ArcView coverages from WMM for Windows scenario results.

3.5.6 Delete Model Run Output Sets. Clicking the **Delete Model Run Output Sets** button displays the Delete Model Output selection screen. The screen shown in Figure 3-44 is used to select the output to be deleted. Using the navigation bar, the user can select the output set to delete. Once selected the user clicks the **Delete** button to delete the results.

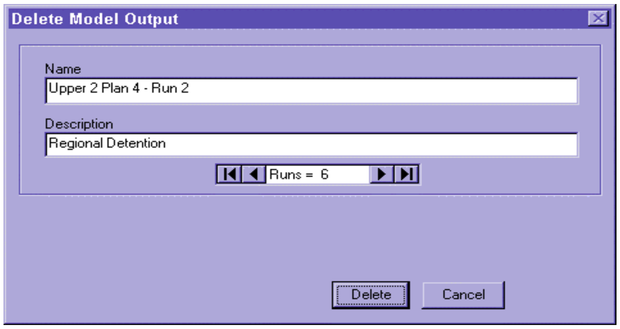


Figure 3-44
Delete Model Run Output Sets

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Appendix A

NURP Data

Locations of the 28 NURP Projects

EPA Region	NURP Code	Project Name/Location	EPA Region	Nurp Code	Project Name/Location
I	MA1	Lake Quinsigamond (Boston Area)		MI1	Lansing, Michigan
	MA2	Upper Mystic (Boston Area)		MI2	SEMCOG (Detriot Area)
	NH1	Durham, New Hamshire		MI3	Ann Arbor, Michigan
II	NY1	Long Island (Nassau and Suffolk Counties)		WI1	Milwaukee, Wisconsin
	NY2	Lake George	VI	AR1	Little Rock, Arkansas
	NY3	Irondequoit Bay (Rochester Area)		TX1	Austin, Texas
III	DC1	WASHCOG (Washington D.C. Metropolitan Area)	VII	KS1	Kansas City
	MD1	Baltimore, Maryland	VIII	CO1	Denver, Colorado
IV	FL1	Tampa, Florida		SD1	Rapid City, South Dakota
	NC1	Winston-Salem, North Carolina		UT1	Salt Lake City, Utah
	SC1	Myrtle Beach, South Carolina	IX	CA1	Coyote Creek (San Francisco Area)
	TN1	Knoxville, Tennessee		CA2	Fresno, California
V	IL1	Champaign-Urbana, Illinois	X	OR1	Springfield -Eugene, Oregon
	IL2	Lake Ellyn (Chicago Area)		WA1	Bellevue (Seattle Area)

Figure A-1
Locations of the 28 NURP Projects

Table A-4
Individual NURP Site Event Mean Concentrations (USEPA, 1983)

Land Use		Site	Land Use %	Area (A)	Pop. Den. (#/A)	% IMP.	TSS No. of OBS	TSS Mean mg/L	TSS COV	TSS Median mg/L	BOD No. of OBS	BOD Mean mg/L	BOD COV	BOD Median mg/L	COD No. of OBS	COD Mean mg/L	COD COV	COD Median mg/L	Total P No. of OBS	Total P Mean ug/L	Total P COV	Total P Median ug/L	Soluble P No. of OBS	Soluble P Mean ug/L	Soluble P COV	Soluble P Median ug/L
Resid.	1	CO1 Big Dry Cr	100	33	19	41	16	383	1.04	265	0	-	-	-	16	129	0.72	105	16	693	0.94	505	15	193	0.64	163
	2	CO1 Cherry	100	57	24	38	14	180	0.98	129	0	-	-	-	14	122	0.66	102	14	429	0.54	377	14	212	0.47	192
	3	CO1 116/Claude	100	167	14	24	16	365	1.17	232	0	-	-	-	15	137	0.74	103	15	630	0.65	513	16	196	0.35	179
	4	DC1 Dufief	100	12	-	-	8	56	1.02	39	0	-	-	-	7	64	0.26	62	5	499	0.32	475	6	448	0.55	392
	5	DC1 Lakeridge	100	68	21	27	49	175	1.47	98	0	-	-	-	44	60	0.66	50	48	323	0.78	256	47	69	0.62	59
	6	DC1 Stratton	100	8	-	-	33	54	1.01	38	4	-	-	-	31	51	0.55	45	28	340	0.54	300	27	251	0.65	210
	7	IL1 John M	100	54	18	19	51	205	1.36	122	0	-	-	-	31	126	0.80	98	33	750	0.62	636	0	-	-	-
	8	KS1 Overton	100	58	8	38	15	2216	1.47	1247	5	12	0.59	11	14	162	0.67	135	8	1636	0.91	1207	8	313	0.41	290
	9	MA2 Hemlock	100	50	5	16	5	78	2.49	29	0	-	-	-	0	-	-	-	5	314	1.05	216	5	160	0.89	120
	10	MD1 Bolton Hill	100	14	30	51	18	74	1.32	45	0	-	-	-	19	218	1.38	128	19	932	1.15	613	0	-	-	-
	11	MD1 Homeland	100	23	9	29	13	50	1.65	26	0	-	-	-	13	172	0.73	139	13	421	0.70	345	0	-	-	-
	12	MD1 Mt Wash	100	17	12	29	20	95	1.12	63	0	-	-	-	20	168	0.85	128	20	556	0.83	428	0	-	-	-
	13	MD1 Res Hill	100	10	55	76	13	127	1.05	88	0	-	-	-	13	177	0.85	135	13	4090	1.05	2825	0	-	-	-
	14	NY1 Carll's K.	100	73	13	20	23	42	0.85	32	0	-	-	-	0	-	-	-	24	221	0.54	195	0	-	-	-
	15	NY1 Unqua	100	-	-	-	8	65	0.53	57	0	-	-	-	0	-	-	-	8	229	0.61	196	0	-	-	-
	16	NY3 Cranston	100	166	5	22	10	134	1.15	88	0	-	-	-	8	33	0.43	31	13	301	0.54	265	0	-	-	-
	17	NY3 E. Roch.	100	346	18	38	7	294	1.12	196	0	-	-	-	7	86	0.31	82	8	448	0.47	405	0	-	-	-
	18	TX1 Rollingwood	100	60	3	21	9	227	1.13	150	0	-	-	-	9	70	0.45	64	9	268	0.56	233	0	-	-	-
	19	WA1 Surrey	100	95	9	29	113	113	0.51	101	0	-	-	-	118	48	0.54	42	118	239	0.83	184	0	-	-	-
	20	Wl1 Burbank	100	63	15	50	45	266	0.44	243	28	7	0.64	6	27	39	0.79	30	45	229	0.45	209	0	-	-	-
	21	Wl1 Hastings	100	33	17	51	33	170	0.68	141	20	9	0.62	8	23	41	0.55	36	35	258	0.51	230	0	-	-	-
	22	FL1 Young Apts	100	9	-	6	12	53	1.23	34	12	16	1.1	11	12	73	0.96	52	12	333	0.65	279	0	-	-	-
	23	TR1 Hart	99	378	9	40	15	156	1.61	82	0	-	-	-	11	82	0.83	63	14	333	0.80	260	0	-	-	-
	24	Wl1 Lincoln	97	36	18	57	23	251	0.69	206	11	18	1.23	12	16	91	0.95	66	23	453	0.69	373	0	-	-	-
	25	TN1 R2	96	89	4	13	11	63	1.13	42	10	9	0.66	7	11	45	0.39	42	11	246	0.41	227	11	132	0.63	112
	26	DC1 Westleigh	93	41	3	21	41	75	1.45	43	3	-	-	-	39	51	0.46	46	41	397	0.75	319	41	223	0.71	182
	27	KS1 IC - 92nd	92	63	-	37	13	156	0.84	119	5	28	0.66	23	11	176	0.98	126	10	1297	1.31	787	10	241	0.62	205
	28	IL1 John S.	91	39	18	18	49	248	1.50	138	0	-	-	-	29	111	0.80	87	32	732	0.65	604	0	-	-	-
	29	TN1 R1	91	69	11	33	11	611	0.73	492	9	14	0.87	11	11	120	0.96	87	11	705	0.35	665	11	136	0.94	99
	30	WA1 Lake Hills	91	102	12	37	126	127	0.80	100	0	-	-	-	127	44	0.54	38	127	264	0.81	204	0	-	-	-
	31	IL1 Mattis S.	90	28	22	37	59	311	1.08	211	0	-	-	-	30	180	0.72	146	32	587	0.69	483	0	-	-	-
	32	FL1 Charter Hdg.	89	42	-	16	12	33	1.76	16	12	13	1.24	8	12	55	0.64	47	12	395	1.61	208	0	-	-	-
	33	DC1 Fairidge	88	19	-	34	47	25	1.55	14	5	5	0.64	4	48	51	0.46	47	47	351	0.73	254	46	297	0.87	224
	34	CD1 Asbury	86	127	9	22	9	493	0.82	380	0	-	-	-	9	234	1.12	156	9	1025	0.71	834	9	212	0.22	207
	35	IL2 Comb Inlets	85	524	8	17	27	250	0.75	200	0	-	-	-	24	138	0.90	102	26	506	0.79	397	24	98	1.21	63
	36	MA1 Locust	85	154	11	16	6	257	1.75	128	0	-	-	-	6	104	0.45	95	6	1228	0.79	966	6	184	0.42	169
	37	MC1#1023	84	324	6	27	66	291	1.92	135	7	11	0.63	10	34	90	0.97	64	67	529	0.99	375	0	-	-	-
	38	MA1 Jordan	79	110	10	21	9	78	1.74	39	0	-	-	-	9	79	0.53	70	8	448	0.95	324	7	202	1.11	136
	39	DC1 Stedwick	78	27	15	34	47	54	1.02	38	3	-	-	-	45	45	0.60	39	44	388	0.65	326	41	261	0.70	206
Open	1	CA1 Seaview	100	633	-	-	13	718	0.83	551	0	-	-	-	14	111	0.42	102	13	590	0.82	455	12	145	1.24	91
	2	CO1 Rooney Gulch	100	405	0	1	7	403	0.63	341	0	-	-	-	7	73	0.33	69	7	420	0.47	380	7	137	0.46	124
	3	NY3 Thornell	100	28,416	-	4	11	154	0.92	113	0	-	-	-	8	25	0.36	23	13	193	0.46	175	0	-	-	-
	4	NY2 English Br	98	5,248	-	1	28	17	2.46	6	0	-	-	-	0	-	-	-	30	27	1.20	17	18	5	0.35	5
	5	NY2 West Br	97	5,338	-	1	28	64	2.77	22	0	-	-	-	0	-	-	-	31	52	1.27	32	26	8	0.54	7
	6	NY3 Thomas Cr	91	17,728	1	11	9	63	0.74	51	0	-	-	-	6	26	0.26	26	12	195	0.47	177	0	-	-	-
	7	NY3 Traver Cr	90	2,303	-	6	5	33	0.77	26	5	2	0.41	2	5	25	0.19	25	5	91	0.38	85	5	33	0.55	29
	8	NY2 Sheriff Dock	80	552	-	7	32	378	2.33	149	0	-	-	-	0	-	-	-	33	264	1.01	186	32	39	1.11	26

Table A-4 (ctd.)
Individual NURP Site Event Mean Concentrations (USEPA, 1983)

Land Use		Site	Land Use %	Area (A)	Pop. Den. (#/A)	% IMP.	TSS No. of OBS	TSS Mean mg/L	TSS COV	TSS Median mg/L	BOD No. of OBS	BOD Mean mg/L	BOD COV	BOD Median mg/L	COD No. of OBS	COD Mean mg/L	COD COV	COD Median mg/L	Total P No. of OBS	Total P Mean ug/L	Total P COV	Total P Median ug/L	Soluble P No. of OBS	Soluble P Mean ug/L	Soluble P COV	Soluble P Median ug/L
Mixed	1	KS1 Noland	-	36	3	68	16	280	0.91	208	3	-	-	-	12	106	0.66	89	7	555	0.34	526	8	165	0.52	146
	2	MD1 Hampden	-	17	40	72	20	82	1.62	43	0	-	-	-	20	111	0.73	89	20	754	1.41	436	0	-	-	-
	3	IL1 Mattis N	-	17	3	58	58	282	1.01	199	0	-	-	-	35	198	0.68	164	35	498	0.58	431	0	-	-	-
	4	MI1 Waverly	-	30	11	68	35	85	1.28	52	21	9	0.64	7	27	64	0.80	50	35	198	0.64	167	32	43	0.76	34
	5	IN1 SC	-	187	3	43	13	71	1.07	48	12	14	0.87	11	13	60	0.70	49	13	352	0.64	296	13	197	1.17	128
	6	WL1 Wood Ctr	-	45	12	81	47	383	0.78	302	31	14	0.54	13	39	92	0.57	80	47	289	0.59	249	0	-	-	-
	7	MA1 Rt 9	-	338	7	23	7	351	2.05	153	0	-	-	-	6	107	0.68	88	5	1176	0.63	995	5	160	0.38	150
	8	MA1 convent	-	100	1	33	8	54	1.53	30	0	-	-	-	8	72	0.62	61	8	459	1.99	206	6	106	1.83	51
	9	MI1 Grand R Ot	-	453	5	38	23	158	1.26	98	13	8	0.62	7	18	71	0.47	65	22	458	0.65	384	20	68	0.68	56
	10	MI3 Pitt AA-S	-	2001	2	21	6	46	0.37	43	6	5	0.49	5	4	-	-	-	6	103	0.50	93	6	13	0.37	13
	11	NY2 Cedar	-	76	-	5	27	291	1.92	134	0	-	-	-	0	-	-	-	32	363	1.20	233	26	49	1.16	32
	12	MA1 Anna	-	601	9	12	6	150	2.95	48	0	-	-	-	6	88	0.51	78	6	534	0.88	402	4	-	-	-
	13	MI3 Pitt AA-N	-	2871	7	26	6	68	0.47	61	6	6	0.76	5	3	-	-	-	6	268	0.47	243	6	59	0.88	44
	14	MI1 Grace N	-	164	5	28	23	172	0.85	131	11	8	0.78	7	17	72	0.43	66	23	394	0.54	347	21	47	0.47	42
	15	MI3 Swift Run	-	1207	2	4	5	80	0.91	59	5	3	0.41	3	5	29	0.12	29	5	134	0.56	117	5	39	0.46	35
	16	SD1 Meade	-	2030	-	-	15	3093	1.39	1804	14	19	0.75	15	14	179	0.39	167	15	1885	1.28	1163	14	87	0.61	74
	17	CA1 Knox	-	1542	12	-	19	283	1.32	171	0	-	-	-	21	93	0.60	80	19	418	0.50	374	18	169	0.99	120
	18	FL1 N. Jesult	-	30	-	13	15	87	3.59	23	15	16	0.95	12	15	50	1.18	33	15	196	0.71	160	0	-	-	-
	19	FL1 WIlder	-	194	-	97	14	33	0.71	27	15	16	1.18	10	15	51	0.38	48	15	229	0.52	204	0	-	-	-
	20	CO1 North Ave	-	69	9	50	32	492	0.96	354	32	-	-	-	32	280	0.74	225	32	784	0.60	673	30	228	0.95	165
Comm	1	CO1 Villa Italia	100	74	0	91	27	260	1.89	122	0	-	-	-	27	184	0.87	139	27	704	1.26	438	26	293	1.09	198
	2	NC1 1013 (CBD)	100	23	0	69	60	163	1.15	107	23	18	0.86	13	40	120	0.79	94	61	395	0.58	342	0	-	-	-
	3	NY3 Southgate	100	179	2	21	12	141	0.76	112	0	-	-	-	9	40	0.34	38	12	216	0.26	209	0	-	-	-
	4	Wl1 Post Office	100	12	0	100	58	212	0.86	161	35	9	0.5	8	40	57	0.62	48	60	108	0.56	94	0	-	-	-
	5	NH1 Pkg Lot	100		0	90	32	74	1.66	38	33	17	0.86	13	33	98	0.72	79	27	273	1.21	174	0	-	-	-
	6	TN1 CBD	100	26	0	99	15	123	0.73	99	13	13	0.46	12	15	73	0.52	65	15	212	0.43	195	15	46	0.72	37
	7	Wl1 Rustler	100	12	0	100	42	202	0.68	167	27	13	0.79	10	26	59	0.76	47	44	105	0.79	82	0	-	-	-
	8	KS1 IC Metcalf	96	58	-	97	22	80	2.12	34	13	8	0.48	7	20	55	0.86	41	20	246	0.98	176	21	116	1.06	80
	9	FC1 Norma Pk	91	47	-	45	12	22	1.13	14	12	12	0.88	9	12	41	0.47	37	12	151	0.60	135	0	-	-	-
	10	Wl1 State Fair	74	29	10	77	29	412	0.97	296	15	19	0.72	15	21	113	0.88	84	29	544	1.19	330	0	-	-	-
Indus.	1	MA2 Addison	100	18	0	69	5	48	0.81	37	0	-	-	-	0	-	-	-	5	114	0.89	85	5	75	0.92	55
	2	MI1 Indus Drain	100	63	0	64	18	92	0.82	71	8	10	0.58	9	12	67	0.46	61	18	546	0.58	472	14	127	0.72	103
	3	KS1 Lenaxa	56	72	-	44	18	102	1.33	61	8	14	0.77	11	16	58	0.60	50	16	599	0.87	452	16	346	1.66	179
	4	MI1 Grace S.	52	75	5	39	20	188	0.94	137	9	5	0.34	5	11	60	0.79	47	17	435	0.71	355	16	59	1.24	37

Table A-4 (ctd.)
Individual NURP Site Event Mean Concentrations (USEPA, 1983)

Land Use		Site	Land Use %	Area (A)	Pop. Den. (#/A)	% IMP.	TKN No. of OBS	TKN Mean ug/L	TKN COV	TKN Median ug/L	Nitrite plus Nitrate No. of OBS	Nitrite plus Nitrate Mean ug/L	Nitrite plus Nitrate COV	Nitrite plus Nitrate Median ug/L	Total Copper No. of OBS	Total Copper Mean ug/L	Total Copper COV	Total Copper Median ug/L	Total Lead No. of OBS	Total Lead Mean ug/L	Total Lead COV	Total Lead Median ug/L	Total Zinc No. of OBS	Total Zinc Mean ug/L	Total Zinc COV	Total Zinc Median ug/L
Resid.	1	CO1 Big Dry Cr	100	33	19	41	16	2369	0.58	2041	15	527	0.34	499	16	32	0.82	25	16	183	0.88	137	15	194	0.80	151
	2	CO1 Cherry	100	57	24	38	14	2603	0.39	2430	14	709	0.40	657	14	35	1.48	20	14	194	0.92	143	14	195	0.63	165
	3	CO1 116/Claude	100	167	14	24	15	2893	0.51	2501	16	670	0.51	579	16	28	0.74	22	16	292	0.87	210	16	195	0.66	158
	4	DC1 Dufief	100	12	-	-	6	2066	0.13	2048	8	470	0.35	445	21	-	-	-	1	-	-	-	8	156	0.26	151
	5	DC1 Lakeridge	100	68	21	27	48	1724	0.64	1450	49	746	0.62	633	14	38	0.55	33	19	227	0.54	200	48	129	0.70	106
	6	DC1 Stratton	100	8	-	-	28	1811	0.39	1686	33	418	0.86	317	10	28	0.30	27	0	-	-	-	28	84	0.47	76
	7	IL1 John M	100	54	18	19	33	3994	0.81	3107	0	-	-	-	36	83	0.85	63	36	237	0.73	191	0	-	-	-
	8	KS1 Overton	100	58	8	38	5	-	-	-	0	-	-	-	12	91	0.50	81	11	138	0.39	128	13	831	0.97	596
	9	MA2 Hemlock	100	50	5	16	5	3679	0.55	3217	4	-	-	-	0	-	-	-	0	-	-	-	0	-	-	-
	10	MD1 Bolton Hill	100	14	30	51	18	6067	0.77	4815	19	9535	1.59	5073	19	107	0.70	88	19	2745	4.53	592	19	1388	2.21	573
	11	MD1 Homeland	100	23	9	29	13	6505	0.40	6044	13	6343	4.56	1358	13	312	0.34	296	13	76	0.46	69	13	120	0.35	113
	12	MD1 Mt Wash	100	17	12	29	20	6935	0.41	6408	20	7822	1.56	4229	20	26	0.78	20	20	86	0.48	77	20	92	0.54	81
	13	MD1 Res Hill	100	10	55	76	13	10803	0.43	9915	13	6938	1.08	4707	13	42	0.69	34	13	461	1.86	218	13	531	1.20	340
	14	NY1 Carll's K.	100	73	13	20	24	1487	0.73	1201	24	730	1.38	442	0	-	-	-	0	-	-	-	0	-	-	-
	15	NY1 Unqua	100	-	-	-	8	1408	0.26	1363	8	1533	-	-	0	-	-	-	8	88	1.36	52	0	-	-	-
	16	NY3 Cranston	100	166	5	22	13	1492	0.45	1358	0	-	-	-	0	-	-	-	13	34	0.77	27	9	415	0.88	312
	17	NY3 E. Roch.	100	346	18	38	7	3246	0.90	2411	0	-	-	-	0	-	-	-	8	193	0.89	144	8	488	1.10	327
	18	TX1 Rollingwood	100	60	3	21	9	5004	2.37	1942	9	879	0.51	783	0	-	-	-	0	-	-	-	0	-	-	-
	19	WA1 Surrey	100	95	9	29	118	1007	0.62	857	0	-	-	-	0	-	-	-	118	152	0.51	136	118	124	0.42	114
	20	Wl1 Burbank	100	63	15	50		1260	0.50	1125	18	775	0.48	699	0	-	-	-	44	95	0.72	77	18	106	1.34	63
	21	Wl1 Hastings	100	33	17	51	15	1102	0.54	969	24	625	0.39	582	0	-	-	-	35	108	0.67	90	21	108	1.20	69
	22	FL1 Young Apts	100	9	-	6	12	1339	0.70	1097	12	311	0.64	262	12	6	0.36	6	12	76	1.03	53	12	60	0.45	55
	23	TR1 Hart	99	378	9	40	11	3016	0.75	2412	10	1625	0.54	1430	0	-	-	-	0	-	-	-	0	-	-	-
	24	Wl1 Lincoln	97	36	18	57	1	-	-	-	3	-	-	-	0	-	-	-	22	303	1.14	200	0	-	-	-
	25	TN1 R2	96	89	4	13	11	476	0.33	452	11	397	1.34	237	11	28	1.54	15	11	133	0.41	123	11	93	0.57	81
	26	DC1 Westleigh	93	41	3	21	41	1901	0.56	1660	41	702	0.59	606	6	37	0.43	34	5	186	0.17	184	34	67	0.96	48
	27	KS1 IC - 92nd	92	63	-	37	8	4187	0.94	3051	0	-	-	-	2	-	-	-	3	-	-	-	3	-	-	-
	28	IL1 John S.	91	39	18	18	32	3527	1.04	2441	0	-	-	-	36	43	0.84	33	33	217	0.80	169	1	-	-	-
	29	TN1 R1	91	69	11	33	11	1131	0.34	1071	11	578	0.77	458	11	61	0.60	52	11	440	0.61	376	11	412	0.59	354
	30	WA1 Lake Hills	91	102	12	37	127	1056	0.73	852	0	-	-	-	5	22	0.34	21	126	192	0.67	159	126	120	0.53	107
	31	IL1 Mattis S.	90	28	22	37	32	3440	0.69	2825	0	-	-	-	36	45	0.76	36	37	595	1.12	396	0	-	-	-
	32	FL1 Charter Hdg.	89	42	-	16	12	1704	0.83	1309	12	610	0.77	483	12	10	0.94	7	12	49	1.60	26	12	54	1.02	38
	33	DC1 Fairidge	88	19	-	34	46	2212	0.53	1958	48	927	0.66	772	9	26	0.39	25	1	-	-	-	44	86	0.52	76
	34	CD1 Asbury	86	127	9	22	7	3735	0.56	3263	9	881	0.21	862	9	59	0.84	46	9	433	0.72	351	9	349	0.63	295
	35	IL2 Comb Inlets	85	524	8	17	0	-	-	-	21	796	0.55	699	26	49	0.53	43	24	322	1.01	227	27	230	0.69	189
	36	MA1 Locust	85	154	11	16	6	2695	0.38	2522	5	1705	0.69	1406	6	107	0.23	104	6	271	0.67	225	6	247	0.31	236
	37	MC1#1023	84	324	6	27	67	1488	0.94	1086	67	716	0.68	591	66	39	0.60	33	66	254	0.98	182	66	178	0.81	138
	38	MA1 Jordan	79	110	10	21	9	1391	0.60	1194	9	1247	0.55	1094	8	74	0.24	72	9	168	0.32	160	9	218	0.28	210
	39	DC1 Stedwick	78	27	15	34	43	1895	0.57	1643	47	837	0.70	686	9	30	0.35	28	11	141	0.41	130	45	91	0.70	75
Open	1	CA1 Seaview	100	633	-	-	13	3674	0.59	3159	12	1542	0.49	1383	12	58	0.33	55	7	214	0.89	159	17	190	0.64	160
	2	CO1 Rooney Gulch	100	405	0	1	7	2954	0.53	2615	7	581	1.03	405	7	37	1.09	25	7	52	0.91	39	7	105	0.58	91
	3	NY3 Thornell	100	28,416	-	4	13	1099	0.50	982	0	-	-	-	0	-	-	-	10	12	0.42	11	9	792	2.39	306
	4	NY2 English Br	98	5,248	-	1	15	340	0.50	305	30	240	0.60	206	0	-	-	-	21	9	0.60	8	0	-	-	-
	5	NY2 West Br	97	5,338	-	1	24	392	0.52	347	31	862	0.53	763	0	-	-	-	25	38	1.40	22	0	-	-	-
	6	NY3 Thomas Cr	91	17,728	1	11	10	1111	0.36	1045	0	-	-	-	0	-	-	-	12	35	1.65	18	9	1063	3.14	322
	7	NY3 Traver Cr	90	2,303	-	6	5	889	0.11	883	5	1108	0.17	1092	0	-	-	-	0	-	-	-	2	-	-	-
	8	NY2 Sheriff Dock	80	552	-	7	33	963	0.76	765	33	383	1.02	268	0	-	-	-	33	132	1.05	91	0	-	-	-

Table A-4 (ctd.)
Individual NURP Site Event Mean Concentrations (USEPA, 1983)

							TKN				Nitrite plus Nitrate				Total Copper				Total Lead				Total Zinc			
Land Use		Site	Land Use %	Area (A)	Pop. Den. (#/A)	% IMP.	No. of OBS	Mean ug/L	COV	Median ug/L	No. of OBS	Mean ug/L	COV	Median ug/L	No. of OBS	Mean ug/L	COV	Median ug/L	No. of OBS	Mean ug/L	COV	Median ug/L	No. of OBS	Mean ug/L	COV	Median ug/L
Mixed	1	KS1 Noland	-	36	3	68	0	-	-	-	0	-	-	-	9	48	0.38	45	9	164	0.49	147	9	814	1.19	525
	2	MD1 Hampden	-	17	40	72	19	6994	0.55	6140	20	11529	4.00	2793	20	81	0.86	61	20	227	0.82	176	13	318	0.35	112
	3	IL1 Mattis N	-	17	3	58	35	2822	0.64	2372	0	-	-	-	37	48	0.81	37	41	554	1.06	380	0	-	-	-
	4	MI1 Waverly	-	30	11	68	35	1490	0.53	1316	35	775	0.49	696	16	15	0.54	13	24	111	1.09	75	17	121	0.45	110
	5	IN1 SC	-	187	3	43	13	623	0.50	558	13	587	1.49	327	13	42	1.35	25	13	237	0.31	227	13	149	0.40	138
	6	WL1 Wood Ctr	-	45	12	81	16	1462	0.35	1369	17	751	0.69	618	0	-	-	-	45	582	0.94	424	27	476	1.21	303
	7	MA1 Rt 9	-	338	7	23	5	2446	0.50	2188	5	1789	0.48	1613	7	112	0.49	100	7	439	1.02	307	7	244	0.43	225
	8	MA1 convent	-	100	1	33	8	1080	0.64	910	6	960	0.39	894	7	105	0.43	96	7	196	0.94	143	7	202	0.59	174
	9	MI1 Grand R Ot	-	453	5	38	23	1631	0.42	1506	23	883	0.44	807	13	30	0.63	26	18	122	0.90	91	14	245	0.71	200
	10	MI3 Pitt AA-S	-	2001	2	21	6	845	0.29	811	6	284	0.48	256	0	-	-	-	6	21	1.63	11	4	-	-	-
	11	NY2 Cedar	-	76	-	5	21	1237	0.83	951	32	248	0.72	201	0	-	-	-	28	75	1.25	47	0	-	-	-
	12	MA1 Anna	-	601	9	12	6	1888	0.70	1547	6	1268	0.60	1086	5	54	0.51	48	4	-	-	-	5	178	1.50	99
	13	MI3 Pitt AA-N	-	2871	7	26	6	1056	0.22	1031	5	469	0.24	456	0	-	-	-	5	61	0.71	50	4	-	-	-
	14	MI1 Grace N	-	164	5	28	23	1988	0.47	1802	23	875	0.43	803	9	14	0.31	13	18	170	1.39	99	9	149	0.35	140
	15	MI3 Swift Run	-	1207	2	4	5	1116	0.15	1104	5	1033	0.76	821	0	-	-	-	4	-	-	-	2	-	-	-
	16	SD1 Meade	-	2030	-	-	13	4243	0.50	3802	15	616	0.40	571	0	-	-	-	24	383	1.13	254	0	-	-	-
	17	CA1 Knox	-	1542	12	-	20	2220	0.75	1775	17	1111	0.36	1044	17	98	1.14	65	22	495	0.99	351	21	303	0.85	231
	18	FL1 N. Jesult	-	30	-	13	15	1388	0.49	1249	14	376	0.54	332	15	7	0.63	6	15	56	1.22	35	15	94	0.68	78
	19	FL1 WIlder	-	194	-	97	15	1107	0.31	1056	15	456	0.47	412	15	6	0.84	5	15	85	0.85	65	15	51	0.95	37
	20	CO1 North Ave	-	69	9	50	23	4196	0.65	3522	32	1744	0.92	1286	32	77	0.83	59	33	358	0.81	278	33	543	0.82	421
Comm	1	CO1 Villa Italia	100	74	0	91	27	3657	0.85	2785	27	1180	0.86	895	27	33	0.87	25	27	262	1.21	167	27	320	0.82	247
	2	NC1 1013 (CBD)	100	23	0	69	61	1613	0.70	1318	61	1118	0.55	980	61	70	0.54	61	61	382	0.81	296	60	533	0.51	474
	3	NY3 Southgate	100	179	2	21	13	1256	0.45	1144	0	-	-	-	0	-	-	-	13	47	0.50	42	9	1416	2.55	517
	4	Wl1 Post Office	100	12	0	100	27	1023	0.44	936	28	708	0.68	584	0	-	-	-	59	193	0.83	148	32	145	1.16	94
	5	NH1 Pkg Lot	100	1	0	90	18	2112	0.66	1761	28	801	0.84	615	31	104	0.13	103	33	208	0.93	152	33	513	0.65	430
	6	TN1 CBD	100	26	0	99	15	646	0.41	597	15	662	0.62	562	15	42	0.60	36	15	158	0.52	140	15	315	0.43	289
	7	Wl1 Rustler	100	12	0	100	25	1073	0.61	916	26	781	0.69	642	0	-	-	-	44	121	0.73	98	19	156	0.75	125
	8	KS1 IC Metcalf	96	58	-	97	17	1175	0.73	949	0	-	-	-	6	41	0.33	39	7	-	-	-	7	465	0.78	368
	9	FC1 Norma Pk	91	47	-	45	12	826	0.84	633	12	356	0.46	323	12	11	0.47	10	12	46	1.01	32	12	37	0.88	28
	10	Wl1 State Fair	74	29	10	77	8	1656	0.65	1389	12	783	0.50	702	0	-	-	-	27	409	0.86	310	7	280	0.66	234
Indus.	1	MA2 Addison	100	18	0	69	5	2092	0.49	1879	5	1355	0.29	1301	0	-	-	-	0	-	-	-	0	-	-	-
	2	MI1 Indus Drain	100	63	0	64	18	1274	0.57	1107	18	686	0.40	637	6	36	0.53	32	13	116	0.77	92	7	244	0.42	225
	3	KS1 Lenaxa	56	72	-	44	12	1385	0.73	1117	0	-	-	-	5	36	0.24	35	6	-	-	-	6	2721	3.29	791
	4	MI1 Grace S.	52	75	5	39	18	1713	0.56	1493	17	742	0.52	657	7	25	0.65	21	13	115	0.76	92	7	223	0.54	196

Appendix B

Variable Dictionary

$AC_{1,SB}$	=	Fractional areal coverage of BMP type 1 on subbasin SB.
$AC_{2,SB}$	=	Fractional areal coverage of BMP type 2 on subbasin SB.
$AC_{3,SB}$	=	Fractional areal coverage of BMP type 3 on subbasin SB.
$AC_{4,SB}$	=	Fractional areal coverage of BMP type 4 on subbasin SB.
$AC_{5,SB}$	=	Fractional areal coverage of BMP type 5 on subbasin SB.
C_I	=	Pervious area runoff coefficient.
C_P	=	Impervious area runoff coefficient.
CSO	=	annual CSO pollution load generated from the CSO subarea.
CSOMASS	=	annual CSO pollution load discharged from the CSO subarea.
CSOREM	=	percent of annual pollution load captured by the control alternative.
CV	=	Coefficient of variation (standard deviation/mean).
EMC_L	=	Event mean concentration of runoff from land use L (mg/L). EMC_L varies by land use and by pollutant.
$EMC_{(High,Low)}$	=	Event mean concentration for a given probability of exceedance.
IMP_L	=	Fractional imperviousness of land use L.
I	=	Long-term average annual precipitation (in/yr).
K	=	0.2266, a unit conversion constant.
MASS	=	Annual nonpoint pollution load washed off the watershed (lbs/yr).
M_L	=	Loading factor for land use L (lb/ac/yr).
$P_{L,SB}$	=	Percent of annual nonpoint pollution load captured in subbasin SB by application of five BMP types on land use L.
REM_1	=	Removal efficiency of BMP type 1. REM_1 varies by pollutant type but not by land use.
REM_2	=	Removal efficiency of BMP type 2. REM_2 varies by pollutant type but not by land use.
REM_3	=	Removal efficiency of BMP type 3. REM_3 varies by pollutant type but not by land use.
REM_4	=	Removal efficiency of BMP type 4. REM_4 varies by pollutant type but not by land use.

REM_5	=	Removal efficiency of BMP type 5. REM_5 varies by pollutant type but not by land use.
R_L	=	Total average annual surface runoff from land use L (in/yr).
T	=	Median value.
U	=	Log mean (base e).
Z	=	Standardized normal deviate.
W	=	Log standard deviation (base e).

Appendix C

Sample Application

To create a sample scenario, enter the Scenario Manager Module of WMM for Windows. Click on the **New** button found next to the Scenario Name and Description box when the box is highlighted. Enter the desired scenario name and description in the appropriate locations.

To create the land use file, click on the **New** button found next to the land use types data files when the list is highlighted. Default impervious percentages will appear, as shown in Figure C-1. These default land use types and percent impervious values will be used for this modeling exercise. Enter the desired name and description of this data set and click **Save** to return to the Scenario Manager 1 Screen.

To create the parameters file, click on the **New** button found next to the parameters file list when the list is highlighted. A list of default parameters will appear, as shown in Figure C-2. Enter the desired name and description for this file. For this modeling exercise, the following parameters will be used: BOD, TSS, Total Phosphorus, Dissolved Phosphorus, TKN, NO_3+NO_2-N, Lead, Copper, Zinc, Cadmium and Fecal Coliform. To remove the undesired parameters from the parameter set, click on the **Add/Delete** button. Remove the undesired parameters by highlighting the undesired parameter in the User Parameter Set list and clicking on the left arrow button, as shown in Figure C-3. After all the needed changes are made, click **Save** to return to the Parameter Set Information Screen, then click **Save** again to return to the Scenario Manager 1 Screen.

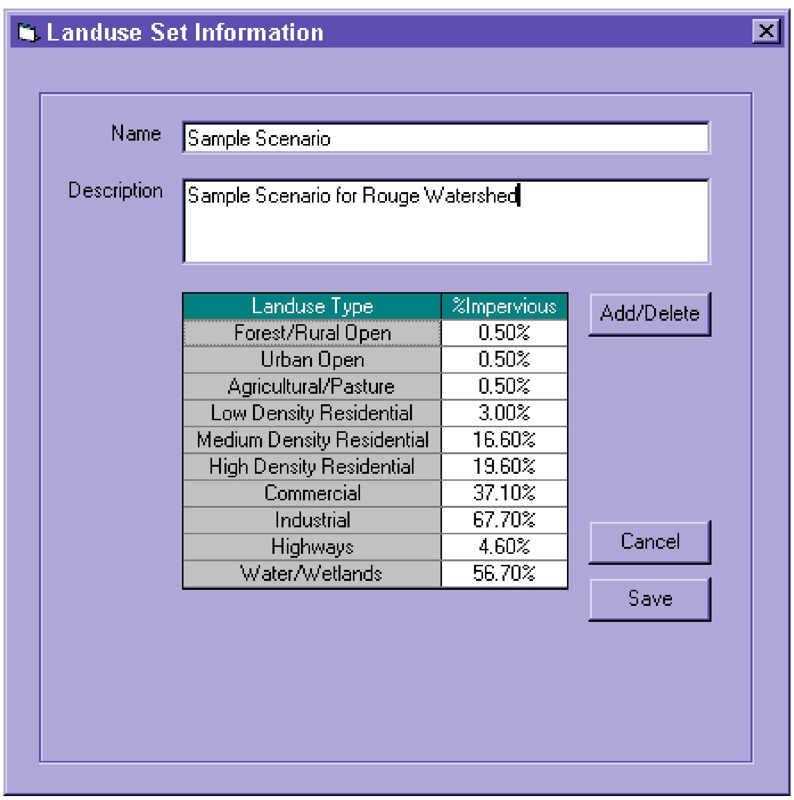


Figure C-1
Land Use Set Information

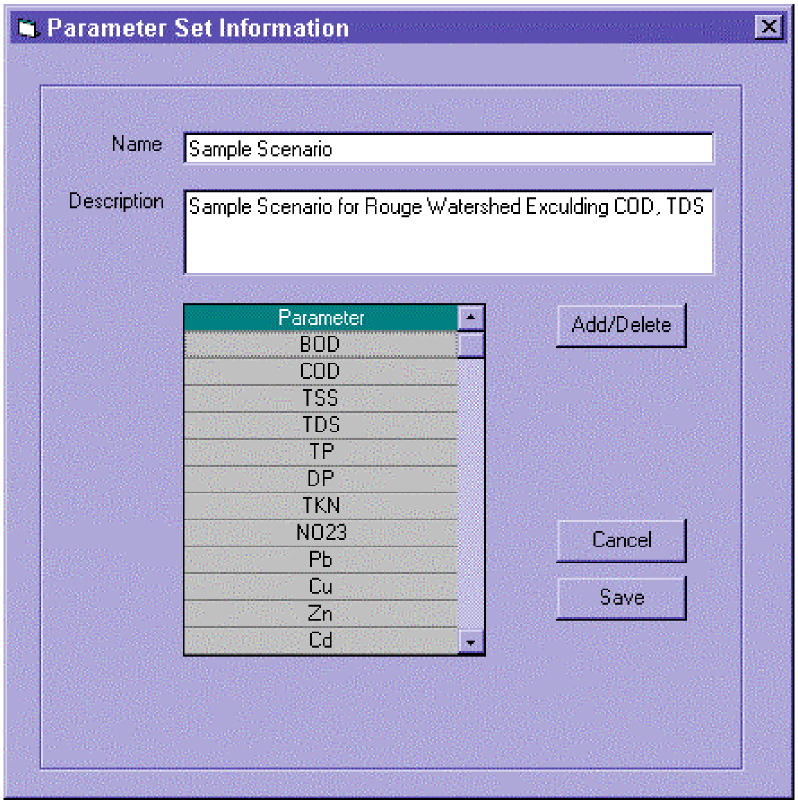


Figure C-2
Parameter Set Information

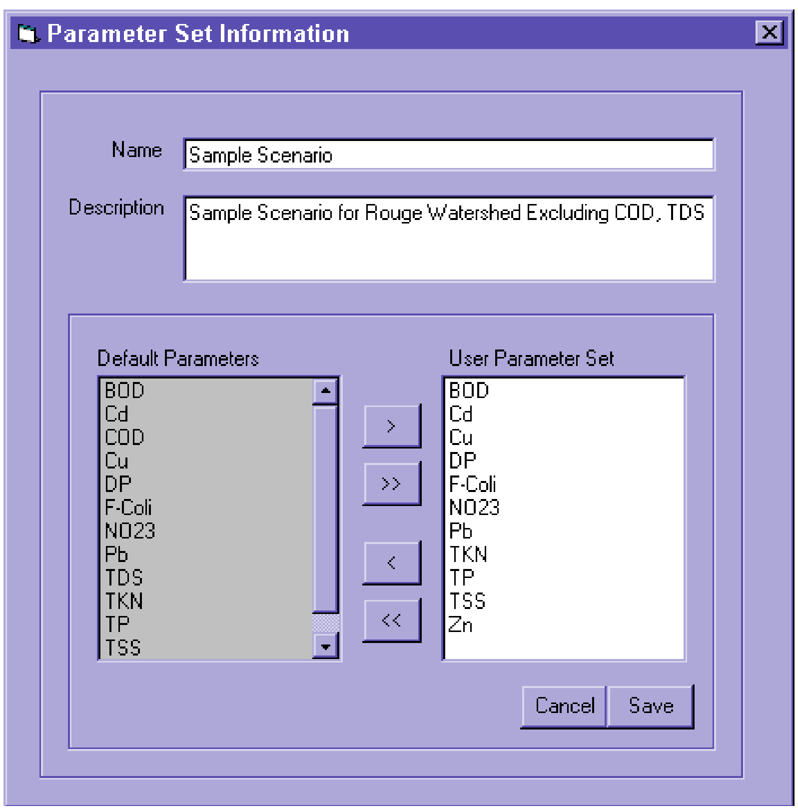


Figure C-3
Add/Delete Parameters

To create the watershed file, click the **New** button found next to the watershed data file list when the file list is highlighted. Enter the desired file name and description in the appropriate locations. Next, enter the subbasin name and jurisdiction, in the appropriate locations. Next, enter acreage totals for each land use type for the subarea. These values can be found in Figure C-4, which shows a completed WMM for Windows screen for this first subarea. Notice that as the acreage numbers for each land use are entered, the total acres are automatically calculated in the acres box to the left of the land use acreage breakdown. For this modeling exercise, a delivery ratio of one will be used. Enter this value in the appropriate location. Click on the box located next to the words septic impact to activate this option. Notice that the three residential land use types appear with default percent area values of zero. None of the residential areas located within subbasin 3205 Livonia are served by septic systems, so these values are left as zero. Although not necessary for this subbasin, a default septic failure rate of eleven percent may be entered in decimal format (e.g. 0.11 equals 11%). After all of the data for this first subbasin are entered, click on the **Add** button to add one additional subbasin. All of the required data for the second subbasin are shown in Figure C-5 Click the **Save** button to save these entries.

To create the hydrologic data file for this scenario, click on **New** found next to the hydrologic data file list when the file list is highlighted. Enter the desired file name, file description, and the hydrologic parameter data given in Figure C-6. Click **Save** to return to the Scenario Manager 1 Screen.

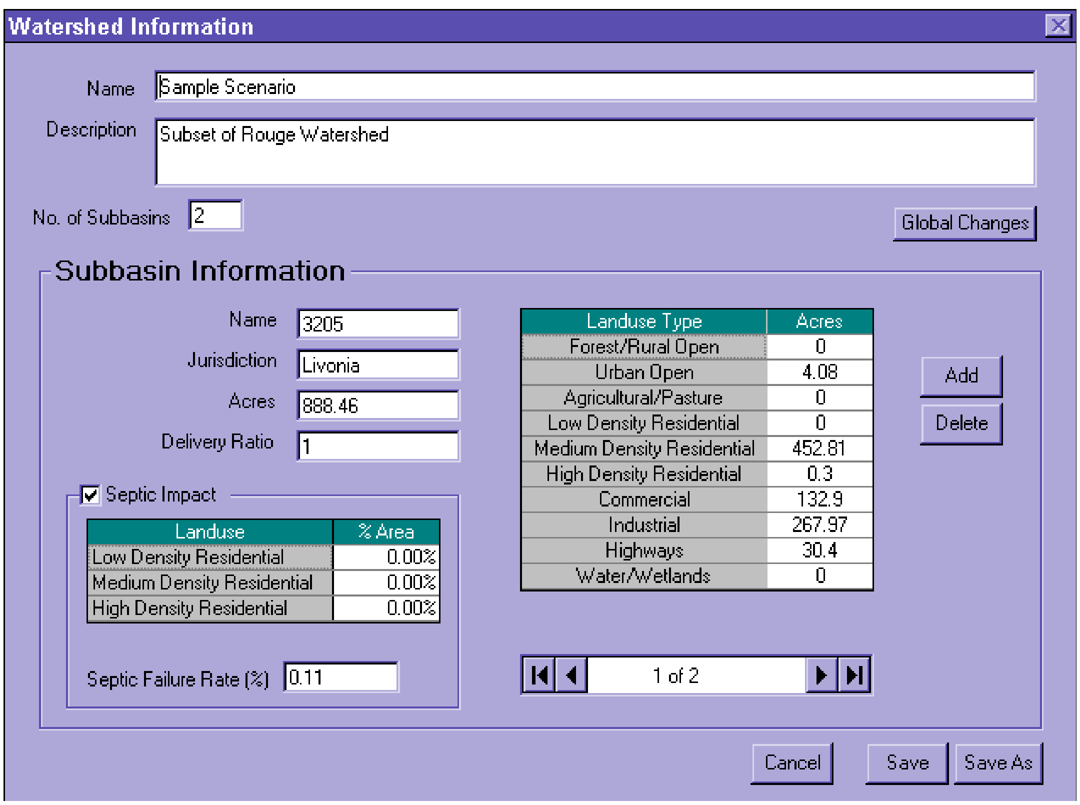


Figure C-4
Subbasin 3205 - Livonia

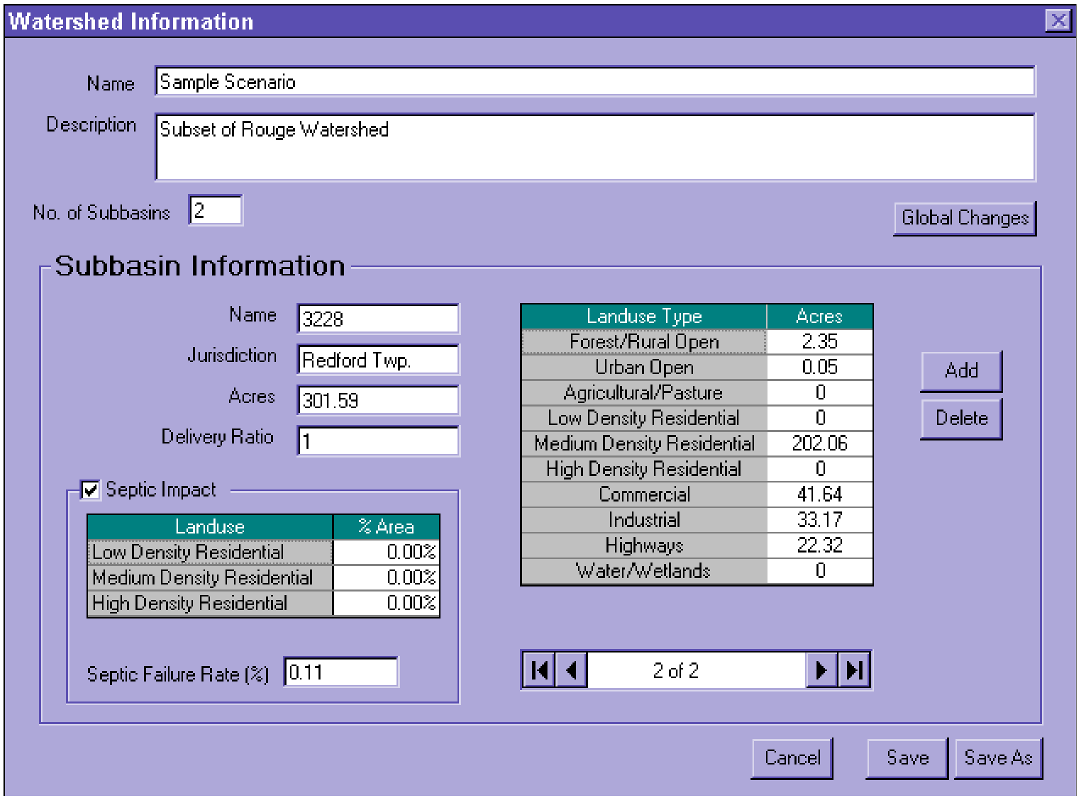


Figure C-5
Subbasin 3228 - Redford Twp.

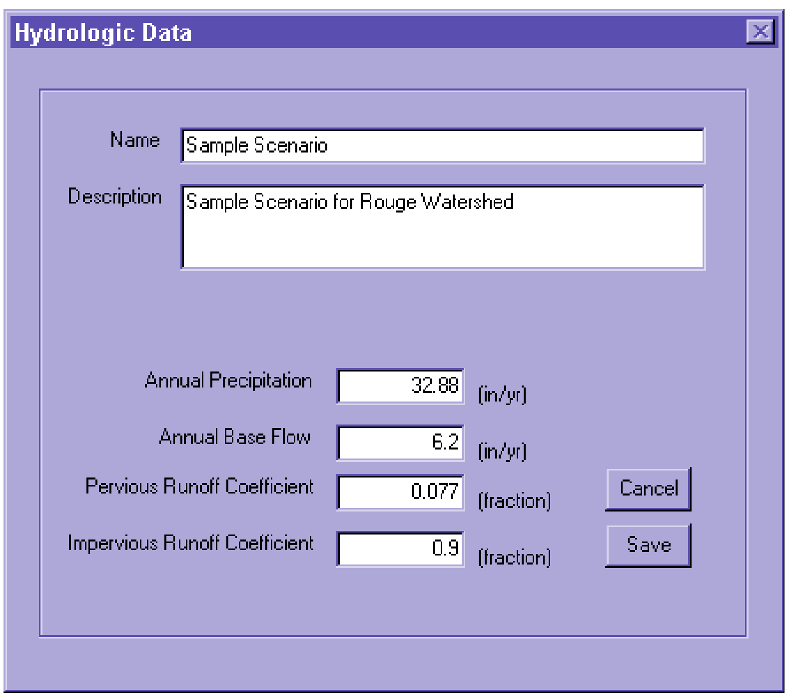


Figure C-6
Hydrologic Data

To create the EMC file for this scenario, click on **New** button found next to the EMC mean values file list when the file list is highlighted. A screen (Figure C-7) will appear with the EMC values that were originally defined in the Default Manager. These values are appropriate for this modeling excercise so no changes are necessary. Enter the desired file name and description and click **Save** to return to the Scenario Manager 1 Screen.

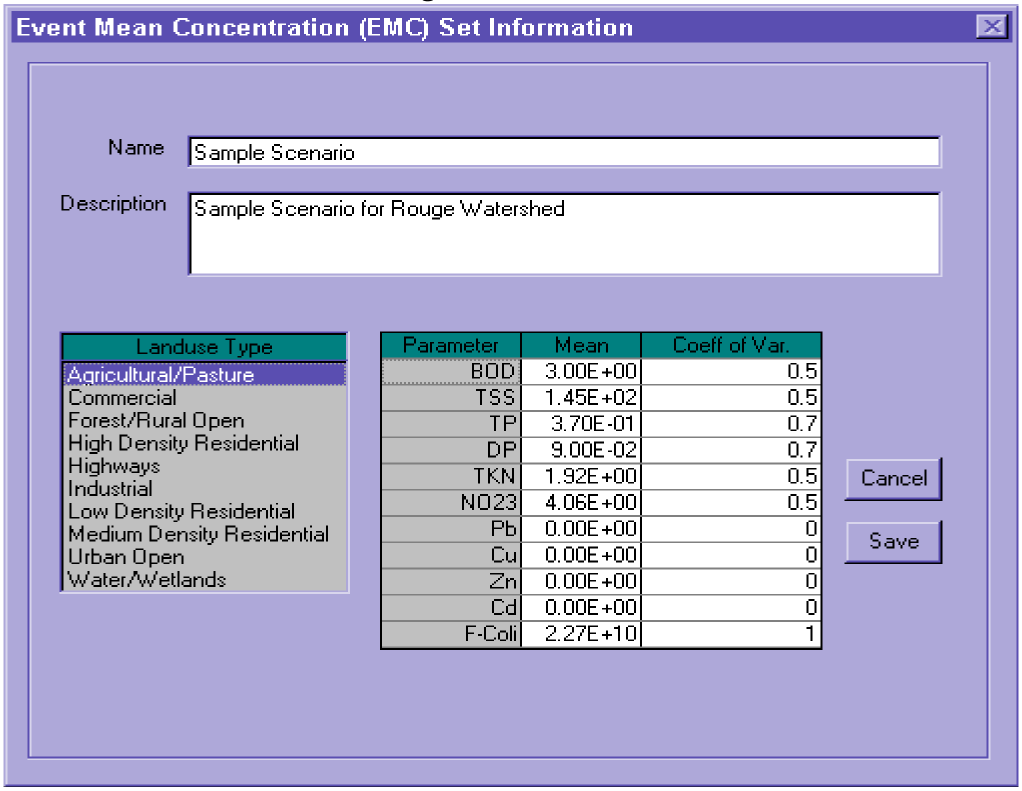


Figure C-7
EMC Data

To create the baseflow parameter concentrations file for this scenario, click on the **New** button found next to the file list when it is highlighted. Enter the desired file name and description and then enter the concentrations for each parameter, as shown in Figure C-8. Note that the fecal coliform base flow value is actually a concentration of 300 counts per 100 mL multiplied by a conversion factor of 4,535,000. Click Save to return to Scenario Manager - 1.

To create the suspended fraction file for this scenario, click on the **New** button which appears next to the file list when the list is highlighted. The default suspended fraction values for each parameter and land use will automatically be shown in this table, so no data needs to be entered in this screen except for the desired file name and description. Although suspended fraction data are needed to run the model, these data will not affect the results of this sample scenario because delivery ratio values of one were input in the Watershed file. Click **Save** to return to the Scenario Manager - 1 screen.

To create the septic tank loading failure rates file, click on the **New** button located next to the file list when the list is highlighted. Enter the desired file name and description and click **Save** to return to the Scenario Manager - 1 screen. No additional input is required for this file because the data from the default manager are automatically entered as the default values.

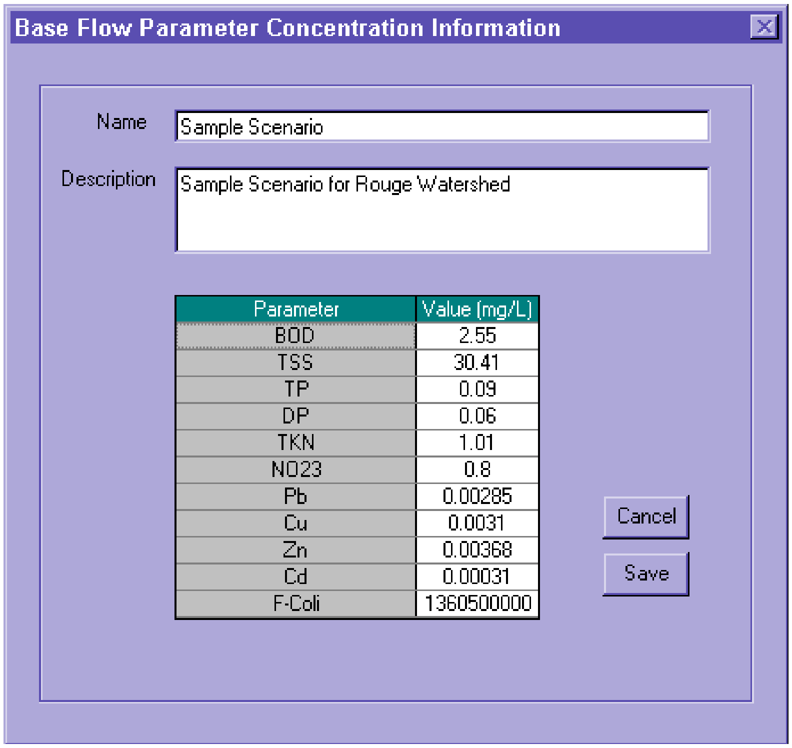


Figure C-8
Baseflow Data

After creating the septic tank loading failure rates file, click the **Next** button to move on to Scenario Manager - 2. Click the box next to Medium to select the loading factor type in the Uncertainty Analysis Section.

Click on the box next to "Include CSOs" to activate this option. Click the **New** button to create the CSO concentration data set file. Enter the desired file name and description in the appropriate location. For this modeling exercise, subbasin 3228-Redford Township contains CSOs. Highlight this subbasin and click on the right arrow button to move this subarea to the selected subbasin list. Click on the **Save** button.

After adding subbasin 3228-Redford Township to the selection list and saving the file, a screen will appear allowing you to enter the CSO flow and pollutant concentrations. The data required for this CSO are shown in Figure C-9. Remember that the value entered for Fecal Coliform is actually a concentration of 1,000,000 in counts per 100 mL multiplied by a conversion factor of 4,535,000.

Click on the box next to "Include BMPs" to activate this option. Click the **New** button to create the BMP Types data set file. A list of default BMPs will appear. After entering a file name and description in the appropriate locations, click the **Add/Delete** button to select the BMPs desired for this sample application. Remove all BMPs but the Extended Dry Detention BMP from the User BMP Types Set List to create a screen that looks like the one shown in Figure C-10. Click **Save** to return to the previous screen, then click **Save** again to return to the Scenario Manager - 2 Screen.

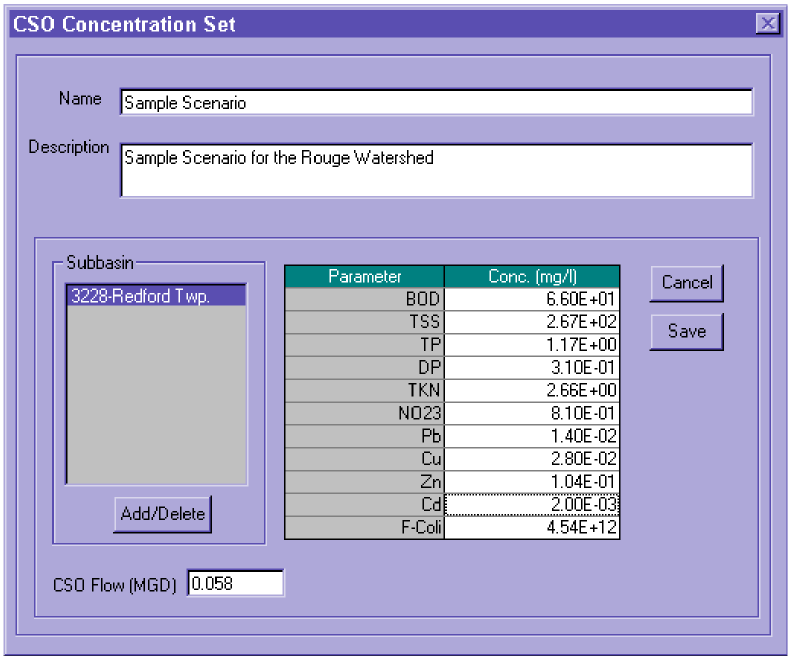


Figure C-9
CSO Concentrations

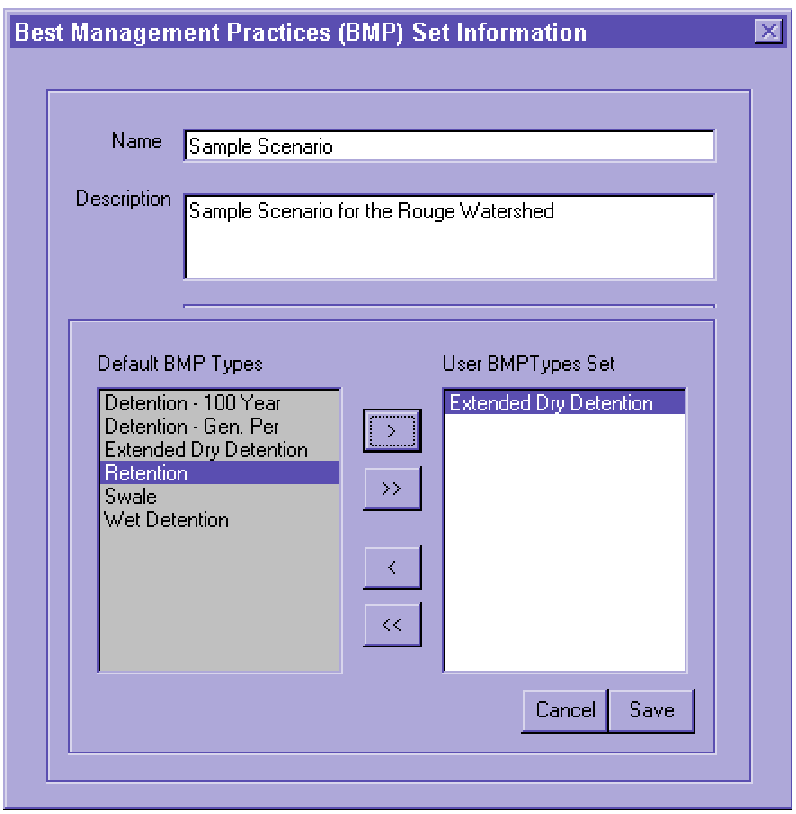


Figure C-10
BMP Types

To create the BMP removal rates file, click on the **New** button located next to the file list when the list is highlighted. Enter the desired file name and description in the appropriate locations and click **Save** to return to the Scenario Manager - 2 screen. No additional input is required for this file because the BMP pollutant removal rates from the Default Manager are automatically entered as the default values.

To create the BMP spatial extent file, click on the **New** button located next to the file list when it is highlighted. Enter the desired file name and description in the appropriate locations. For this modeling exercise, the extended dry detention BMP will be applied to a portion of subarea 3205 Livonia. The percentage of area covered for each land use category may be found in Table C.1. In WMM, enter each percentage by moving each appropriate land use category to the list on the right and entering the percent coverage in decimal format (e.g. 0.25 equals 25 percent.) After all desired coverages have been entered, click the **Save** button located at the bottom of the screen to return to the Scenario Manager - 2 screen To verify your entries, click on the View/Edit button to obtain a listing of the entries, as shown in Figure C-11. To view the percent coverage for each land use, click on the land use to highlight it. Click Save to **Save** changes or **Cancel** to return to the Scenario Manager - 2 screen if no changes were made.

Table C.1
Area Served by Extended Dry Detention

Land Use Type	Percent of Area Served by BMP
Medium Density Residential	10%
Commercial	13%
Industrial	75%
Highway	21%

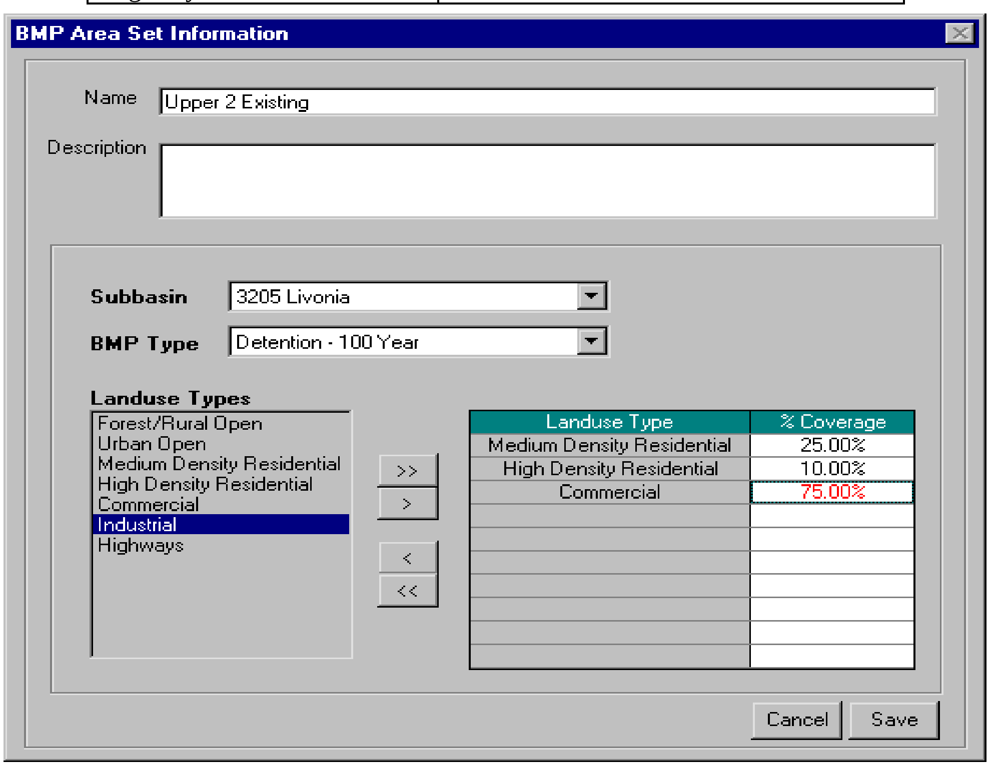


Figure C-11
BMP Spatial Extent

Click on the box next to Include Point Sources to activate this option. Click on the **New** button to create the Point Source data set file. For this exercise, there will be one point source pollutant source located within subbasin 3205 - Livonia. Enter the desired file name and description in the appropriate locations and add Subbasin 3205 - Livonia to the selected subbasin list by highlighting this subbasin and clicking on the right arrow button. Click **Save** to obtain the screen that allows point source pollutant loads to be entered. The required values are shown in Figure C-12. Click **Save** to return to return to the Scenario Manager - 2 screen.

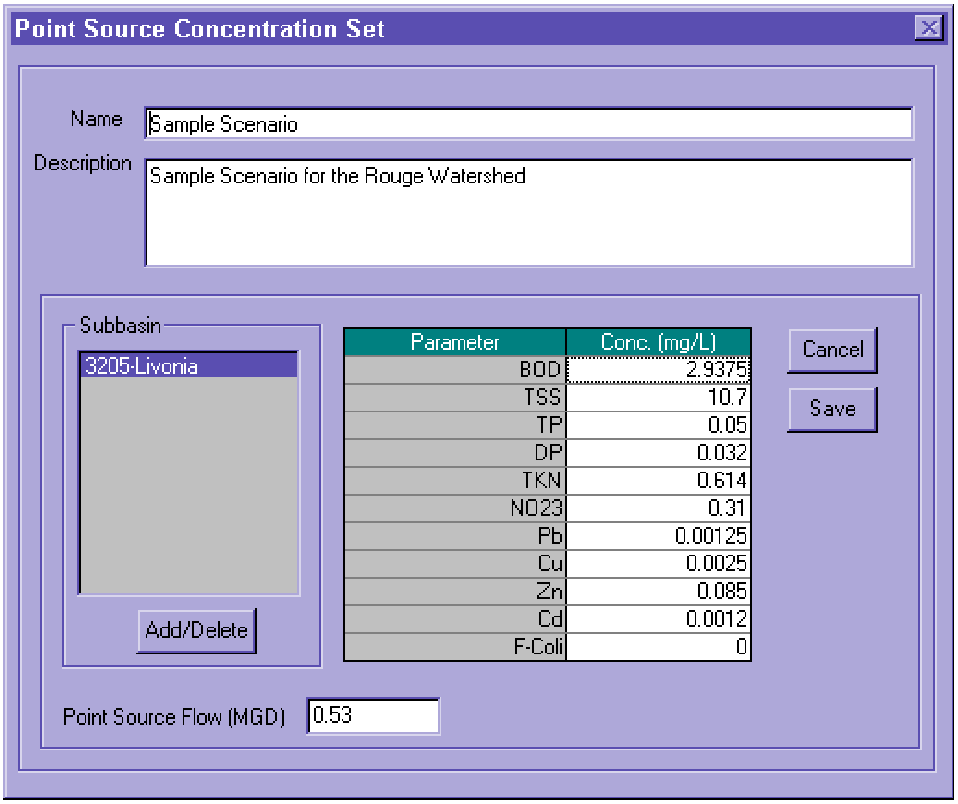


Figure C-12
Point Sources

Click on the box next to Include CSO Controls to activate this option. Click on the **New** button to create the CSO Controls data set file. Click on the **Add** button to add a new CSO control. When prompted, enter the name "Phase II CSO Basin" and click on **Save**. Add this new CSO control to the selected CSO controls list by highlighting the control and clicking on the right arrow button. Note that Sewer Separation is also listed as a control in this column. Although sewer separation will not be a control used in this subbasin, it must remain in the selected CSO controls list. Click **Save** to retain these selections and to obtain the screen that allows entry of pollutant load reductions expected from the selected controls. The required values are shown in Figure C-13. Remember to enter percent reductions as decimal values (e.g. 0.25 equals 25 percent.) Note that no changes are needed to the Sewer Separation control option. Default values of zero are automatically entered for all CSO controls and since sewer separation will not be used in this subarea, no reductions of will be achieved by this control. Click the **Add/Delete** button to add subbasin 3228 Redford Twp. to the list of subbasins controlled by the Phase II CSO Basin. Click **Save** to return to the Scenario Manager - 2 screen.

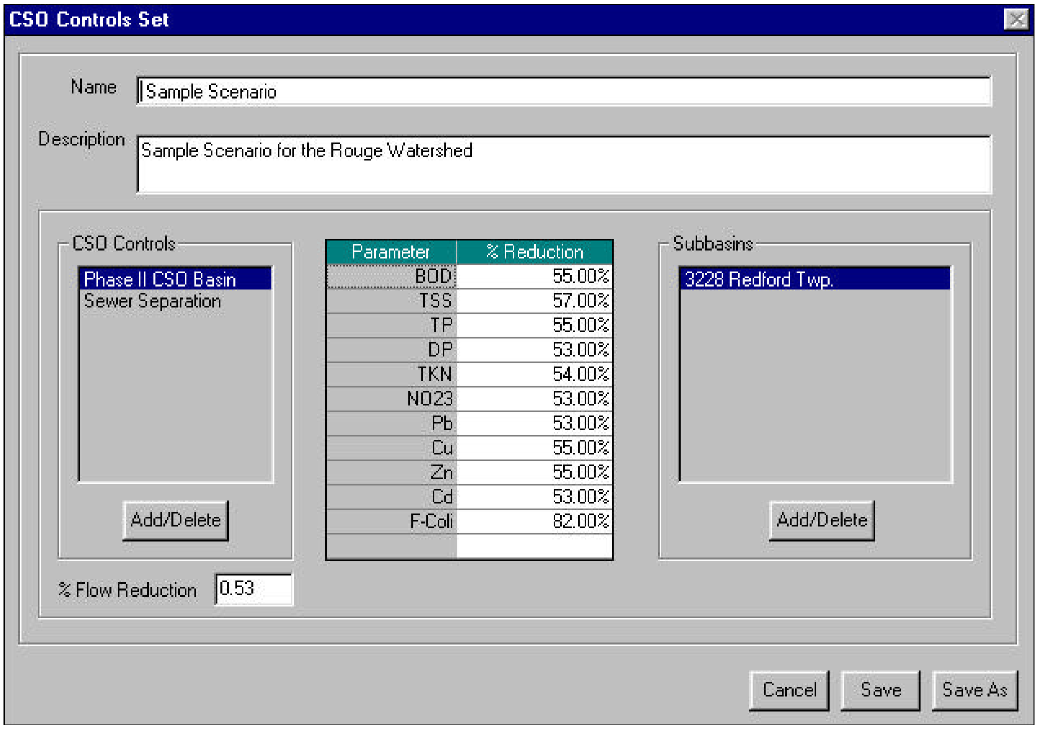


Figure C-13
CSO Controls

After all of the data described in the previous pages have been entered, save this scenario combination by clicking on the **Save Scenario** button found at the bottom of the Scenario Manager - 2 screen.

The model is not ready to be run. You may execute the model by clicking on the **Run Model** button located at the bottome of the Scenario Manager - 2 screen. When prompted, enter the desired model run output name and description and click the **OK** button. When the model run is completed, output will appear like that shown in Table C.2 (if all data were entered correctly during the model setup.)

Table C.2: Output for Sample Data Set

Name	Jurisdiction	Drainage Area (acres)	DCIA Area (acres)	%DCIA	Loading Factor	Parameter	Units	Storm Water	Base Flow	Point Source	CSO	Total	Storm Water with BMP Controls		Total with Controls	%Reduction
3205	Livonia	888	307	34.6	medium	RunOff	(ac-ft/yr)	881	459	594	0	1,933	881	0	1,933	0.0
3205	Livonia	888	307	34.6	medium	BOD	(lbs/yr)	66,364	3,184	4,744	0	74,292	58,356	0	66,284	10.8
3205	Livonia	888	307	34.6	medium	TSS	(lbs/yr)	272,104	37,971	17,280	0	327,356	136,115	0	191,367	41.5
3205	Livonia	888	307	34.6	medium	TP	(lbs/yr)	916	112	81	0	1,110	808	0	1,002	9.7
3205	Livonia	888	307	34.6	medium	DP	(lbs/yr)	405	75	52	0	531	405	0	531	0.0
3205	Livonia	888	307	34.6	medium	TKN	(lbs/yr)	5,735	1,261	992	0	7,988	5,273	0	7,526	5.8
3205	Livonia	888	307	34.6	medium	NO23	(lbs/yr)	4,202	999	501	0	5,702	4,202	0	5,702	0.0
3205	Livonia	888	307	34.6	medium	Pb	(lbs/yr)	152	4	2	0	158	92	0	98	38.1
3205	Livonia	888	307	34.6	medium	Cu	(lbs/yr)	107	4	4	0	115	72	0	80	30.8
3205	Livonia	888	307	34.6	medium	Zn	(lbs/yr)	1,029	5	137	0	1,171	700	0	842	28.1
3205	Livonia	888	307	34.6	medium	Cd	(lbs/yr)	10	0	2	0	13	6	0	9	32.6
3205	Livonia	888	307	34.6	medium	F-Coli	(lbs/yr)	8,416,022,332	77,867,309	0	0	7,193,889,641	708,133,803,791	0	,671,100	9.9
3228	Redford Twp.	302	72	24.0		RunOff	(ac-ft/yr)	0	156	0	65	221	0	31	186	15.6
3228	Redford Twp.	302	72	24.0		BOD	(lbs/yr)	0	1,081	0	11,664	12,745	0	5,249	6,330	50.3
3228	Redford Twp.	302	72	24.0		TSS	(lbs/yr)	0	12,889	0	47,188	60,078	0	20,291	33,180	44.8
3228	Redford Twp.	302	72	24.0		TP	(lbs/yr)	0	38	0	207	245	0	93	131	46.4
3228	Redford Twp.	302	72	24.0		DP	(lbs/yr)	0	25	0	55	80	0	26	51	36.2
3228	Redford Twp.	302	72	24.0		TKN	(lbs/yr)	0	428	0	470	898	0	216	644	28.3
3228	Redford Twp.	302	72	24.0		NO23	(lbs/yr)	0	339	0	143	482	0	67	406	15.7
3228	Redford Twp.	302	72	24.0		Pb	(lbs/yr)	0	1	0	2	4	0	1	2	35.6
3228	Redford Twp.	302	72	24.0		Cu	(lbs/yr)	0	1	0	5	6	0	2	4	43.5
3228	Redford Twp.	302	72	24.0		Zn	(lbs/yr)	0	2	0	18	20	0	8	10	50.7
3228	Redford Twp.	302	72	24.0		Cd	(lbs/yr)	0	0	0	0	0	0	0	0	38.6
3228	Redford Twp.	302	72	24.0		F-Coli	(lbs/yr)	0	54,433,638	0	,251,337	7,182,684,975	0	00,817,948	,251,585	81.9

Appendix D

Sample Output Reports

Table D.1: Standard Report

Name	Jurisdiction	Drainage Area (acres)	DCIA Area (acres)	%DCIA	Loading Factor	Parameter	Units	Storm Water	Base Flow	Point Source	CSO	Total	Storm Water with BMP Controls	CSOs with Controls	Total with Controls	%Reduction
3201	Livonia	0	0	17.4		RunOff	(ac-ft/yr)	0	0	0	0	0	0	0	0	0.0
3201	Livonia	0	0	17.4		BOD	lbs/yr	0	0	0	20	20	0	20	20	0.0
3201	Livonia	0	0	17.4		TSS	lbs/yr	0	2	0	81	84	0	81	84	0.0
3201	Livonia	0	0	17.4		TP	lbs/yr	0	0	0	0	0	0	0	0	0.0
3201	Livonia	0	0	17.4		DP	lbs/yr	0	0	0	0	0	0	0	0	0.0
3201	Livonia	0	0	17.4		TKN	lbs/yr	0	0	0	1	1	0	1	1	0.0
3201	Livonia	0	0	17.4		NO23	lbs/yr	0	0	0	0	0	0	0	0	0.0
3201	Livonia	0	0	17.4		Pb	lbs/yr	0	0	0	0	0	0	0	0	0.0
3201	Livonia	0	0	17.4		Cu	lbs/yr	0	0	0	0	0	0	0	0	0.0
3201	Livonia	0	0	17.4		Zn	lbs/yr	0	0	0	0	0	0	0	0	0.0
3201	Livonia	0	0	17.4		Cd	lbs/yr	0	0	0	0	0	0	0	0	0.0
3201	Livonia	0	0	17.4		F-Coli	counts/yr	0	313	0	,014,153	1,925,014,466	0	25,014,153	,014,466	0.0
3201	Redford Twp.	60	11	18.2		RunOff	(ac-ft/yr)	37	31	0	0	69	37	0	69	0.0
3201	Redford Twp.	60	11	18.2		BOD	lbs/yr	0	217	0	2,300	2,517	0	2,300	2,517	0.0
3201	Redford Twp.	60	11	18.2		TSS	lbs/yr	0	2,584	0	9,373	11,956	0	9,373	11,956	0.0
3201	Redford Twp.	60	11	18.2		TP	lbs/yr	0	8	0	41	49	0	41	49	0.0
3201	Redford Twp.	60	11	18.2		DP	lbs/yr	0	5	0	11	16	0	11	16	0.0
3201	Redford Twp.	60	11	18.2		TKN	lbs/yr	0	86	0	93	179	0	93	179	0.0
3201	Redford Twp.	60	11	18.2		NO23	lbs/yr	0	68	0	28	96	0	28	96	0.0
3201	Redford Twp.	60	11	18.2		Pb	lbs/yr	0	0	0	0	1	0	0	1	0.0
3201	Redford Twp.	60	11	18.2		Cu	lbs/yr	0	0	0	1	1	0	1	1	0.0
3201	Redford Twp.	60	11	18.2		Zn	lbs/yr	0	0	0	4	4	0	4	4	0.0
3201	Redford Twp.	60	11	18.2		Cd	lbs/yr	0	0	0	0	0	0	0	0	0.0
3201	Redford Twp.	60	11	18.2		F-Coli	counts/yr	0	376,421	0	,630,462	7,762,006,882	0	61,630,462	,006,882	0.0
3202	Redford Twp.	256	39	15.4	medium	RunOff	(ac-ft/yr)	142	133	0	0	275	142	0	275	0.0
3202	Redford Twp.	256	39	15.4	medium	BOD	lbs/yr	10,796	920	0	0	11,716	10,796	0	11,716	0.0
3202	Redford Twp.	256	39	15.4	medium	TSS	lbs/yr	27,030	10,973	0	0	38,003	27,030	0	38,003	0.0
3202	Redford Twp.	256	39	15.4	medium	TP	lbs/yr	156	32	0	0	189	156	0	189	0.0
3202	Redford Twp.	256	39	15.4	medium	DP	lbs/yr	79	22	0	0	101	79	0	101	0.0
3202	Redford Twp.	256	39	15.4	medium	TKN	lbs/yr	971	364	0	0	1,335	971	0	1,335	0.0
3202	Redford Twp.	256	39	15.4	medium	NO23	lbs/yr	592	289	0	0	880	592	0	880	0.0
3202	Redford Twp.	256	39	15.4	medium	Pb	lbs/yr	19	1	0	0	20	19	0	20	0.0
3202	Redford Twp.	256	39	15.4	medium	Cu	lbs/yr	10	1	0	0	11	10	0	11	0.0
3202	Redford Twp.	256	39	15.4	medium	Zn	lbs/yr	55	1	0	0	57	55	0	57	0.0
3202	Redford Twp.	256	39	15.4	medium	Cd	lbs/yr	1	0	0	0	1	1	0	1	0.0
3202	Redford Twp.	256	39	15.4	medium	F-Coli	counts/yr	3,384,263,390	1,598,458	0	0	3,385,861,847	853,384,263,390	0	,861,847	0.0
3203	Livonia	0	0	3.6	medium	RunOff	(ac-ft/yr)	0	0	0	0	0	0	0	0	0.0

Table D.2: Subarea Loads by Pollutant

BOD (lbs/yr)

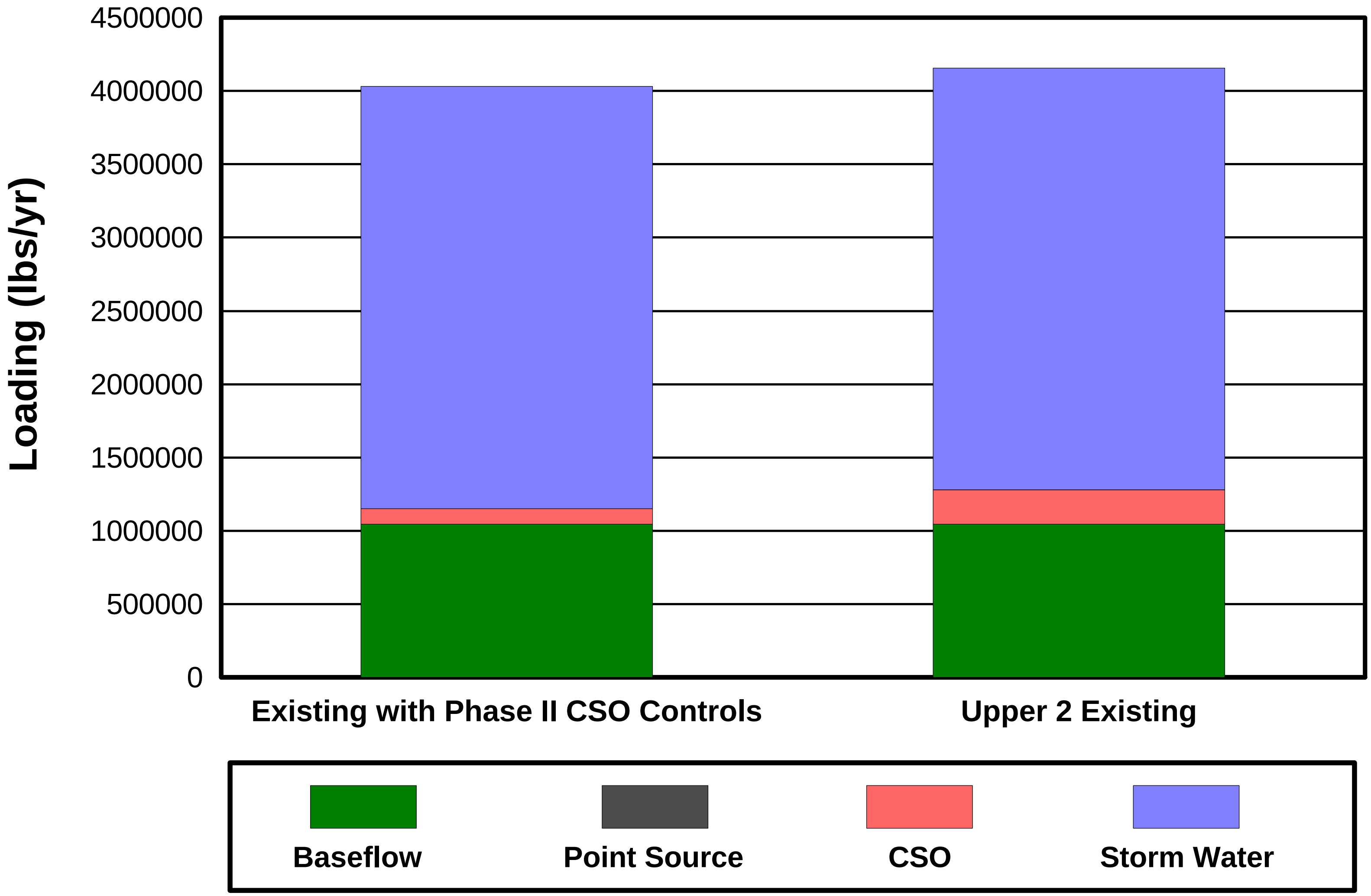
Name	Jurisdiction	% DCIA	Storm Water	Baseflow	Point Source	CSO	Total	% Change from Existing with Phase II CSO Controls
3201	Livonia	17	0	0	0	9	9	-55
3201	Redford Twp.	18	0	217	0	1,035	1,252	-50
3202	Redford Twp.	15	10,796	920	0	0	11,716	0
3203	Livonia	4	1	0	0	0	2	0
3203	Redford Twp.	17	23,702	1,972	0	0	25,674	0
3204	Farmington Hills	35	306	18	0	0	324	0
3204	Livonia	18	67,305	4,610	0	0	71,915	0
3204	Redford Twp.	20	19	1	0	0	21	0
3205	Livonia	17	37,996	3,200	258	0	41,453	0
3205	Redford Twp.	43	16	1	0	0	16	0
3206	Farmington	21	14,721	986	0	0	15,707	0
3206	Farmington Hills	9	20,630	2,139	0	0	22,769	0
3206	Livonia	18	33,777	2,313	0	0	36,090	0
3207	Livonia	18	49,981	3,467	0	0	53,448	0
3208	Livonia	24	93,623	5,667	0	0	99,289	0
3209	Farmington	42	26	1	0	0	27	0
3209	Farmington Hills	15	96	12	0	0	109	0
3209	Livonia	14	76,726	6,409	0	0	83,134	0
3210	Livonia	17	61,558	4,340	0	0	65,898	0
3211	Farmington	12	10,165	1,100	0	0	11,265	0
3211	Farmington Hills	10	26,393	3,557	0	0	29,950	0
3212	Livonia	15	50,145	4,095	0	0	54,239	0
3213	Farmington	18	7,105	590	0	0	7,695	0
3213	Farmington Hills	22	57,591	4,939	0	0	62,530	0
3213	Novi	12	2,124	351	0	0	2,475	0
3214	Farmington Hills	6	21,215	3,334	0	0	24,549	0
3214	Livonia	6	1,173	313	0	0	1,486	0
3215	Farmington Hills	3	3,954	496	0	0	4,449	0

Table D.3: Multiple Scenario by Pollutant

Parameter	Units	Upper 2 Existing	Existing with Phase II CSO Controls	
		Total	Total	% Change from Upper 2 Existing
Runoff	ac-ft/yr	26,123	26,123	0
BOD	lbs/yr	1,109,131	1,078,937	-3
Cd	lbs/yr	133	132	-1
Cu	lbs/yr	1,166	1,154	-1
DP	lbs/yr	9,143	9,008	-1
F-Coli	counts/yr	6,233,704,815,364,508	3,049,556,973,688,836	-51
NO23	lbs/yr	84,914	84,558	0
Pb	lbs/yr	1,872	1,865	0
TKN	lbs/yr	122,959	121,758	-1
TP	lbs/yr	18,087	17,551	-3
TSS	lbs/yr	4,156,708	4,029,816	-3
Zn	lbs/yr	7,433	7,385	-1

Table D.4

Bar Chart Run Comparison



Appendix E

Importing WMM Version 3.30 Data Files

The user may import data from WMM Version 3.30 using tools provided in the Scenario Manager portion of WMM for Windows. Version 3.30 spreadsheet files containing EMC, land use, BMP, imperviousness and hydrologic data may be imported for use in WMM for Windows.

To import old data files, enter the scenario manager. Note that it is easiest to import data files in the same order as the buttons are shown in Scenario Manager. Click on the **New** button located to the left of the Landuse Types file list to begin the import exercise. After entering a new scenario name and description, select the Import from Version 3.30 option when prompted, and click the **OK** button to continue. The user will be asked to locate the WMM 3.30 land use data file by clicking the **Browse** button and selecting the proper file location, as shown in Figure E-1. Click the **Open** button once you have chosen the proper file and then click the **Import File** button to continue. Note that it is important that the spreadsheet file to be imported is in the original format required to run WMMJ Version 3.30. A sample of this format is shown in Figure E-2.

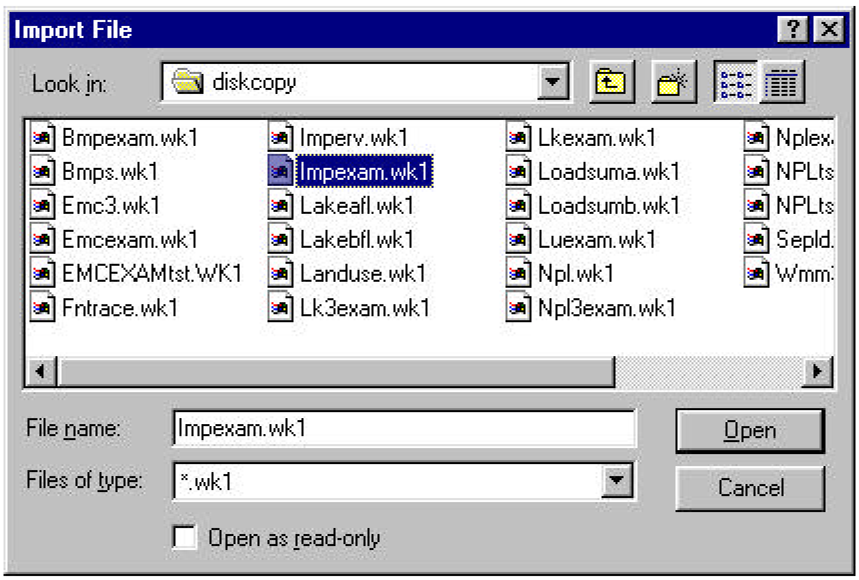


Figure E-1
Land Use Import

Once the file has been opened, the user may be prompted to match landuse types from the Version 3.30 data file to the default land use types found in WMM for Windows (as shown in Figure E-3.) The user may assign the old land use type to one of the default values by clicking on the desired default value and clicking on the **Next** button. If there is not an appropriate WMM for Windows default land use type available for the old land use type, the user should click the **Next** button without selecting any of the default land use types. This will allow the WMM 3.30 land use type name to become a WMM for Windows land use type. The user will continue to be prompted to match all WMM 3.30 land use type names until all unmatching land use type names have been assigned to default values or have been added to the data base. After all matches have been made, enter a name and description for the Land Use Set Information and click **Save** to retain your new data set.

WATERSHED MANAGEMENT MODEL
VERSION 3.30

Percent Impervious Edit File

Land Use	Percent Impervious
Forest/Open	0.5%
Agricultural/Pasture	0.5%
Cropland	0.5%
Low Density Single Fam.	10.0%
Med. Density Single Fam.	30.0%
High Density Single Fam.	50.0%
Commercial	90.0%
Office/Lt. Industrial	70.0%
Heavy Industrial	80.0%
Water	100.0%
Wetlands	100.0%
Major Roads	90.0%
Optional Land Use #1	0.0%
Optional Land Use #2	0.0%
Optional Land Use #3	0.0%

Figure E-2
WMM Version 3.30 Sample Land Use File

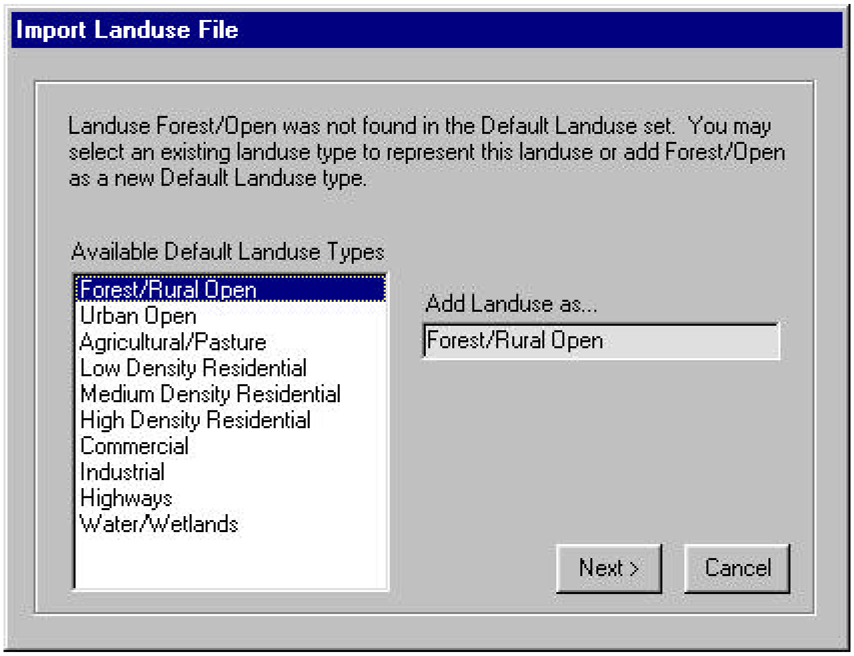


Figure E-3
Select Landuse Types from Defaults

After the land use data set has been imported, continue building your new scenario by importing the watershed data used in WMM Version 3.30. Click the New button located next to the Watershed file lists, select the Import from Version 3.30 option and locate the desired file. (A sample of this file format is shown in Figure E-4.) The user will be prompted to match land use type names to WMM land use type defaults, similar to the way the user was prompted when importing the imperviousness data. It is important that the same land use names are used so that the data sets are compatible. After matched have been created for the land use data, the user will be asked if he wishes to import septic failure impact data. Select yes if your file contains these data or no if this information is not contained in your WMM Version 3.30 file. If the user selects yes to import septic impact data, he will be prompted to identify the land use types affected by septics, as shown in Figure E-5. After the desired land use types affected by septics are selected, click **ok** to complete the import. Once the data have been imported, the

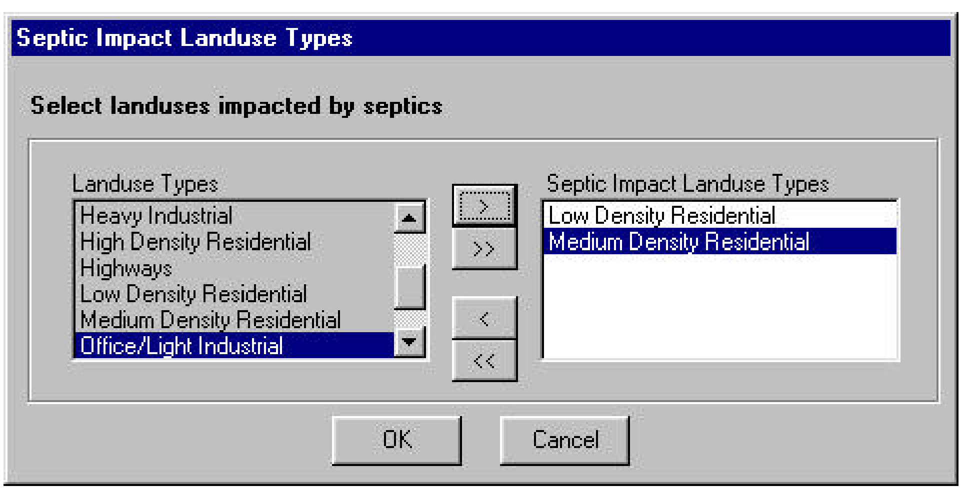


Figure E-5
Areas Affected by Failing Septic Systems

WATERSHED MANAGEMENT MODEL
VERSION 3.30

LAND USE MODULE

LAND USE FILE NAME: LUEXAM

Number of Sub-basins:	3		
Subbasin Range Name:	SB1	SB2	SB3
LAND USE SCENARIO:	EXISTING	EXISTING	EXISTING
SUBBASIN NAME:	WATERSHED 1	WATERSHED 2	WATERSHED 3
JURISDICTION:	YOUR COUNTY	YOUR COUNTY	YOUR COUNTY

Land Use Category	Acres	Acres	Acres
Forest/Open	250	500	0
Agricultural/Pasture	100	500	0
Cropland	100	0	0
Low Density Single Fam.	300	0	0
Med. Density Single Fam	0	0	0
High Density Single Fam.	0	0	300
Commercial	100	0	500
Office/Light Industrial	0	0	50
Heavy Industrial	50	0	150
Water	100	0	0
Wetlands	0	0	0
Major Roads	0	0	0
Optional Land Use #1	0	0	0
Optional Land Use #2	0	0	0
Optional Land Use #3	0	0	0
Total	1,000	1,000	1,000
Delivery Ratio	100%	100%	100%
Septic Tank Failure Data			
Ann. Septic Failure Rate	15.0%	0.0%	0.0%
eptic Failure Impact Area	100.0%	0.0%	0.0%

Figure E-4
WMM Version 3.30 Sample Watershed Data File

Watershed Information screen will appear and the user must enter the desired watershed name and description. At this point, data imported should be reviewed to confirm it's correct importation. Once the data have been reviewed, click **Save** to return to the Scenario Manager screen.

Similar steps must be taken to import the remaining WMM Version 3.30 data, including the hydrologic data, EMC mean value data, base flow parameter concentrations, suspended fraction data, septic loading data, BMP data, and point source data. Sample file formats for the WMM Version 3.30 data are shown in Figures E-6 through E-9. Figure E-6 shows the first page of the file containing the data for the hydrologic, baseflow, suspended fraction and point source data inputs. Consequently, this file is also the main file for WMM Version 3.30 containing the macros used to run the model, and is usually named npl.wk1. An example file format for the EMC mean values is shown in Figure E-7 and an example file format for the septic tank failure loading rates and BMP data sets can be found in Figures E-8 and E-9, respectively.

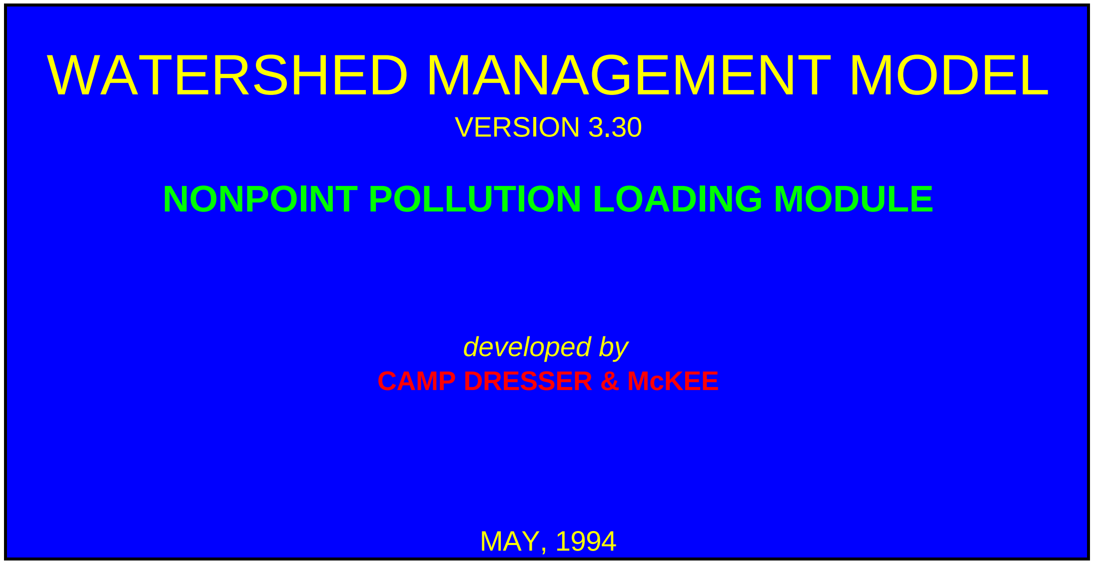


Figure E-6
WMM Version 3.30 Sample NPL File

MEAN EMCS

	mg/L											
	Oxygen Demand & Sediment				Nutrients				Heavy Metals			
Land Use	BOD	COD	TSS	TDS	TP	DP	TKN	NO23	Pb	Cu	Zn	Cd
Forest/Open	8.0	51	216	100	0.23	0.06	1.36	0.73	0.00	0.00	0.00	0.00
Agriculture/Pasture	8.0	51	216	100	0.23	0.06	1.36	0.73	0.00	0.00	0.00	0.00
Cropland	8.0	51	216	100	0.23	0.06	1.36	0.73	0.00	0.00	0.00	0.00
Low Density Single Family	10.8	83	140	100	0.47	0.16	2.35	0.96	0.18	0.05	0.18	0.002
Medium Density Single Fa	10.8	83	140	100	0.47	0.16	2.35	0.96	0.18	0.05	0.18	0.002
High Density Single Famil	10.8	83	140	100	0.47	0.16	2.35	0.96	0.18	0.05	0.18	0.002
Commercial	9.7	61	91	100	0.24	0.10	1.28	0.63	0.13	0.04	0.33	0.002
Office/Light Industrial	9.7	61	91	100	0.24	0.10	1.28	0.63	0.13	0.04	0.33	0.002
Heavy Industrial	9.7	61	91	100	0.24	0.10	1.28	0.63	0.13	0.04	0.33	0.002
Water	3.3	17	7	100	0.03	0.01	0.60	0.60	0.00	0.00	0.11	0.000
Wetlands	3.3	17	7	100	0.03	0.01	0.60	0.60	0.00	0.00	0.11	0.000
Major Roads	9.7	103	142	100	0.44	0.17	1.78	0.83	0.53	0.05	0.37	0.002
Optional Land Use #1	0.0	0	0	0	0	0	0	0	0	0	0	0
Optional Land Use #2	0.0	0	0	0	0	0	0	0	0	0	0	0
Optional Land Use #3	0.0	0	0	0	0	0	0	0	0	0	0	0

COEFFICIENT OF VARIATION

	Oxygen Demand & Sediment				Nutrients				Heavy Metals			
	BOD	COD	TSS	TDS	TP	SP	TKN	NO23	Pb	Cu	Zn	Cd
Land Use	CV	CV	CV	CV	CV	CV	CV	CV	CV	CV	CV	CV
Forest/Open	0.5	0.5	0.5	0.5	0.7	0.7	0.5	0.5	0.0	0.0	0.0	0.0
Agriculture/Pasture	0.5	0.5	0.5	0.5	0.7	0.7	0.5	0.5	0.0	0.0	0.0	0.0
Cropland	0.5	0.5	0.5	0.5	0.7	0.7	0.5	0.5	0.0	0.0	0.0	0.0
Low Density Single Family	0.4	0.6	1.0	1.0	0.7	0.5	0.7	0.8	0.8	1.0	0.8	0.8
Medium Density Single Fa	0.4	0.6	1.0	1.0	0.7	0.5	0.7	0.8	0.8	1.0	0.8	0.8
High Density Single Famil	0.4	0.6	1.0	1.0	0.7	0.5	0.7	0.8	0.8	1.0	0.8	0.8
Commercial	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Office/Light Industrial	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Heavy Industrial	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Water	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Wetlands	0.3	0.4	0.9	0.9	0.7	0.7	0.4	0.5	0.7	0.8	1.1	1.1
Major Roads	0.7	0.7	1.2	1.2	1.1	1.1	0.7	0.8	2.0	0.9	1.4	1.4
Optional Land Use #1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Optional Land Use #2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Optional Land Use #3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure E-7
WMM Verison 3.30 Sample Mean EMC File

WATERSHED MANAGEMENT MODEL
Version 3.30b
Septic Tank Failure Loading Rate Multipliers

NUTRIENTS	TP	DP	TKN	NO2&NO3
LDSF & MDSF: MEDIUM	2.1	2.1	2.0	2.0
LDSF & MDSF: HIGH	3.3	3.3	3.0	3.0
LDSF & MDSF: LOW	1.6	1.6	1.5	1.5
ODS	BOD	COD	TSS	TDS
LDSF & MDSF: MEDIUM	1.0	1.0	1.0	1.0
LDSF & MDSF: HIGH	1.0	1.0	1.0	1.0
LDSF & MDSF: LOW	1.0	1.0	1.0	1.0
METALS	LEAD	CU	ZINC	CD
LDSF & MDSF: MEDIUM	1.0	1.0	1.0	1.0
LDSF & MDSF: HIGH	1.0	1.0	1.0	1.0
LDSF & MDSF: LOW	1.0	1.0	1.0	1.0

NOTE: These multipliers are applied to —_Large Lot Single Family˜, —_Low Density Sin
and —_Low-Medium Density Single Family˜ residential areas.

Figure E-8
WMM Version 3.30 Sample Septic Impact File

BMP COVERAGE DATABASE

WATERSHED:
BMP COVERAGE FILE: BMPEXAM
LAND USE FILE NAME: LUEXAM.WK1
SCENARIO: EXISTING

Number of sub-basins: 3

Constituent	RETENTION	EXTENDED DRY	WET DETENTION	BMP4	BMP5
BOD	90%	30%	30%	0%	0%
COD	90%	30%	30%	0%	0%
TSS	90%	90%	90%	0%	0%
TDS	90%	0%	40%	0%	0%
Total-P	90%	30%	50%	0%	0%
Dissolved-P	90%	0%	70%	0%	0%
TKN	90%	20%	30%	0%	0%
NO—d2˜ + NO—d3	90%	0%	30%	0%	0%
Lead	90%	80%	80%	0%	0%
Copper	90%	60%	70%	0%	0%
Zinc	90%	50%	50%	0%	0%
Cadmium	90%	80%	80%	0%	0%

	SB1 Scenario WATERSHED 1 YOUR COUNTY					SB2 Scenario WATERSHED 2 YOUR COUNTY				
Land Use	BMP1	BMP2	BMP3	BMP4	BMP5	RETENTION	EXTENDED DRY	WET DETENTION	BMP4	BMP5
Forest/Open	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Agricultural/Pasture	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Cropland	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Low Density Single Family	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Medium Density Single Fam	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
High Density Single Family	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Commercial	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Office/Light Industrial	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Heavy Industrial	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Water	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Wetlands	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Major Roads	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Optional Landuse #1	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Optional Landuse #2	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Optional Landuse #3	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Figure E-9
WMM Version 3.30 Sample BMP File

Appendix F

WMMAV Application User's Guide

WMMAV is an application developed using ESRI's ArcView 3.1 GIS software to spatially display data generated by the WMM for Windows model. WMMAV connects directly to the WMM database and allows display of stored model output. All that is required to run WMMAV is ArcView 3.1, WMM for Windows 4.1 and a polygon theme containing the delineated basin areas which are being modeled. The source of the polygon theme can include any ArcView compatible spatial data including shape files, ArcInfo coverages, CAD drawings or Map Info Interchange Format files.

Note: Use of WMMAV assumes a working knowledge of ArcView and an understanding of the basic concepts of themes, attribute tables and polygon topology.

WMMAV Operation

WMMAV may be started directly from WMM by clicking the ArcView Map button located in Output Manager or by starting ArcView and loading the wmmav.apr project file. WMM does not have to be running to use WMMAV.

When initially loaded, WMMAV presents the user with the standard ArcView interface window (Figure F-1) to which has been added 5 buttons and 1 tool through which WMMAV is implemented.

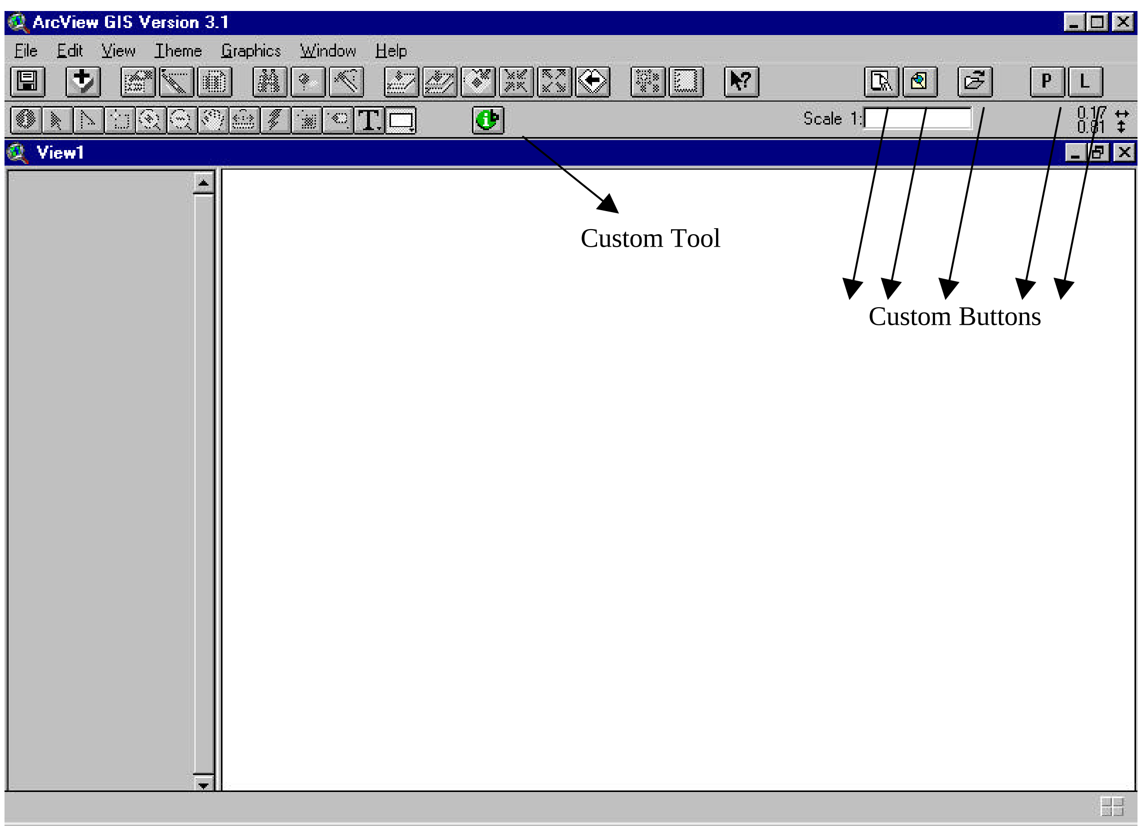
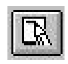


Figure F-1

Initial Theme Setup

In order to connect an ArcView polygon theme containing the delineated basin areas that are being modeled to associated WMM model output, a new field must be added to the theme's attribute table. This new field, Subareaid, serves as a link between the theme and the WMM output data.

To add the Subareaid field to the theme attribute table:

1. Open ArcView and add the basin theme to a View and set it active.
2. Click the Add Subareaid Field  button to add the Subareaid field to the active theme's attribute table.

After adding the Subareaid field to the theme's attribute table, the field must be populated with subarea ID values. The subarea ID values consists of the basin name concatenated with "/" and the jurisdiction. The basin name and jurisdiction are as entered in WMM for each basin. **All entries must be made in uppercase.**

Example:

Basin name = 1234
Jurisdiction = Northville

Subarea ID = 1234/NORTHVILLE

To populate the Subareaid field, open the theme's attribute table, select *Start Editing* from the Table menu, add the subarea ID values to the Subareaid field and then select *Stop Editing* from the Table menu and click OK to save edits.

Theme/Watershed Association

Once a theme has had the Subareaid field added and populated it needs to be associated with a WMM watershed.

To associate an ArcView theme with a WMM watershed click the  button which will display the Watershed -Theme Association window (Figure F-2).

From the Watershed list box, select the watershed that you wish to associate and click the Select Theme button which will display the Select Theme window (Figure F-3).

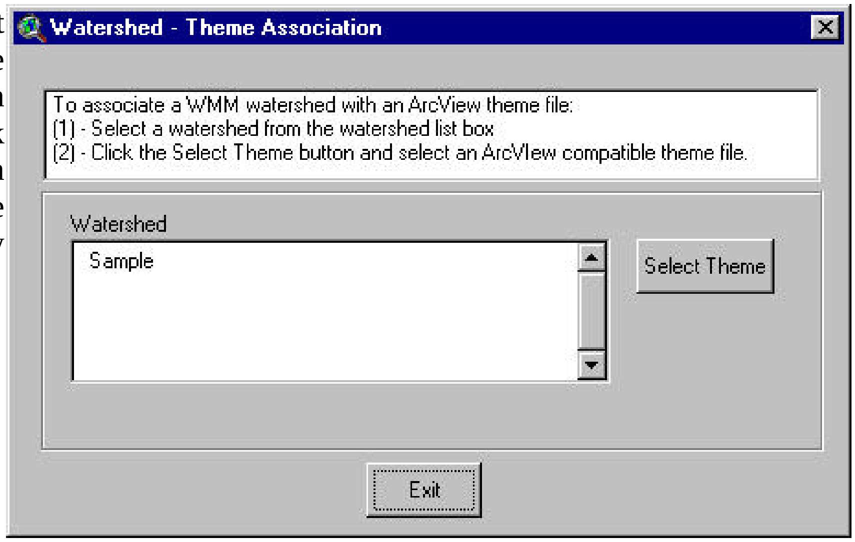


Figure F-2

From the Select Theme window move to the file of the theme you wish to associate to the selected watershed and click OK which will display the Enter Theme Display Name input window (Figure F-4).

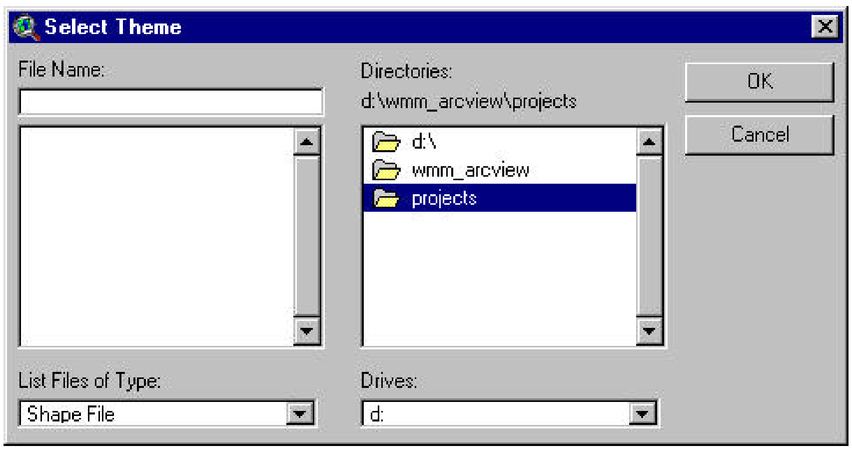


Figure F-3

The user has the option of entering a more meaningful theme name that will be used in the ArcView View table of contents or of accepting the default file name.

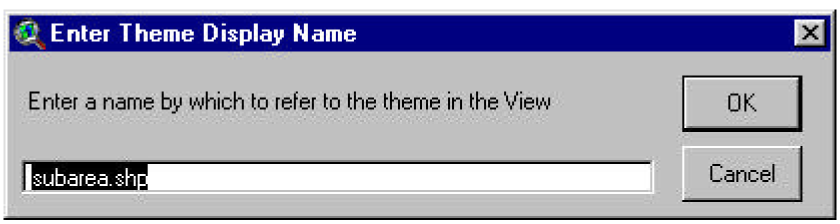


Figure F-4

After the theme display name information has been entered and the user clicks the OK button, the Theme/Watershed Association Info window (Figure F-5) is displayed showing the newly added association information. To accept the association click OK, to undo the association, click the Cancel button.

Once the association is accepted, WMMAV is ready to display WMM model output data.

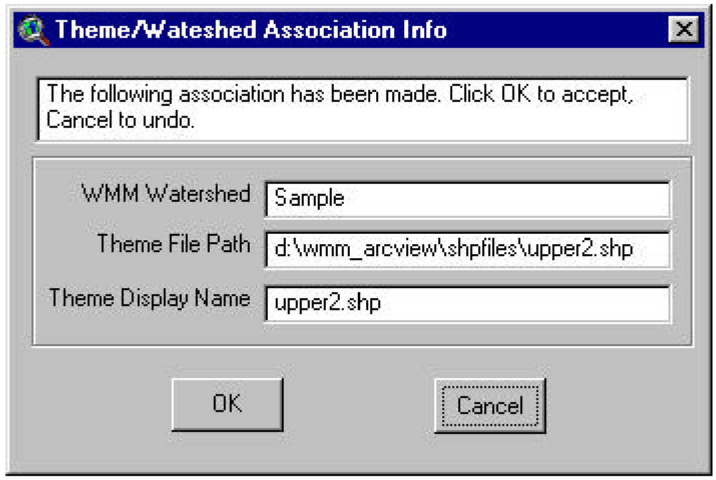
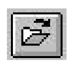


Figure F-5

Associations are stored in the ArcView table wshedlu and can be viewed, edited or deleted by working directly with the table.

Displaying WMM Output Data

The first step in displaying WMM output data is to select the WMM output run you wish to display. This is done by clicking the  button on the ArcvView View button bar, which will display the Select WMM Output window (Figure F-6).

Select the desired WMM output run from the list box and click the OK button.

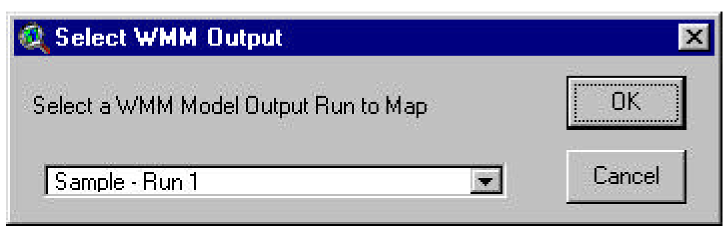


Figure F-6

The WMM Model Output Theme Association window (Figure F-7) will be displayed showing the current theme association information. Click OK to continue.

Figure F-7

If the associated theme is not already in the View you will be prompted asking if you would like it added to the current View.

The L and P buttons determine what data will be displayed. Clicking the P button displays the select basin property selection list (Figure F-8).

Form this window the user can select basin property data such as % DCIA, Acres, Base Flow, etc. to display. Selecting a property and clicking OK will cause a map to be displayed with basins color-coded based on the selected property range values.

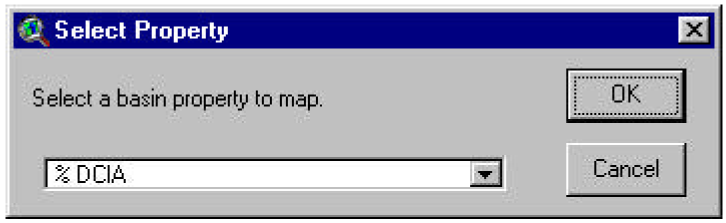


Figure F-8

Clicking the L button will display the Parameter Selection window (Figure F-9).

The Parameter Selection window allows the user to select a parameter of interest. Selecting a parameter and clicking the OK button will display the Load Selection window (Figure F-10).

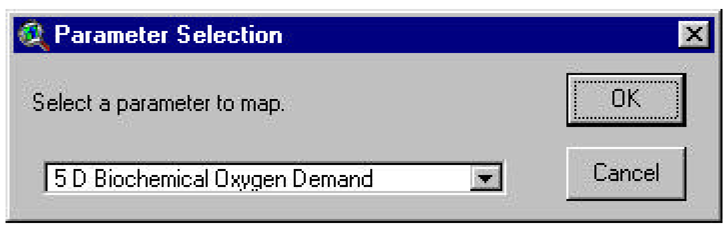


Figure F-9

From the Load Selection window the user can select the type of load they wish to display such as base load, CSO load, surface load, etc. Selecting a load type and clicking OK will cause a map to be displayed with basins color-coded based on the selected load range values.

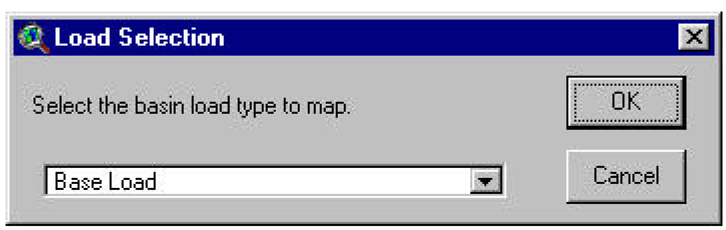


Figure F-10

Displaying Basin Information

Once a map is displayed showing the selected property or load values, the Show Basin Info tool will display additional basin information based upon the current map.

Selecting the the Show Basin Info tool  and clicking on a basin while the basin property map is displayed will display the Basin Property Information window (Figure F-11).

Clicking on additional basins will cause the values in the information window to update dynamically.

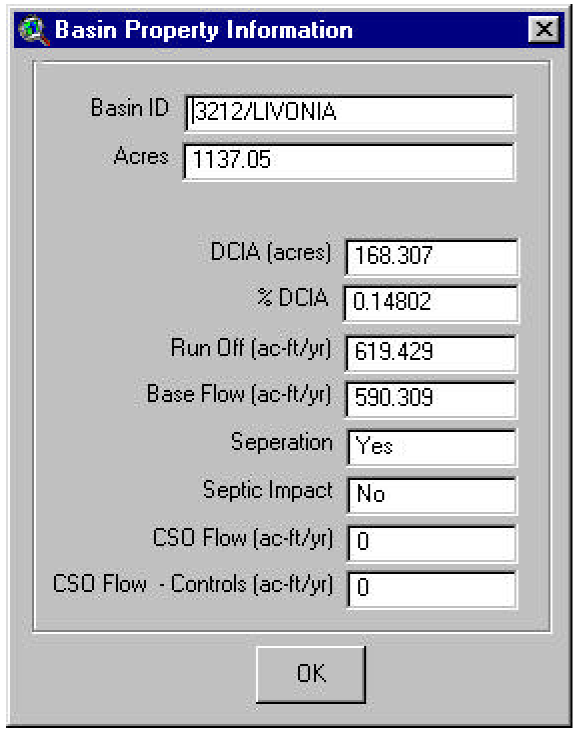


Figure F-11

Similarly, selecting the Show Basin Info tool and clicking on a basin while the basin load map is displayed will display the Basin Load Information window (Figure F-12).

Clicking on additional basins will cause the values in the information window to update dynamically.

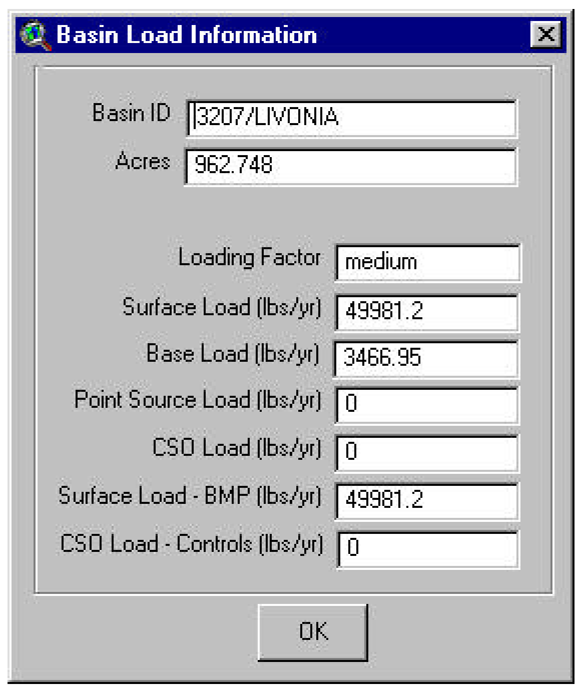


Figure F-12